Diabetes mellitus, a complex metabolic disorder, is a syndrome characterized by abnormalities in carbohydrate, lipid, and protein metabolism that results either from a profound or an absolute deficiency of insulin (type 1) or from target tissue resistance to its cellular metabolic effects (type 2). A third type of diabetes mellitus, gestational diabetes, represents carbohydrate intolerance with its onset or first recognition during pregnancy. There is no definitive cure for diabetes mellitus. The most common endocrine metabolic disorder, it affects an estimated 14 million people in the United States, with the incidence of new cases increasing by more than 700,000 cases per year. An additional estimated 7 million people have diabetes mellitus and do not know it because it has not yet been diagnosed. Without a proper diagnosis, these individuals are at significant risk for life-threatening complications. In some cases, these patients are diagnosed with diabetes only when they arrive at an emergency department with severe hyperglycemia (diabetic coma).

Diabetes mellitus is also a pernicious disease. It is the third leading cause of mortality and morbidity in the United States, accounting for about 40,000 deaths per year. The relative risk for persons with diabetes acquiring end-stage renal disease is 25 times that of persons without diabetes. The relative risk for diabetic patients having a limb amputated because of diabetic complications is over 40 times that of normal. More than 20,000 amputations per year are performed on patients with diabetes mellitus, representing nearly 50% of all nontraumatic amputations. The relative risk of an individual with diabetes becoming blind is 20 times greater than that of other individuals. Myocardial infarction is 10 times more likely in the diabetic patient. Types 1 and 2 diabetes mellitus represent the largest category of diabetic patients. Therefore, this section will focus on these two types and discuss concepts of their etiology, pathogenesis, and complications.

**TYPE 1 DIABETES MELLITUS**

Hyperglycemia is a hallmark of diabetes mellitus—as are its chronic metabolic complications. The chronic metabolic complications are generally more severe in the person with type 1 diabetes. These include increased susceptibility to infection and delayed healing, neuropathy, retinopathy, and nephropathy (microvascular disease); accelerated atherosclerosis with associated myocardial infarction, stroke, atherosclerotic aneurysms (macrovascular disease), and amputation. The development of secondary lesions in the diabetic patient relates largely to the severity and the duration of hyperglycemia. In general, the major classic findings of hyperglycemia—polyuria, polydipsia, polyphagia, weight loss, and fatigue—occur in the setting of new-onset diabetes in young patients whose disease is caused by profound insulin deficiency (type 1). Type 1 diabetes, or insulin-dependent diabetes mellitus (IDDM), constitutes approximately 3% to 5% of all cases of diabetes mellitus and is related to autoimmune-mediated destruction of the insulin-producing pancreatic islet beta cells. Thus, these patients are prone to ketoacidosis, an acute and potentially life-threatening metabolic complication, and are completely dependent on exogenous insulin to sustain life. Ketoacidosis can develop rapidly and lower the pH of the blood, leading to coma and death. The onset of signs and symptoms in these patients is relatively abrupt.
and usually occurs at a young age (mean, 15 years), although IDDM can arise at any age.

The destruction of the beta cells in the type 1 diabetic has been linked to the presence of certain major histocompatibility locus antigens (HLA), some of which are also associated with other autoimmune diseases. In fact, the only genes definitely associated with type 1 diabetes are those of the major HLA. Ninety-five percent of persons with type 1 diabetes, compared with 40% of the general population, express either HLA-DR3 or HLA-DR4, or both. Thus, one must take into careful consideration the potential for the development of other autoimmune-mediated endocrine diseases characterized by hyperfunction when assessing the overall clinical management of the person with type 1 diabetes.

**Type 2 diabetes mellitus**

Type 2 diabetes mellitus, or non–insulin-dependent diabetes mellitus (NIDDM), accounts for approximately 95% of all cases of diabetes. The insulin levels of affected patients may be normal, increased, or decreased, but there is no profound insulin deficiency. However, over many years, the majority of persons with type 2 diabetes show a continual decrease in their insulin levels. The etiology and pathogenesis of type 2 diabetes may be more heterogeneous with multiple biochemical or molecular lesions. These defects may include impaired insulin secretion; a defect at the insulin receptor; or shown more recently, a defect distal to the insulin receptor; and a defect in the hepatic uptake of glucose contributing to insulin intolerance. These patients are not prone to ketoacidosis under basal conditions and are not completely dependent on exogenous insulin to sustain life. However, insulin treatment for patients with NIDDM (25%-30% of cases) can improve the control of hyperglycemia.

The hyperglycemia in NIDDM is not caused by autoimmune destruction of beta cells, but it is rather a failure of those cells to meet an increased demand for insulin (impaired insulin secretion). Obesity is an overwhelming risk factor and is frequently associated with NIDDM. Obesity and its associated high serum cholesterol levels can also exacerbate accelerated atherosclerosis, which is frequently a preexisting component of clinical diabetes. Diabetes develops more commonly in persons with shoulder girdle obesity or truncal obesity. The diagnosis of type 2 diabetes usually occurs after a person reaches 40 years of age, when the basal metabolic rate declines and the body weight increases. However, a recent increasing trend in type 2 diabetes is now seen in teenagers and in the 20-year-old age group; this disturbing trend may be related to dietary obesity. Eighty percent of adult diabetics are obese or have a history of obesity. Among adults who are at least 25% over their ideal body weight, 1 of 5 has elevated fasting blood sugar levels, and 3 of 5 have abnormal oral glucose tolerance test results. Obesity increases insulin levels and decreases the concentration of insulin receptors in terms of their sensitivity in tissue (clinical insulin resistance). Exercise increases the number of insulin receptors and improves insulin sensitivity, whereas a sedentary lifestyle is associated with glucose intolerance. Regular exercise with weight loss is associated with a decreased incidence of NIDDM after adjusting for the body mass index.

Multifactorial inheritance also contributes clinically to the development of type 2 diabetes. However, a family history of diabetes is not a prerequisite for the development of the disease. It develops in persons with no known family history of diabetes. Still, there is usually a stronger family history in type 2 than in type 1 diabetes mellitus. Sixty percent of type 2 patients have either a parent or a sibling with the disease. In some populations—notably the Pima Indians of Arizona and the natives of Nauru in the Gilbert Islands of the Pacific—a third to a half of all persons are afflicted with type 2 diabetes. When one member of a monozygotic twinship has the disease, the second twin is almost invariably affected. However, there is no association with genes of the major HLA similar to that occurring in type 1 diabetes. Despite the high familial prevalence of type 2 diabetes, the precise mode of inheritance remains undefined.

**MEDICAL MANAGEMENT**

**Screening and diagnostic tests**

In 1979, the National Diabetes Data Group published criteria for the diagnosis of diabetes, criteria that have become widely accepted as the gold standard for the diagnosis of diabetes mellitus. By these criteria, at least one of the following conditions must exist to establish the diagnosis of diabetes in the nonpregnant adult:

1. Presence of the classic symptoms of diabetes (polyuria, polydipsia, polyphagia), with unequivocal hyperglycemia (random plasma glucose >200 mg/dL);
2. Fasting plasma glucose >140 mg/dL, or fasting venous (or capillary) whole blood glucose >120 mg/dL on more than one occasion; or
3. Abnormal oral glucose tolerance test result, with test performed under standardized conditions (75-g glucose load, with blood measurements performed every 30 minutes for 2 hours). Both the 2-hour level and at least one other sample must exceed 200 mg/dL.

**Tight control: redefining an established concept**

Both acute and chronic, prolonged exposure to hyperglycemia is the primary factor responsible for the
development of diabetic complications. The common biochemical basis for complications is hyperglycemia-mediated formation of nonenzymatic advanced glycation end-products. Advanced glycation end-products are chemically irreversible glucose-derived compounds that form slowly and continuously in plasma and tissues as a function of blood glucose concentration. They have been linked to the development of diabetic complications, such as renal failure.4

The glycated or glycosylated hemoglobin test (HbA1c) is widely used to assess glycemic control. It also has prognostic value, as was shown in the Diabetes Control and Complications Trial in 1993,4 the randomized prospective 6-year study in Japan in 1995,5 and in the United Kingdom Prospective Diabetes Study Group in 1998.6 Reducing glycated hemoglobin levels decreases the incidence of some diabetic complications (Table I). This test measures glucose that binds to blood hemoglobin within the circulating erythrocytes and remains attached for the life-cycle of the red blood cell. Hemoglobin is a marker to measure the glucose pool. Thus, it is the preferred test for the medical evaluation of diabetic control because it measures the blood glucose levels over a period of 8 to 12 weeks.

Data from the American Diabetes Association (1999) show the values of glycosylated hemoglobin that target for tight metabolic control10 (Table II). Continuous or prolonged hyperglycemia as measured by the glycated hemoglobin test is associated with chronic toxicity and tissue damage. But the hemoglobin A1c alone is not sufficient to assess diabetes control.

It has been shown that other features of diabetic glucose control not reflected in the HbA1c might add to or modify the risk of complications.5 For example, recent clinical data show that the risk and severity of complications may be even more highly dependent on the extent of 1- to 2-hour postprandial (after meal) excursions of blood glucose (acute glycemia and toxicity).11,12 Hyperglycemia postmeal is associated with increased free-radical production that can lead to tissue damage. Hyperglycemia 2 hours postload is associated with an increased risk of death, independent of fasting blood.13 Data also show that the risk of microvascular (eye and kidney) disease increases with the progression in postprandial glucose levels from 180 to 260 mg/dL.5 Thus, tight control in current therapy now includes a shift to a new focus: constant daily glucose monitoring, often before and after meals, to target postprandial levels and minimize the occurrence of acute hyperglycemia and acute toxicity. The target levels shown are for the patient taking rapid-acting insulin, such as insulin lispro (Humalog; Table III). The battery-operated glucometer is a home monitoring device that enables the patient to obtain and record blood glucose data. The glucometer measures the glucose in a drop of blood obtained from the tip of the finger by a stick with a sterile lancet. The patient should perform this test, on average, 4 to 6 times per day. As shall be discussed later, walking this metabolic tightrope also carries a risk: The patient may fall into profound hypoglycemia (insulin shock) while using multiple insulin injections or into severe hyperglycemia with ketoacidosis (diabetic coma) while using an insulin pump.

**Type 1 diabetes mellitus**

Exogenous insulin is administered by subcutaneous injection. Insulin (U-100) is classified as rapid (insulin lispro [Humalog] and Regular), intermediate (insulin [NPH and Lente]), and long-acting (insulin [Ultralente]). These different types of insulin vary in their onset, peak, and duration of activity. The major disadvantage of the intermediate and long-acting insulin is the lack of consistent predictability, owing to the fact that these preparations are suspensions. It is therefore important for the patient to mix the suspensions carefully (by slowly rotating the insulin vial) before injection. A recently developed long-acting, suspension-free insulin (garglone; Lantus) comparable to NPH insulin activity will soon be available. It should provide improved predictability.

**Types of insulin.** Lispro and regular insulin are generally taken close to mealtime to match the peak activity of the injected insulin with the peak absorption of glucose from the small intestine into the bloodstream. Humalog is the most rapidly acting insulin. It is administered 5 to 15 minutes before a meal and has a peak activity of 30 to 90 minutes. Therefore, patients must avoid delaying a meal by more than 45 minutes if taking Humalog.

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**Table I. Good glycemic control reduces incidence of complications**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DCCT*</th>
<th>Kumamoto†</th>
<th>UKPDS‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>HbA1c</td>
<td>9%-7%</td>
<td>9%-7%</td>
<td>8%-7%</td>
</tr>
<tr>
<td>Retinopathy</td>
<td>65%</td>
<td>69%</td>
<td>17%-21%</td>
</tr>
<tr>
<td>Nephropathy</td>
<td>54%</td>
<td>70%</td>
<td>24%-33%</td>
</tr>
<tr>
<td>Neuropathy</td>
<td>60%</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Macrovascular disease</td>
<td>41%§</td>
<td>—</td>
<td>16%‡</td>
</tr>
</tbody>
</table>

*References 4,7-9.†Reference 5.‡Reference 6.§Not statistically significant.

**Table II. Metabolic targets for tight control**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasting blood glucose</td>
<td>80-120 (mg/dL)</td>
</tr>
<tr>
<td>HbA1c</td>
<td></td>
</tr>
<tr>
<td>Optimal</td>
<td>&lt;6% (&lt;120 mg/dL)</td>
</tr>
<tr>
<td>Goal</td>
<td>&lt;7% (&lt;150 mg/dL)</td>
</tr>
<tr>
<td>Action level</td>
<td>≥8% (≥180 mg/dL)</td>
</tr>
</tbody>
</table>
Table III. Target values for preprandial and postprandial blood glucose levels

<table>
<thead>
<tr>
<th>If premeal blood sugar is:</th>
<th>Then 1 hour postmeal should be:</th>
<th>And next premeal should be:</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100 mg/dL</td>
<td>120-160 mg/dL</td>
<td>100-120 mg/dL</td>
</tr>
<tr>
<td>100-150 mg/dL</td>
<td>20-40 mg/dL higher</td>
<td>Same as premeal</td>
</tr>
<tr>
<td>151-200 mg/dL</td>
<td>0-20 mg/dL higher</td>
<td>0-20 mg less than premeal</td>
</tr>
<tr>
<td>201-250 mg/dL</td>
<td>0-20 mg/dL lower</td>
<td>20-40 mg less than premeal</td>
</tr>
<tr>
<td>251-300 mg/dL</td>
<td>20-40 mg/dL lower</td>
<td>40-60 mg less than premeal</td>
</tr>
<tr>
<td>&gt;300 mg/dL</td>
<td>40-60 mg/dL lower</td>
<td>60-80 mg less than premeal</td>
</tr>
</tbody>
</table>

Otherwise, they may rapidly progress to severe hypoglycemia (insulin shock). Ultralente insulin simulates the basal metabolic rate of insulin secreted from a normally functioning pancreas. It is “peakless” insulin because of its slow onset, minimal peak activity, and long duration of action. Intermediate-acting insulin, such as NPH and Lente, has a slower onset (2 to 4 hours) and peak (4 to 12 hours) activity than rapidly acting insulin. Thus, NPH or Lente insulin injected at 8 AM will usually enter its peak at noon. It is essential that the clinician be fully knowledgeable about the peak activity and duration of these different types of insulin. Severe hypoglycemia (insulin shock) is a life-threatening medical emergency and is far more common during multiple insulin injections associated with intensive insulin regimens.

**Insulin injection regimens.** Conventional insulin injection regimens may include 1 daily injection of either NPH or Lente insulin or 1 injection of either NPH or Lente insulin mixed with more rapidly acting Humalog or regular insulin. These regimens are not as effective as the intensive insulin regimens in terms of obtaining tight metabolic control, and the number of injections is more limited and leads to wider fluctuations in blood glucose levels.

An advance that is gaining wider use in the medical management of type 1 diabetes is the insulin pump. The pump uses only one rapid-acting insulin and therefore eliminates the variability of the intensive insulin regimen. Pump therapy reduced the incidence of severe hypoglycemia in a number of studies, with a 6-fold reduction in incidence over that of multiple daily injections in the intensive regimen. Nonetheless, pump therapy (if not carefully monitored) can lead to rapid hyperglycemia and ketoacidosis, a life-threatening emergency.

**The insulin pump.** The insulin pump is a battery-powered device that uses phosphate-buffered rapid-acting regular insulin (peak activity of 1-2 hours) stored in a reservoir syringe that is located within the pump and is replaceable. Humalog also has significant potential for use with the pump; however, the Food and Drug Administration has not yet approved its use for the pump. If the insulin is not buffered, then it may precipitate inside of the system, resulting in occlusions that can stop the flow of insulin. Insulin is delivered from the device by means of an infusion set. This is available in a variety of lengths and consists of a plastic tube (the catheter) with a metal or plastic needle that is placed subcutaneously in the patient. Typically, the cannula is inserted into the abdomen, upper thigh, or upper arm. The patient replaces the infusion set every 48 hours to avoid infection at the site of insulin delivery. The pump is plastic, weighs about 3.6 oz, and is the size of a beeper. With the assistance of pouches or waterproof containers that are now readily available, the patient can wear the external pump almost anywhere on the body (eg, on a belt).

The pump is a continuous subcutaneous insulin infusion (CSII) system. CSII is an open-loop system, and therefore, it does not use a blood glucose sensor that automatically adjusts the insulin rate to fluctuations in the blood glucose levels. Patients must be taught how to be their own “glucose sensor” and learn a system of insulin algorithms based on frequent self-monitoring of blood glucose levels with a glucometer. This is the best way to “close the loop” of the infusion system. The battery-powered pump delivers a continuous basal infusion of insulin that can be automatically programmed for multiple basal rates over a 24-hour period (basal profile). Thus, the pump also delivers basal insulin automatically throughout a patient’s sleep. The basal profile is analogous to a continuous intravenous drip of insulin. The purpose of the basal insulin program or profile is to release insulin and thus maintain glucose homeostasis by preventing significant glycogenolysis from the liver. Otherwise, there would be a very rapid rise in the blood glucose levels, leading to severe hyperglycemia and ketoacidosis. In the absence of food or infection, the basal program alone would not usually require modification—unless there was a change in the level of the patient’s activity (eg, an active lifestyle vs a more sedentary lifestyle). Before meals or at other times (eg, hyperglycemia after anticipated caloric intake), the patient can activate the pump to deliver a bolus of insulin by pressing a button. For someone on an intensive multiple-dose injection regimen, this is similar to taking an injection of premeal rapid-acting insulin.

Insulin pumps use only rapid or short-acting insulin, and therefore only one variable is present. This offers...
significant advantages over the use of longer-acting insulin (eg, NPH and Lente) with intensive multiple-dose injection regimens. Longer-acting insulin shows a high degree of variability in absorption—from 10% to 52% of the injected dose—and can peak at unpredictable times; hypoglycemia from the longer-acting insulin can also occur at those times. In contrast, the use of only short-acting insulin with an insulin pump demonstrates a day-to-day variation in absorption of less than 3%. Insulin pumps may also reduce the insulin depot effect sometimes encountered with multiple daily injections. Subcutaneous depots of injected insulin can mobilize unexpectedly, particularly with exercise, leading to sudden episodes of hypoglycemia. This depot effect is reduced by pumps with only short-acting insulin and by slower, more reproducible bolus dose delivery. Thus, insulin pumps significantly reduce severe hypoglycemia better than multiple-dose injection regimens.15

The major risk associated with the insulin pump is the rapid development of severe hyperglycemia and diabetic ketoacidosis (DKA), leading to diabetic coma. The pump provides a steady-state control of blood glucose levels through a programmed basal profile. This program is tailored to the individual diabetic patient. The pump can deliver incremental doses as low as 0.1 unit of insulin/hour. The lowest dose that a patient can deliver with any accuracy using a syringe is 1.0 unit. Thus, insulin activity and duration are more tightly “packaged” to fit the specific metabolic demands of the patient. Consequently, reductions several-fold in terms of insulin dosage occur while the patient is on the pump as opposed to the higher doses the patient gets from multiple dose injection therapy; this also significantly reduces the occurrence of severe hypoglycemia in a patient using the pump. However, if there is a disruption in this finely tuned glucose control, then potent counter-regulatory hormones to insulin, such as epinephrine and cortisol, will cause a very rapid mobilization of the glycogen stores from the liver (glycogenolysis). This leads to severe and sudden hyperglycemia with DKA.

A major cause of the disruption of this finely tuned glucose control is the mechanical failure of the pump and therefore its inability to deliver insulin. Thus, the patient must constantly monitor blood glucose levels. If hyperglycemia and ketones (in urine) are present, then the patient must troubleshoot with the pump to determine why the insulin was not delivered.

The dentist must be aware of the signs and symptoms of hyperglycemia and DKA in the patient using an insulin pump. The dental clinician must ensure that the tubing or catheter from the pump is not pinched or compressed by the dental chair because this will block the flow of the patient’s insulin. The signs and symptoms of DKA include nausea, disorientation, abdominal cramps (common), and fatigue; these often resemble flu-like signs and symptoms and the patient will feel ill. The dentist should have a glucometer available at all times to monitor all diabetic patients for both hypoglycemia and, particularly, hyperglycemia in the patient using an insulin pump. The dentist should call the physician immediately if the glucometer readings show severe hyperglycemia (eg, >400 mg/dL). The physician may instruct the dentist to disconnect the pump from the patient and administer a bolus of the patient’s rapid-acting insulin with an insulin syringe. The dentist should call an ambulance or refer the patient for immediate follow-up medical care. Patients using insulin pumps generally carry back-up supplies of insulin and insulin syringes in case there is a mechanical problem with the pump.

**Type 2 diabetes mellitus**

Diet modification for weight loss with the corresponding reduction of insulin resistance, as well as oral agents, are the main therapy for NIDDM. Weight loss enhances the sensitivity of peripheral insulin receptors to endogenous insulin and reduces the requirements for administered insulin. Thus, most persons with type 2 diabetes can control hyperglycemia by maintaining an ideal body weight. However, such weight reduction is often a difficult goal to sustain, requiring a permanent restriction in caloric intake. Indeed, the most common cause of death for patients with NIDDM is myocardial infarction and coronary artery disease, which are often related to obesity. Drug therapy is indicated in medical management when maintaining the ideal body weight fails to control blood sugar or to ameliorate the symptoms, or when the patient is unable to lose weight or ketosis is present. Drug therapy includes oral agents and insulin. An increasing number of type 2 patients inject exogenous insulin to improve their glycemic control. Although the administration of exogenous insulin to a patient with clinical insulin resistance seems paradoxical, the insulin can improve glucose control. A wide range of oral agents to treat NIDDM exist, including α-glucosidase inhibitors (acarbose); insulin sensitizers (biguanides, such as metformin, and thiazolidinediones, such as rosiglitazone); insulin secretagogues (sulfonylureas, first- and second-generation agents); and benzoic acid derivatives (meglitindes such as repaglinide). These oral agents are of no value in the treatment of type 1 diabetes mellitus.

At the outset of treating a patient, it is important to recognize that some oral agents do promote hypoglycemia; in certain instances, this may become severe. Although severe hypoglycemic reactions are less likely with the oral agents than with insulin, the duration of some of these agents and their hypoglycemic effect can extend to 24 hours. Sulfonylureas act primarily by trim-
ulating the pancreatic beta cells to increase insulin production. If food intake is insufficient to elevate blood glucose levels adequately, a relative excess of plasma insulin may occur, resulting in hypoglycemia. The \( \alpha \)-glucosidase inhibitors, like acarbose, block the proximal absorption of carbohydrate in the small intestine and pose an interesting dilemma. In combination with sulfonylureas or insulin, the \( \alpha \)-glucosidase inhibitors can cause hypoglycemia. However, this hypoglycemia is not typically reversible with sucrose (candy or table sugar), a disaccharide, because \( \alpha \)-glucosidase inhibitors slow the conversion rate of disaccharides into free monosaccharide glucose units. Thus, only glucose tablets will rapidly and effectively reverse \( \alpha \)-glucosidase—induced hypoglycemia. In contrast, metformin does not raise insulin levels and rarely causes hypoglycemia. Thiazolidinediones increase tissue sensitivity to insulin, especially in muscle; this effect counters the clinical insulin resistance common in NIDDM. Hypoglycemia is also rarely associated with thiazolidinediones.

**Angiotensin-converting enzyme inhibitors: prophylaxis and reduction of diabetic complications**

A recent remarkable study found that the angiotensin-converting enzyme (ACE) inhibitor ramipril may reduce not only cardiovascular events but also the incidence of diabetes-related complications and even the incidence of diabetes itself.\(^{10}\) Although ACE inhibitor is a standard antihypertension drug, its use to reduce or even prevent diabetic complications adds another dimension to treatment. Thus, an increasing number of diabetic patients are taking ACE inhibitor drugs, even in the absence of hypertension. However, the dentist must be aware that ACE inhibitor drugs can cause sudden swelling of the face, lips, tongue, and laryngeal tissues, as well as potential asphyxiation at any time. Such a life-threatening emergency requires the administration of epinephrine (1:1000) to reduce the tissue swelling.

**Medical Management of Diabetic Emergencies**

Dental practitioners should encourage diabetic patients who self-monitor blood glucose levels to bring their glucometer to the dental office at each visit. The dentist should also purchase a glucometer and make it available to diabetic patients. Patients can check their blood glucose levels within 1 minute of the beginning of the dental appointment. If glucose levels are at or below the lower end of the normal fasting range (80 to 120 mg/dL), then it may be necessary for the patient to consume a fast-acting carbohydrate. The dentist should have glucose tablets—a rapidly acting, simple carbohydrate—available in the office at all times. These are inexpensive and have a stable shelf-life. Each glucose tablet contains 4 g of carbohydrate. If the anticipated procedure is long (eg, 2 hours), then the patient can take the glucose tablets. If the patient initially presents with hyperglycemia, then the patient can take a small bolus of rapidly acting insulin before the procedure. This approach is helpful because a long, stressful procedure can lead to endogenous epinephrine release, mobilization of glycogen from the liver, and additional hyperglycemia.

The most common causes of hypoglycemia include injection of excess insulin, delaying or missing meals or snacks with the usual dose of insulin, increasing exercise without adjusting the insulin dose (exercise reduces the requirement for insulin), and consuming alcohol (alcohol inhibits gluconeogenesis in the liver and thus prevents the release of newly synthesized glucose into the bloodstream). The signs and symptoms include confusion, shakiness (tremors), agitation, belligerence, sweating (diaphoresis), and tachycardia. The dentist can avoid a hypoglycemic reaction in a patient by taking an accurate history. The dentist must know the time, dose, and type of insulin the patient took that day and the time, amount, and type of carbohydrate (simple vs complex) the patient consumed before the dental visit. In this way, the dentist can match the patient’s plasma insulin levels with the food intake, thus determining the likelihood of hypoglycemia.\(^{14}\)

Hypoglycemic symptoms are more likely to occur if the blood glucose falls below 60 mg/dL. If a glucometer determination shows hypoglycemia, then the administration of glucose tablets usually rapidly reverses it. If the patient is sedated or unable to take food or drink by mouth, then 25 to 30 mL of 50% dextrose or 1 mg of glucagon can be administered intravenously, intramuscularly, or subcutaneously. A glucagon injection causes glycogenolysis in the liver. It will rapidly reverse hypoglycemia, usually within 15 minutes. In other instances, rubbing a preparation of glucose (available in most pharmacies) or dissolved sugar under the tongue of the unconscious patient may reverse the hypoglycemia. The glucose can be rapidly absorbed from the sublingual site.

In some cases, hyperglycemia can present with symptoms similar to those of hypoglycemia (eg, confusion and disorientation). If a glucometer is not available to determine blood glucose levels accurately and the conscious patient has symptoms suggestive of hypoglycemia, then the dentist must administer glucose tablets (or fruit juice). Treat patients *presumptively* for hypoglycemia if they experience tremors, diaphoresis, tachycardia, or disorientation and agitation. If the symptoms were from hyperglycemia rather than hypoglycemia, then the additional amount of carbohydrate will generally cause no harm. The rapid development of hyperglycemia with DKA,
possibly leading to diabetic coma, is now, with the advent of the insulin pump, more likely.

More type 1 patients with diabetes are entering pump therapy; therefore, the dentist must be aware of the signs and symptoms of hyperglycemia and be prepared to manage it. The patient can administer a small bolus of insulin (by tenths of a unit with a pump) to treat the hyperglycemia. The patient should also carry a supply of reagent strips to test for ketones in the urine (ketonuria). If the hyperglycemia and ketonuria persist despite the administration of the insulin bolus, then the dentist must contact the patient’s physician and refer the patient for immediate medical evaluation. The best way to determine the true nature of a diabetic emergency quickly is to measure blood glucose levels with a glucometer. The accuracy of the glucometer readings is generally within an error range of 5%.

DENTAL MANAGEMENT

Oral complications

The oral complications of uncontrolled diabetes mellitus can include xerostomia, infection, poor healing, increased incidence and severity of caries, candidiasis, gingivitis, periodontal disease, periapical abscesses, and burning mouth syndrome. The oral findings in patients with uncontrolled diabetes are most likely related to the excessive loss of fluids through excessive urination (polyuria), the altered response to infection, the microvascular changes, and possibly the increased glucose concentrations in saliva.1

A high percentage of diabetic patients present with xerostomia and the complaint of dry mouth. When the normal environment of the oral cavity is altered because of a decrease in salivary flow or alterations in salivary composition, a healthy mouth can become susceptible to painful decay and deterioration. Dry, atrophic, cracking oral mucosa is the eventual complication of xerostomia. Accompanying mucositis, ulcers, and desquamation—as well as opportunistic bacterial, viral, or fungal infections and an inflamed, deapillated tongue—are also common problems. Difficulty in lubricating, masticating, tasting, and swallowing are among the most devastating complications of xerostomia and may contribute to impaired nutritional intake. An increase in the rate of dental caries may occur in young diabetic patients; this could be related to the reduced salivary flow. Aside from topical treatments for xerostomia, improved metabolic control of the diabetes may mitigate the complications from xerostomia.

Periodontal disease and its impact on diabetic control

In most cases, the dental clinician can manage the well-controlled type 1 or type 2 diabetic patient in a manner consistent with the management of a healthy nondiabetic person. The dentist can perform periodontal surgical procedures, although it is important for the patient to maintain a normal diet during the postsurgical phase.10 The practitioner should review any previous history of diabetic complications, determine the most recent test results (eg, glycosylated hemoglobin and postprandial blood glucose levels), and maintain an ongoing dialogue with the patient’s physician. Supportive periodontal therapy should be provided at relatively close intervals (2 to 3 months) because some studies indicate a slight, but persistent, tendency to progressive periodontal destruction despite effective metabolic control.

The management of the insulin-dependent diabetic requires additional considerations. Before periodontal surgery, it may be appropriate, in consultation with the patient’s physician, to ask the patient to administer a small bolus of rapid-acting insulin. This bolus may reduce the hyperglycemia associated with infection, pain, and stress. If the patient on the multiple-injection dose regimen is unable to eat after surgery, then the patient must modify the regimen. The patient can eliminate or significantly reduce all rapid-acting insulin for the remainder of the day; this reduces the likelihood of hypoglycemia in the absence of food during the postsurgical phase. At the same time, the patient can also reduce his long-acting insulin by a half of the usual recommended dose to prevent hypoglycemia. Therefore, the patient will have an ongoing basal level of long-acting insulin, although reduced, that will still ensure glucose homeostasis but prevent further hyperglycemia.

A patient using an insulin pump follows different algorithms for insulin management. If patients are unable to eat during the postsurgical phase, they may require no adjustment in the basal insulin program or profile. The programmed insulin release over the 24-hour period may be adequate to ensure glucose homeostasis. The risk of hypoglycemia is also less than with the multiple insulin injection regimen because the patient is using the pump. If the patients are unable to eat for more than 24 hours, they may need to modify the basal profile by increasing the insulin dosage. Prolonged fasting depletes the finite glycogen stores in the liver. In such a starvation mode, the liver then uses the pathway of gluconeogenesis to synthesize new glucose from protein; this glucose is then released into the bloodstream, leading to hyperglycemia. Thus, the patient should increase the insulin dosage in the basal profile of the pump to maintain glucose homeostasis.

If the periodontal infection is particularly severe, then the patient should also reprogram the basal profile in the pump to increase the insulin dosage during the postsurgical phase in treatment. By increasing the
insulin dose, the pain and stress from infection and the bacterial endotoxins are less likely to exert a counter-regulatory effect on the liver, which may cause glyco-genolysis and rapid hyperglycemia with ketoacidosis. These management algorithms are particularly critical because the patient using an insulin pump is more prone to severe hyperglycemia and DKA. Once there is adequate resolution of the periodontal infection and a return to a normal diet, the patient can then reprogram the insulin dosage to the previous basal profile.

A diabetic patient who has the disease under control generally does not require antibiotics after surgical procedures. However, the administration of antibiotics during the postsurgical phase is appropriate, particularly if there is significant infection, pain, and stress. A recent study has shown that the elimination of periodontal infection through the use of systemic antibiotic (doxycycline) improved the metabolic control of diabetes, as was shown by a reduction in the patient’s glycosylated hemoglobin value.20

Islet cell transplantation: the first step toward a cure

Clinical studies have investigated islet cell transplantation as a treatment for type 1 diabetes mellitus in selected patients with inadequate glucose control despite insulin therapy. However, the perennial hope that such an approach would result in long-term freedom from the need for exogenous insulin, with stabilization of the secondary complications of diabetes, has failed to materialize in practice. Of the 267 allografts transplanted since 1990, only 12.4% have resulted in insulin independence for periods of more than a week, and only 8.2% have done so for periods of more than a year. However, improved techniques for the isolation of larger numbers of viable islet cells, along with a modified (corticosteroid-free) immunosuppressive regimen, have dramatically changed the future of transplantation therapy.21

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REFERENCES


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