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Diabetes Mellitus: Pathophysiology and Clinical Guidelines

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Beverly Thomassian, RN, BC-ADM, MPH, CDE

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Objectives

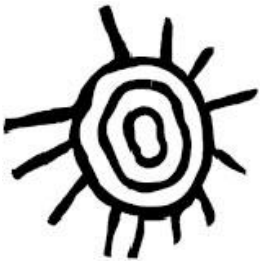
After completing this course, the learner will be able to:

- List factors pertaining to the etiology and pathogenesis of diabetes mellitus.
- Recognize criteria relevant to the diagnosis of diabetes mellitus.
- Describe complications associated with diabetes mellitus.
- Discuss concepts related to dental intervention, education and treatment planning of patients with diabetes mellitus.
- Identify key factors in maintaining optimal blood glucose levels.
- Describe life saving procedures for individuals experiencing a diabetic emergency.

Introduction

Historical Perspective

"Yes, I am an old enemy of the human race, but I am not that unbeatable once my name is said…"
John McLeod (From a Native American story about diabetes)



Writers describe people with symptoms of diabetes mellitus as early as 1500 BC. The disease name (meaning, "to siphon") originated with the Greeks in 230 BC, and related to the excessive urination and wasting that occurs with untreated diabetes. Early classifications of diabetes are credited to the Susrata of the Hindus, the father of medicine in India. Later, classifications of diabetes mellitus (mellitus is Latin for "honey-sweet") are refined, and suggested treatments vary from the removal of diuretic food to taking tepid baths.

During the 19th Century, Claude Bernard theorized glycogenolysis as connected to the cause of diabetes mellitus. By the 1920's scientists recognized insulin's role in the regulation of blood glucose. Today the pathophysiology of diabetes is more clearly understood yet the cure remains elusive (ADA 2017).

About the Author

Beverly Thomassian, RN, BC-ADM, MPH, CDE

Author, Nurse, Educator and Clinician, Beverly Dyck Thomassian has specialized in diabetes management for the past thirteen years. She has been awarded board certification in Advanced Diabetes Management and has been published in the American Journal of Nursing, NurseWeek, Progress for Cardiovascular Nursing, Stanford Nurse and the Japanese Journal of Nursing.

Beverly is a nationally recognized speaker and consultant, dedicated to improving diabetes care. She is a working educator, currently serving as a Diabetes Program Manager and is an Assistant Clinical Professor in the graduate-nursing program at the University of California, San Francisco. She knows what you need TODAY in your clinical practice!

Glucose Metabolism and Hormonal Regulation Review

Human energy requirements are met predominately by glucose. Cellular plasma membrane's permeability to glucose varies according to type of tissue. Glucose transporters control diffusion of glucose into the cell. These transporters are specific to each type of tissue. Hormonal and neural devices control homeostasis of blood glucose levels. At least eight hormones secreted by various endocrine glands play a role in blood glucose levels.

Insulin (secreted by the pancreas) is the chief glucose regulatory hormone. Insulin is synthesized by beta cells (ß-cells) located in the islets of Langerhans. Insulin decreases blood glucose levels though increased glycogenesis and the transport of glucose into muscle, liver and adipose tissue. Muscle, liver and adipose cells require activation by insulin at insulin receptors in order to facilitate glucose transport into the cell. Neural tissue and erythrocytes do not require insulin for glucose utilization. Once glucose has entered the cell, it may be oxidized for energy (glycolysis) or stored (glycogenesis) in the muscle or liver (See Figure 1) (ADA 2017).

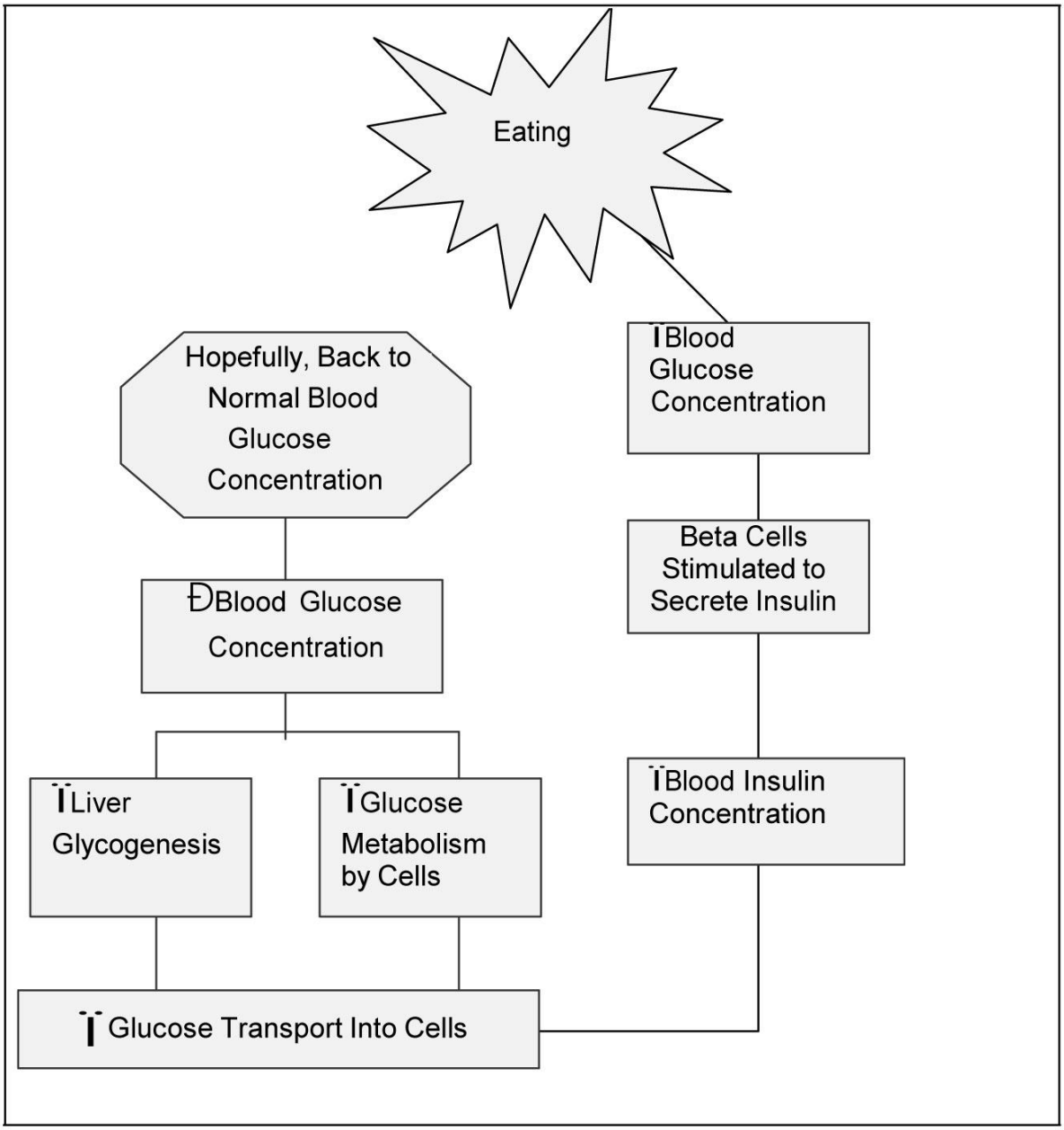


Figure 1: Glucose Metabolism

Also located in the islets of Langerhans are alpha cells. Alpha cells play a role in controlling blood glucose by producing glucagon. Unlike insulin, which acts to lower blood glucose levels, glucagon acts to increase blood glucose level by accelerating glycogenolysis (See Figure 2) (ADA 2017).

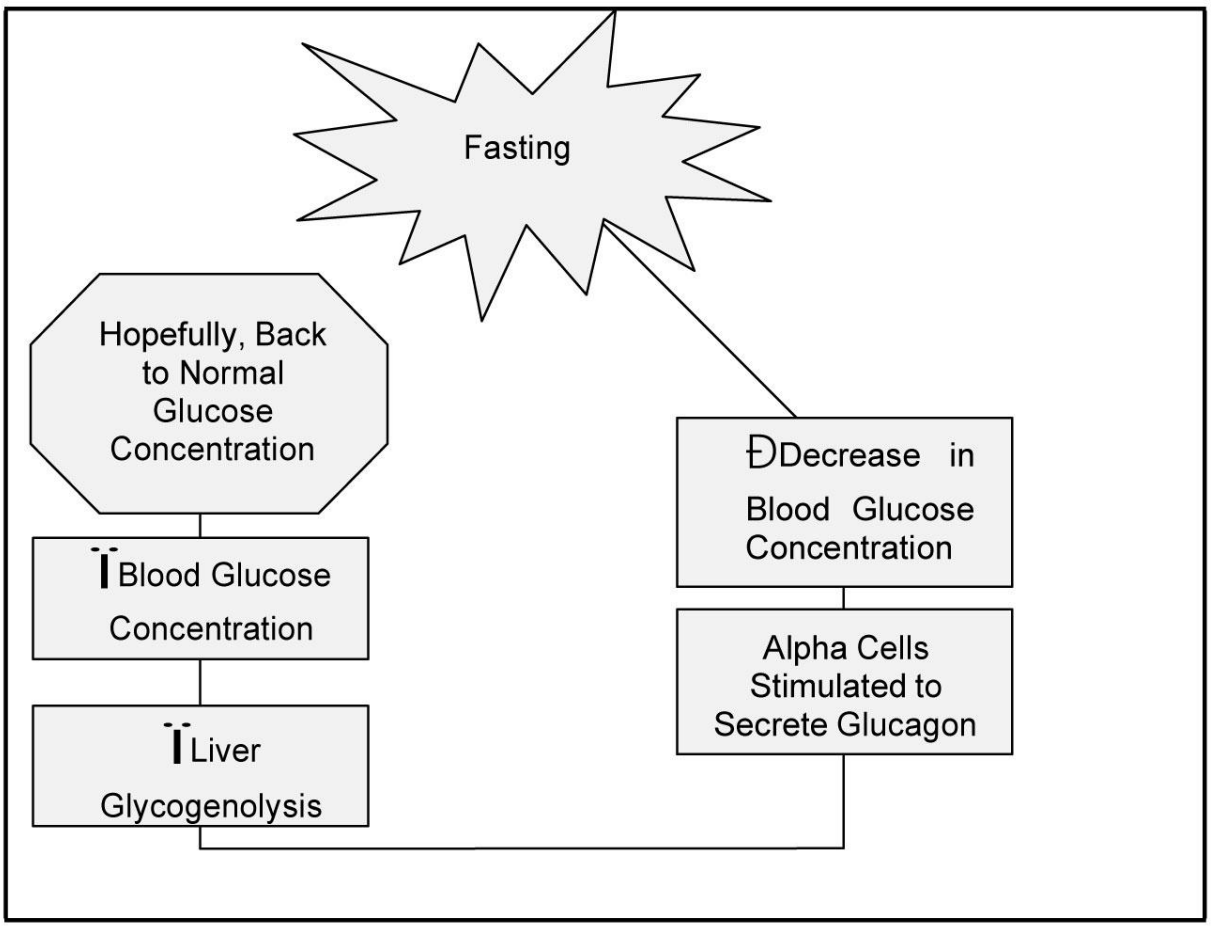


Figure 2: Normal Response to Fasting

Other blood glucose regulating hormones (shown in Table 1) that act to raise glucose concentrations include: epinephrine, growth hormone (GH), Adrenocorticotropic hormone (ACTH) and glucocorticoids (ADA 2017).

Table 1: Hormones Regulating Blood Glucose

HORMONE	ACTION (S)	RESULT ON BLOOD GLUCOSE
INSULIN	ƒ Helps glucose enter cells ƒ Stimulates glycogenesis ƒ Stimulates glucose anabolism	Lowers
GLUCAGON	ƒ Stimulates glycogenolysis	Raises
EPINEPHRINE	ƒ Stimulates glycogenolysis	Raises
GROWTH HORMONE	ƒ Stimulates catabolism of fats ƒ Decreases carbohydrate utilization	Raises
ACTH	ƒ Stimulates secretion of glucocorticoids	Raises
GLUCOCORTICOIDS	ƒ Mobilization of protein ƒ Stimulates gluconeogenesis ƒ Increases insulin resistance	Raises

Effect of Exercise and Stress on Blood Glucose Levels

Exercise

Exercise initially decreases the production of insulin and increases the secretion of glucagon resulting in higher blood glucose levels. After several minutes, the exercising muscle has increased insulin sensitivity, which facilitates the uptake of glucose for an extended period, thus lowering glucose levels (ADA, 2017).

Stress

Stress hormones increase blood glucose levels. Corticosteroids increase glucagon release and insulin resistance, resulting in excess glucose production. Epinephrine increases the rate of glycogenolysis in both the muscles and the liver. The net effect is hyperglycemia (ADA, 2017).

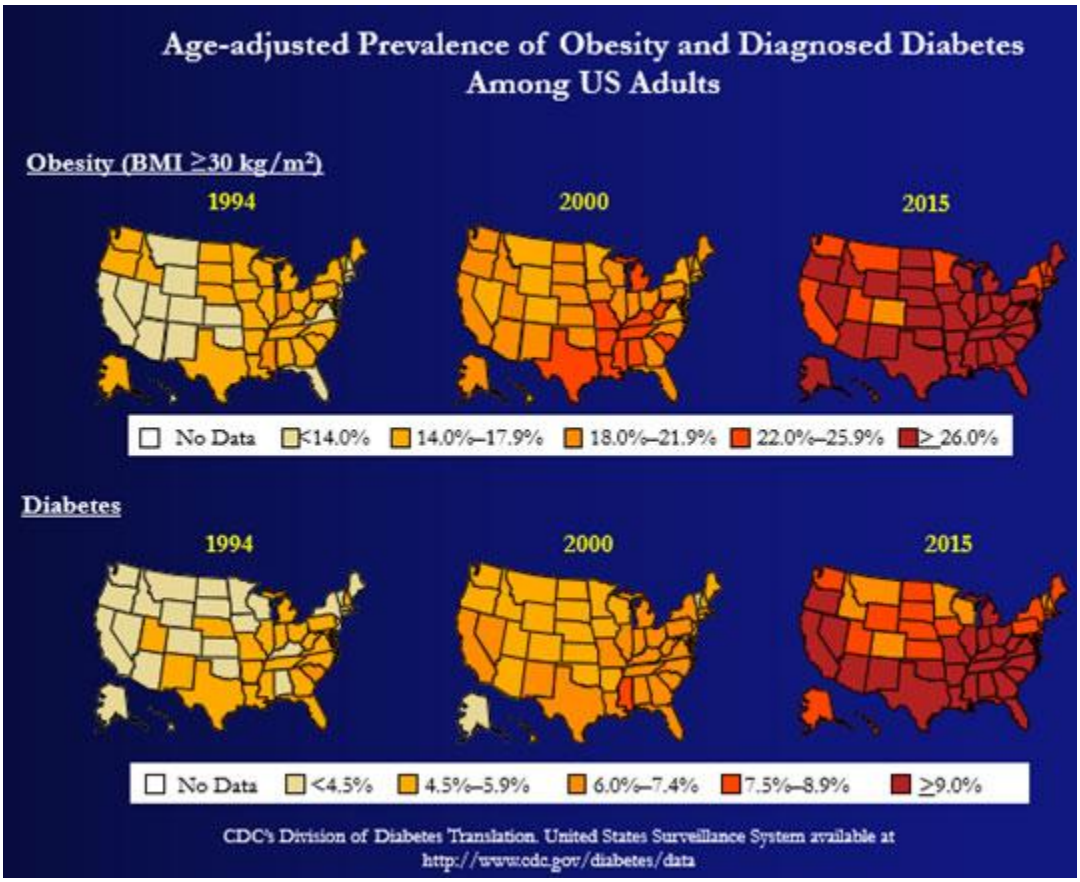
Diabetes Mellitus

Diabetes Mellitus (DM) is an endocrine disorder resulting from an inadequate production or impaired use of insulin. Uncontrolled diabetes leads to chronic hyperglycemia (too

much sugar in the blood). DM is a chronic disease for which there is no single cause. DM is often a secondary diagnosis to other disorders. As of 2016, more than 29 million Americans are living with diabetes, and 86 million are living with prediabetes, a serious health condition that increases a person's risk of type 2 diabetes and other chronic diseases (CDC 2017).. Diabetes was the seventh leading cause of death in the United States in 2013 (and may be underreported) (CDC 2017).

The American Diabetes Association states that About 208,000 Americans under age 20 are estimated to have diagnosed diabetes, approximately 0.25% of that population. In 2008—2009, the annual incidence of diagnosed diabetes in youth was estimated at 18,436 with type 1 diabetes, 5,089 with type 2 diabetes. (ADA 2017)

(CDC, 2017) www.cdc.gov/diabetes/data:



During the 57th Annual Scientific Sessions conducted by the American Diabetes Association experts recommended elimination of the categories "Insulin- dependent diabetes mellitus" and "Non-insulin diabetes mellitus" (See Table 2). The committee suggests the use of the term 'type' as more appropriate, and encourages the use of Arabic numerals to designate the 'type' of diabetes. The change was prompted by a need to remove the name based on treatment and not on the actual disease (ADA,

2017) (Bruno, Merletti, et. al. 1990). As shown in Table 2, the etiologic classifications of DM have also changed.

Table 2: Etiologic Classification of Diabetes Mellitus

PREFERRED NAME	PREVIOUS DESIGNATION
Type 1 Diabetes Mellitus	Insulin dependent diabetes mellitus Juvenile diabetes mellitus
Type 2 Diabetes Mellitus	Non-insulin dependent diabetes mellitus Adult onset diabetes mellitus
Gestational Diabetes Mellitus	Gestational Diabetes Mellitus
Other Specific Types	(Not previously designated)
Pre-Diabetes	Impaired Fasting Glucose (IFG)
Pre-Diabetes	Impaired Glucose Tolerance (IGT)

As of 2017, there have been many riveting scientific breakthroughs in the fight against this all too common disease!

Etiologic Classification of Diabetes Mellitus

I. Type 1 diabetes* (ß-cell destruction, usually leading to absolute insulin deficiency)
    a. Immune mediated
    b. Idiopathic
II. Type 2 diabetes* (due to a progressive loss of insulin secretion on the background of insulin resistance)
III. Other specific types
    a. Genetic defects of ß-cell function
        i. Chromosome 12, HNF-1α (formerly MODY3)
        ii. Chromosome 7, glucokinase (formerly MODY2)
        iii. Chromosome 20, HNF-4α (formerly MODY1)
        iv. Mitochondrial DNA
        v. Others
    b. Genetic defects in insulin action
        i. Type A insulin resistance
        ii. Leprechaunism
        iii. Rabson-Mendenhall syndrome

iv. Lipoatrophic diabetes
v. Others

c. Diseases of the exocrine pancreas
    i. Pancreatitis
    ii. Trauma/pancreatectomy
    iii. Neoplasia
    iv. Cystic fibrosis
    v. Hemochromatosis
    vi. Fibrocalculous pancreatopathy
    vii. Others
d. Endocrinopathies
    i. Acromegaly
    ii. Cushing's Syndrome
    iii. Glucagonoma
    iv. Pheochromocytoma
    v. Hyperthroidism
    vi. Somatostatinoma
    vii. Aldosteronoma
    viii. Others
e. Drug- or chemical-induced
    i. Vacor
    ii. Pentamidine
    iii. Nicotinic acid
    iv. Glucocorticoids
    v. Thyroid hormone
    vi. Diazoxide
    vii. $-adrenergic agonists
    viii. Thiazides
    ix. Dilantin
    x. α-Interferon
    xi. Others
f. Infections
    i. Congential rubella
    ii. Cytomegalovirus
    iii. Others
g. Uncommon forms of immune-mediated diabetes
    i. "Stiff-man" syndrome
    ii. Anti-insulin receptor antibodies
    iii. Others
h. Other genetic syndromes sometimes associated with diabetes

i. Down's syndrome
ii. Klinefelter's syndrome
iii. Turner's syndrome
iv. Wolfram's syndrome
v. Friedreich's ataxia
vi. Huntington's chorea
vii. Lawrence Moon Beidel syndrome
viii. Myotonic dystrophy
ix. Porphyria
x. Prader Willi syndrome
xi. Others

IV. Gestational diabetes mellitus (GDM)

*Patients with any form of diabetes may require insulin treatment at some stage of their disease. Such use of insulin does not, of itself, classify the patient.

Reproduced By Permission American Diabetes Association (Bruno, Merletti, et al, 1990, reviewed 2017)

According to *Diabetes in Control* which puts out a weekly newsletter geared to medical professionals, with developing science-based research comes a need to update the previous diabetes classification system. "However, the inherent setback with the currently established system lays in the fact that it is inadequate with the present understanding of the phenotypes associated with diabetes. Alongside this and the limited research and information present at the time of formulating the current system, the designations related with the different types of diabetes are vague and inaccurate. Due to this fact and current evidence-based practice, there is a call to revise the current classification of diabetes mellitus and focus on a β-cell centric classification schema, according to a new article published online in Diabetes Care Jan. 21, 2016. Based on new research performed by Stanley Schwartz and affiliates, there is a new proposition for using a β-cell centered model for diabetes, which supports the notion that all diabetes originates from an abnormal pancreatic β-cell. Type 1 diabetes has been thought of as an ailment of low insulin production, while type 2 has usually been of insulin resistance. This discrepancy is not clear or helpful. Schwartz and colleagues suppose all diabetes is a product of impairment to beta cells (which produce insulin) and according to this theory, insulin resistance just reveals the rudimentary deficiency in insulin production. Only one-third of individuals with insulin resistance will go on to develop diabetes. The basis of the new classification system is treatment of patients as individuals though currently most prescribers will initiate treatment based on a diagnosis instead of the person. Schwartz believes that diabetes is rooted to β-cell and because of this, classification of diabetes types should be based on causes of that damage so physicians will know how to go about treatment. This "β-cell centric" criterion recognizes

that β-cell damage can be caused by inflammation, immune actions, gut biome, high fatty acids, high glucose levels, genetics and other causes; categorization founded on these sources can help cultivate an improved treatment strategy, as opposed to simply knocking down an individual's glucose level. Defining key markers and the processes of care in using them will allot appropriate patient-centric approaches with either currently established medications or an up-and-coming drug. This proposed model acknowledges a total of 11 interconnecting pathways that contribute to hyperglycemia, which are prompted by the transformation of genetic predispositions to insulin resistance" (Diabetes in Control Newsletter 2016).

Diabetes Mellitus Type 1

Etiology

The absence of insulin characterizes Type 1. Individuals with Type 1 must take insulin shots to live. The etiology of Type 1 is a combination of genetic and environmental factors. Recently, Type 1 was divided into two categories, (a) immune-mediated diabetes (resulting from an autoimmune destruction of ß-cells) and (b) idiopathic diabetes (rare forms without a known cause) (ADA, 2017).

Autoimmune Destruction

Individuals diagnosed with Type 1, show signs of pancreatic ß-cell destruction prior to diagnosis. Autoantibodies, which destroy pancreatic cells, may be present up to nine years before a diagnosis of Type 1. The rate of ß-cell destruction is highly variable. Hyperglycemia would indicate that enough destruction of ß-cells had taken place as to prevent adequate insulin secretion.

The presence of one or more of the following is (are) considered predictor(s) of Type 1 onset:

- islet cell autoantibodies (ICAs),
- insulin autoantibodies (IAAs),
- autoantibodies to the enzyme glutamic acid decarboxylase (GAD) and
- autoantibodies to tyrosine phosphatases IA-2 and IA-2beta

Dr. Mark Atkinson, University of Florida and Dr. Daniel Kaufman, University of California Los Angeles, suggest that autoimmune destruction of GAD is the first phase in the subsequent destruction of ß-cells. These researchers successfully prevented the destruction of ß-cells by inactivating the autoimmune response to GAD (ADA, 2017).

Idiopathic Diabetes

Individuals who have no evidence of an autoimmune disorder, but present with

destroyed ß-cells are identified as having “idiopathic diabetes”. This form of Type 1 is considered rare (Bruno, Merletti, 1990, reviewed 2017).

Pathophysiology

Process

Individuals with Type 1 do not produce insulin. Without insulin, muscle and adipose cells cannot access glucose to meet energy requirements. Glucose production goes unopposed in the liver. Glucagon is produced in response to the glucose deprivation of muscle and adipose tissues, prompting glycogenolysis and gluconeogenesis. Glucose levels rise in the blood.

The kidneys cannot absorb the ever-increasing glucose, so the excess is excreted in the urine (polyuria). The brain, prompted by this loss of fluid, signals thirst (polydypsia) and hunger (polyphagia). If this process continues, stored fats are metabolized and transformed by the liver into keto acids, which leads to lower pH levels and acidosis. The drop in pH level and loss of ketones in urine signals the onset of ketoacidosis.

Intracellular potassium ions are exchanged for hydrogen ions. These potassium ions are lost in urine along with sodium, magnesium and phosphorus. Blood volume drops, increasing hematocrit, hemoglobin and white blood cell counts. Respiratory compensation results in labored, deep respiration (Kussmaul respiration) in an attempt to lower the PCO2 values.

This process is acute but may extend over several days. Ketoacidosis is a likely presenting symptom in an initial Type 1 diagnosis (ADA, 2017).

Signs and Symptoms of DKA

- Hyperglycemia
- Glycosuria
- Polyuria, polydypsia and polyphagia
- Weight loss
- Nausea and vomiting
- Deep, labored respiration
- Fatigue
- Abdominal pain

Epidemiology

Incidence and Prevalence

Type 1 accounts for 10% of all types of diabetes. Prevalence of Type 1 is estimated to be approximately 1.25 million American children and adults. This includes that 40,000 new type 1 diabetes cases are recorded each year in the United States. 29.1 million Americans, or 9.3% of the population, had diabetes. Of the 29.1 million, 21.0 million were diagnosed, and 8.1 million were undiagnosed. (American Diabetes Association, 2013-last edited 2017.) Worldwide incidence rates vary from 1.7/100,000 in Japan to 29.5/100,000 in Finland. The incidence of Type 1 is on the increase (ADA, 2017).

Age

Diagnosis is most commonly made in individuals between the ages of 5-20. Generally, onset of Type 1 occurs under the age of 30 but can happen at any age. Peak incidence of Type 1 is at puberty. This age pattern is consistent across world populations. Age-related factors may include growth spurts, hormonal changes and exposure to infectious agents (ADA, 2003) Bell, 1997).

Gender

Gender does not seem to be a factor in the incidence of Type 1 (ADA, 2017).

Geographic Distribution

Finland, Sweden and Sardinia, Italy have the highest incidence rate of Type 1. Countries with intermediate rates of Type 1 include Caucasians in the US, New Zealand and Spain. The lowest rates of Type 1 incidence occur in Mexico, Chile and Japan. Incidence rates vary within countries and may increase in areas with colder climates (ADA, 2017) (Anthony, Thibodeau, Prezbindowski, 1979).

Race/Ethnicity

The incidence of Type 1 is greater among Caucasians than African Americans, Hispanics, Asians and Native Americans (ADA, 2017).

Familial Factors

Caucasians, native to North America, who are first-degree relatives to a diagnosed Type 1 diabetic are 1 to 15% more likely to have Type 1 themselves.

The American Diabetes Association assesses the risk of developing Type 1 to be between 10%-25% if both parents have Type 1. If the father has Type 1 the child is at a 4% risk. Depending upon the mother’s age at onset (less than or greater than 25 years)

the child's risk is between 1%-4%. More than 80% of cases occur in persons without a family history of diabetes. The remaining 20% have a familial link to diabetes (ADA, 2017).

Other Risk Factors

Several other factors that may promote onset of Type 1 include, but are not limited to:

- diet (decreased length of breast feeding, early introduction of cow's milk, malnutrition)
- exposure to certain viruses such as coxsakie B4 or congenital rubella.

It is clear that the onset of Type 1 is multifactoral. These factors may differ among racial/ethnic groups and there may be many more, yet undiscovered causative agents of Type 1 (ADA, 2017).

Diabetes Mellitus Type 2

Type 2 diabetes is the most common form of diabetes. Decreased production and utilization of insulin characterizes Type 2 diabetes. Unlike Type 1, the body does produce insulin, but cannot use it effectively (insulin resistance). Insulin resistance and the relative lack of insulin production result in Type 2. Type 2 diabetics may or may not need to inject insulin during their lifetime. Although the exact cause is unknown, Type 2 is considered a disease of genetic predisposition with additional causal factors prompting onset. Type 2 does not involve an autoimmune destruction of ß-cells. The identification of several risk factors has been a positive step in the fight against Type 2. It is unknown whether focusing on intervention strategies based solely on non-genetic risk factors will result in a cure (ADA, 2017) (Anthony, Thibodeau, et. al. 1979) (Bruno, Merletti, et al 1990).

Etiology (Risk Factors)

Family History/Genetic Risk

An individual with a family member diagnosed with Type 2 is at greater risk for developing diabetes himself or herself. If an individual is diagnosed by the age of 50 with Type 2 their offspring's risk is around 15%; after the age of 50 it is around 8%. The risk is greater if the mother has Type 2. If both parents have a Type 2 diagnosis the risk to offspring is 50% (ADA, 2017) (Anthony, Thibodeau, et. al. 1979) (Hoehns, Skelly, Graber, 1997).

"As many as 20%-60% of people in the general population may be genetically susceptible to Type 2 diabetes" (Harris, 2017) Several "candidate genes" have been discovered and linked to the inheritance of Type 2. As yet, there appears to be no clear

understanding of the way an individual “inherits” diabetes.

Age

As we age, we are more at risk for developing Type 2. The risk increases dramatically after the age of 40. Specifically, those aged 65-74 years are at highest risk. However, onset of Type 2 under the age of 30 is becoming more common. High-risk groups are more likely to develop Type 2 at an earlier age (Hoehns, Skelly, Graber, 1997).

Gender

There is no significant difference related to gender (ADA, 2017).

Race/Ethnicity & Geographic Distribution

Risk for developing Type 2 is higher for:

- Native Americans
- Pacific Islanders
- African-Americans
- Hispanics
- Asian Americans

Type 2 is strongly linked to western cultures. When there is a high genetic risk for onset, individuals living in non-westernized cultures are less likely to develop Type 2 (ADA, 2017) (Darwazah, MacFarlan, et al, 1991). (Hoehns, Skelly, Graber, 1997).

Obesity

Considered a strong risk factor, obesity places many at risk. Location of body fat (abdominal) and duration of obesity are believed to be significant in increasing risk. The combination of obesity and a family history of diabetes are considered to greatly increase the incidence of Type 2 (ADA, 2017) (Hoehns, Skelly, Graber, 1997).

Other Risk Factors

- Diet-Mostly believed to be related to total calorie intake versus the individual components of food.
- Physical Activity-Because higher insulin activity is associated with physical activity, those with active lifestyles are less likely to develop Type 2 (ADA, 2017).

Pathophysiology

Process

In Type 2 there is interference with the body's utilization of available insulin. Insulin resistance is a decreased responsiveness to sufficient concentration of insulin. The primary causes of insulin resistance are considered genetics and weight gain. This first phase of resistance stimulates an increase in insulin production by ß-cells. ß-cells are unable to make enough insulin to meet the body's perceived need. As the insulin resistance continues hyperglycemia ensues. ß-cell failure due to "exhaustion" or "glucose toxicity" is believed to follow. Autoimmune destruction of ß-cells does not occur in individuals with Type 2 (ADA, 2017) (Bruno, Merletti, et al, 1990).

Although similar to the scenario of Type 1, Type 2 is not identical in its pathophysiologic process. The classic triad of polyuria, polydypsia and polyphagia may be present, but not as striking. Ketoacidosis is less likely, but possible. In Type 2, the presence of insulin prevents the lipogenesis that would lead to the production of ketones. Hyperglycemic Hyperosmolar Syndrome (HHS) is a life-threatening outcome of neglected hyperglycemia in Type 2s. Severe hyperglycemia and extreme dehydration characterize this condition. This outcome is unlikely but may be seen in older populations whose diabetes is not well managed (ADA, 2017) (Bruno, Merletti, et al, 1990).

Signs and Symptoms of Type 2 Diabetes (ADA, 2017) (Bruno, Merletti, et al, 1990) (Cherry-Pepper, Sorkin, et al 1992).

- Polyuria, polydypsia, polyphagia
- Hyperglycemia
- Glycosoria
- Frequent infections
- Sexual dysfunction
- Dry/itchy skin
- Fatigue

Epidemiology

Incidence and Prevalence

Prevalence of diabetes is estimated at 16 million, one third of those are undiagnosed cases. In the US the incidence rate for Type 2 is estimated to be approximately 600,000 new cases annually. 90% of all diabetics have Type 2 (ADA, 2017).

Age

As stated previously, age of onset is generally after 40, but can be earlier. Groups with higher risk factors have an earlier onset of the disease. The prevalence of Type 2 increases with age, except for Pima Indians where it peaks around age 40 and then declines (ADA, 2017) (Hoehns, Skelly, Graber, 1997).

Race/Ethnicity

African Americans and Hispanics are twice as likely to be diagnosed with Type 2 than are Caucasians. The Pima Indians of Arizona have the highest rate of Type 2 in the world (nearly one-half of all Pima Indians between ages 30 and 64) (AADE, 2003).

Gender

In the US there are approximately 4.2 million women and 3.6 million men diagnosed with diabetes (ADA, 2017) AADE, 2003).

Geographic Distribution

Urban dwellers are more likely to receive a Type 2 diagnosis than are individuals residing in rural settings (ADA, 2017).

Gestational Diabetes Mellitus (GDM)

“GDM is defined as any degree of glucose intolerance with onset or first recognition during pregnancy” (Bruno, Merletti, 1990). The pathophysiologic process of GDM is similar to that of Type 2. Weight gain and presence of placental hormones increases insulin resistance. The most common complications of GDM are macrosomia and neonatal hypoglycemia. Blood glucose levels should be reassessed following delivery.

This form of diabetes complicates 2-4% of all pregnancies. Persons with GDM may be at greater risk for developing Type 2 later in life. The screening process should take place between 24 to 28 weeks of gestation. Women should be screened earlier if there is history of previous GDM, polydypsia/polyuria, or having given birth to an infant that was large for their gestational age. Individuals within high-risk groups should be more closely monitored and educated about hypoglycemia, ketoacidosis and coronary atherosclerosis. Follow-up testing should be conducted 6 weeks post-delivery. Women under the age of 25, of normal weight, with no family history of diabetes and are not members of high-risk ethnic/racial groups may not need screening for GDM (ADA, 2017) (Bruno, Merletti, 1990) (Cherry-Pepper, Sorkin, et al, 1992).

Pre Diabetes: Impaired Glucose Homeostasis

The two separate categories of impaired glucose homeostasis (impaired glucose metabolism) are impaired fasting glucose (IFG) and impaired glucose tolerance (IGT). It is important to note that IGT and IFG are now termed pre diabetes and are considered risk factors for the potential onset of diabetes.

These categories (See Table 3) designate blood glucose levels between “normal” and diabetic. Persons with impaired glucose homeostasis are at risk for developing diabetes (Cherry-Pepper, Sorkin, et al, 1992) (Oliver, Tellervo, 1993). (Fasting Plasma Glucose (FPG) test is described later in this course.)

Table3: Impaired Glucose Homeostasis

Category	Level
Normal Fasting Glucose	FPG $<$ 100 mg/dL
Impaired Fasting Glucose	FPG $\geq$ 100 and $<$ 126 mg/dL
Impaired Glucose Tolerance after OGTT	FPG $\geq$ 140 but $<$ 200mg/dL

The current upper limit of normal is a fasting glucose concentration of 100mg/dL. IFG occurs when fasting plasma glucose (FPG) is ≥ 100 mg/dL but < 126 mg/dL.

IGT is ≥ 140 but < 200 mg/dL (results of the oral glucose tolerance test in the two hour sample).

The cutoff point for “normal” at 100 mg/dL is due to the belief that microvascular complications arise at this blood glucose level. Researchers suggest that by separating individuals at the 100 mg/dL point might prevent later complications (Cherry-Pepper, Sorkin, et al, 1992).

Other Specific Types of Diabetes

The following are additional specific types of diabetes:

Genetic Defects of the ß-Cell

Genes located on chromosome 7 and 20 are believed linked to a form of early onset diabetes formerly known and maturity onset diabetes of the young (MODY). The genetic defects result in reduced sensitivity of ß-cells to glucose and defective insulin secretion (ADA, 2017) (Bruno, Merletti, et al, 1990).

Diseases

Damage to the pancreas can result in diabetes. This damage may be the result of trauma, infection or possibly cancer. Damage must be significant in order for diabetes to occur (Bruno, Merletti, et al, 1990).

Endocrinopathies

Conditions and syndromes in which there exists an excessive amount of insulin-antagonistic hormones can cause diabetes. If the hormone levels are normalized the hyperglycemia should resolve itself (Bruno, Merletti, et al, 1990).

Drug/Chemical-Induced Diabetes

Many drugs may damage or impair ß-cell function and/or diminish insulin activity (Bruno, Merletti, et al, 1990). These may include drugs called atypical antipsychotic agents (Siegel, 1994).

Infections

Exposure to viral agents has been explored as a causative factor. Although several specific agents have been named, the most commonly discussed virus is the Coxsackie B4 virus. Researchers have suggested that an autoimmune response to a virus may start or accelerate ß-cell destruction. Other viruses theorized to be associated with the onset of Type 1 are cytomegalovirus, rubella, and mumps. Investigation of a viral-Type 1 connection continues, but it is important to note that most individuals with recently diagnosed Type 1 do not show evidence of a recent viral infection (ADA, 2017) (Bruno, Merletti, 1990).

Uncommon Forms of Immune-Mediated Diabetes

Diabetes has been linked to autoimmune disorders of the central nervous system (Stiff-man's Syndrome), systemic lupus erythematosus, and anti-receptor antibodies (Bruno, Merletti, 1990).

Genetic Syndromes

Several genetic syndromes can cause Diabetes. They include: Downs' Syndrome, Klinefelter's syndrome, Turner's syndrome, Wolfram's syndrome, Friedreich's ataxia, and Huntington's chorea.

Diagnosing Diabetes

Urine Tests

Although high glucose levels in urine can signal that something is wrong, urine tests are not a good measure of diabetes. Urine tests are useful in measuring ketones.

Blood Tests

Fasting Plasma Glucose Test

This is a simple test that can be performed after nothing has been taken by mouth except water for at least 8 hours. A single sample of blood is drawn and analyzed.

Casual or Random Plasma Glucose Test

This test is performed regardless of when the individual last ingested food. It is not abnormal to see blood glucose levels between 140 mg/dL and 200mg/dL after having eaten a meal. However, if other symptoms (polydypsia, polyuria, weight loss) are present and blood glucose levels are ≥ 200 mg/dL there is little doubt about a diagnosis of diabetes.

Oral Glucose Tolerance Test

This test measures glucose levels five times in three hours. In diabetics, levels rise higher than normal and do not come back down as fast as seen in a person without the disease. Individuals must fast at least 10 hours but not more that 16 hours prior to taking this test. After the fasting plasma glucose is tested, the individual receives 75 grams of glucose in dissolved in water (100 grams for pregnant women). Blood samples are then taken at 30 minutes, 1 hour, 2 hours and 3 hours to measure glucose levels. This test requires that the individual be in good health and taking no medications that might affect blood glucose levels (Cherry-Pepper, Sorkin, et al, 1992) (Darwazeh, MacFarlan et al, 1991).

Diagnosis

The diagnosis of diabetes is made based on the excessive level of glucose in the blood.

The three ways to diagnose diabetes are as follows:

1) Symptoms of diabetes plus casual plasma glucose concentration ≥ 200 mg/dL. *(Symptoms present as classic symptoms of diabetes: polydypsia, polyuria and unexplained weight loss. Casual is defined as being measured at any time of day without regard to time since last meal)*

2) Fasting Plasma Glucose (FPG) ≥ 126 mg/dL. *(Fasting is defined as no caloric intake for at least 8 hours)*
3) 3. 2hPG ≥ 200 mg/dL during an Oral Glucose Tolerance Test (OGTT). *(2hPG is defined as two-hour postload glucose sample. The test should be performed using a glucose load containing the equivalent of 75-g anhydrous glucose dissolved in water.)*

When the OGTT is used the following criteria apply:

1) 2hPG < 140 mg/dL = Normal glucose
2) 2hPG ≥ 140 and < 200 mg/dL = IGT
3) 2hPG ≥ 200mg/dL = provisional diagnosis of diabetes

Fasting blood glucose testing is the preferred test, but any one of these three tests may be used to screen for diabetes. To obtain a definitive diagnosis, the same or one of the other tests must be completed on a subsequent day duplicating a positive result. The Expert Committee of the American Diabetes Association's 57th Annual Scientific Session suggests use of the FPG due to its convenience, lower cost and acceptability to patients. In using the OGTT it is important to note that the cutoff at 140 mg/dL will identify more people as having impaired glucose homeostasis. This fact makes identification of the type of test used to measure blood glucose very important (ADA, 2017) (Cherry-Pepper, Sorkin, et al, 1992) (Cruickshanks, Jobim, et al, 1994).

Glucose Monitoring

Self-monitoring of Blood Glucose (SMBG)

Frequent monitoring of blood glucose levels allows individuals to make changes in insulin/diet/exercise therapy to more effectively control diabetes. It also measures the effects of changes in insulin dose, diet and exercise on blood glucose levels. It is necessary to more carefully monitor blood glucose levels during illness or when taking drugs than alter insulin secretion (such as phenytoin, steroids, pentamidine etc.) (Holdren and Patton, 1993) (Katz, Wirthlin et al, 1991).

The procedure for testing varies slightly depending on the SMBG method used. A small drop of blood is obtained (usually by pricking the fingertip with a lancing device) and applied to a small plastic strip. Chemicals on the strip change color when it comes in contact with sugar. Photometric meters use a light source with filters and a lens to detect color changes. Most meters detect glucose electrochemically. In this method a current is produced when glucose in the blood reacts with the test strip to give a glucose reading in mg/dl.

Recent advances in alternate site testing, which allows the user to obtain a blood sample from sites other than the fingertips, and smaller sample size requirements, have improved user satisfaction and decreased pain. The main disadvantage continues to be the expense of the meters and test strips, although most insurance companies will cover the costs. Future technology is aimed at improving glucose monitoring using non-invasive techniques and implantable continuous monitoring systems (Holdren and Patton, 1993).

Suggested SMBG testing frequency varies, but usual testing times include (Katz, Wirthlin et al, 1991):

- Before meals
- 2 hours after a meal
- At Bedtime
- At 3 a.m.
- After a low blood sugar reaction
- Anytime blood glucose levels seem too high or low
- More frequently on sick days
- Before or after exercise

A1c and Fructosamine Testing

The A1c test (previously referred to as glycated hemoglobin, glycohemoglobin, glycosylated Hemoglobin GHb, A1c or HbA1) provides the most accurate account of overall glycemic control. Sugar not used for energy remains in the blood where it attaches to hemoglobin. The A1c test measures the amount of sugar that is attached to the hemoglobin in red blood cells (See Figure 3). Because red blood cells live about two to three months, this test can measures the average blood glucose level over the past several months. This test is most useful because it is not affected by short-term changes (eating, exercise, etc.). The test is usually performed every 3 to 6 months. Treatment goals for diagnosed diabetic are for an A1c < 7%.

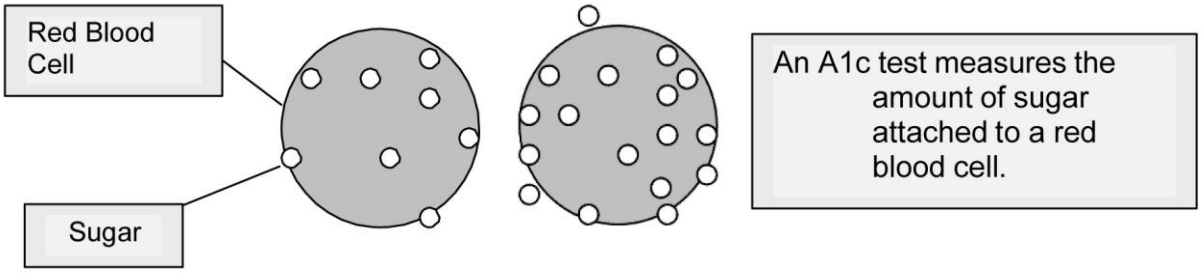


Figure 3

The Fructosamine test refers to the linking of blood sugar on to protein molecules and indicates blood glucose levels over the previous 2-3 weeks. This test is more sensitive

to short-term changes in blood. “Fructosamine levels have been shown to change more rapidly than glycohemoglobin.” Recently, the Food and Drug Administration approved use of a Fructosamine and A1c fingerstick test, both now available without a prescription (Cherry-Pepper, Sorkin, et al, 1992) (Holdren, Patton, 1993) (Katz, Wirthlin, et al, 1991) Knott, 1997) (Rewers, Hamman, 1995).

Controlling blood glucose is the primary goal of diabetes treatment. The American Diabetes Association has suggested the following guideline (ADA, 2017) to measure diabetes control (See Table 4).

Table 4: American Diabetes Association Guidelines

*TEST		GOAL	
Blood sugar before meals		90-130 mg/dl	
Blood sugar 1-2 hours after a meal		Less than 180 mg/dL	
~A1c		Less than 7%	
*test levels are not used for pregnancy			

Urine Testing for Ketones

In Type 1, it may be necessary to test urine for the presence of ketones if blood sugar is over 240 mg/dL. Other conditions where it may be useful to test urine for ketones include pregnancy, periods of stress, presence of infection, or if symptoms of ketoacidosis are present. Some Type 2s may also need to test, especially if ill or pregnant. Testing is achieved by dipping a test strip in urine and comparing the color change to the chart on the test strip bottle (Katz, Wirthlin, et al, 1991) (Knott, 1997).

Professional Monitoring

It is important for the individual diagnosed with any type of diabetes to work closely with a team of health care providers to facilitate improving glycemic control, lessening the risk of complications and enhancing the quality of life.

Qualified individuals and organizations that may assist in the care of a diabetic individual include:

- American Diabetes Association
- Dentist/Dental Hygienist
- Diabetes Educator

- Dietitian
- Endocrinologist
- Exercise Specialists
- General Physician/ Nurse
- Juvenile Diabetes Foundation
- Mental Health Counselors
- Ophthalmologist
- Pharmacist
- Podiatrist

It is also necessary for these providers/organizations to work closely together to insure the best possible outcomes for diabetic individuals in their care. Complications of diabetes are common but can be treated and prevented more effectively by health care professionals who are carefully networked, conscientious and educated about all facets of diabetes care.

Complications of Diabetes

Acute Complications

Acute complications from diabetes arise from the relative lack or absence of insulin causing hyperglycemia or the relative excess of insulin causing hypoglycemia. (Refer to section “Successful Intervention of Diabetic Emergencies” on page 39).

Chronic Complications

Diabetics undergoing intensive therapy to keep blood glucose levels as close to normal as possible experience lower the risk of chronic complications when compared to diabetic individuals undergoing conventional treatment (See Figure 4) (AAP, 1996).

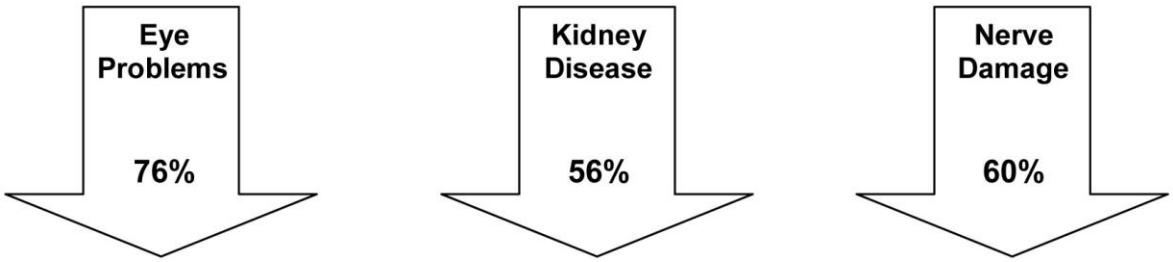


Figure 4: Type 1 Decreased Risk of Complications after Intensive Treatment for Diabetes

High levels of blood glucose cause microvascular damage and impair the body’s infection fighting abilities. This can result in frequent infections of the skin, mouth, bladder and sexual organs (ADA, 2017) Cherry-Pepper, Sorkin et al, 1992) (Darwazeh,

MacFarlan, et al, 1991) (NE JMED, 1993).

Diabetic Retinopathy and Macular Edema

Diabetic retinopathy is the leading cause of blindness in adults. There are two types, non- proliferative diabetic retinopathy (early stage usually left untreated) and proliferative retinopathy (more advanced and usually treated with laser surgery). The deterioration or alteration of small blood vessels in the eye result in loss of vision or blindness. In the early stage, diabetic retinopathy goes unnoticed by the individual. Nearly half of all persons with diabetes will develop diabetic retinopathy during their lifetime. The risk of onset increases with the duration of diabetes and degree of hyperglycemia.

Diabetic macular edema (macula swells from the leaking fluid) can be associated with any stage of diabetic retinopathy. 40% of Type 1 diabetics will develop diabetic macular edema. This condition may also result in loss of vision or blindness.

The connection between diabetes and these disorders remains unclear. Decreased retinal capillary integrity, proliferation of new vessels and contraction of fibrous tissues are all pathological processes resulting from chronic hyperglycemia.

Treatment for these disorders centers on timely surgical intervention. Laser surgery is indicated in the early stages. Vitrectomy (necessary when there has been massive bleeding into the vitreous) is performed if the disease is too advanced for laser surgery.

Cataracts

Cataracts (clouding of the lens) can occur at a younger age in those diagnosed with diabetes. An individual with diabetes is twice as likely to develop cataracts then those without diabetes. Although complications occur frequently, surgery is up to 95 percent successful in restoring vision.

Glaucoma

Open angle glaucoma (a progressive form of glaucoma in which the drainage channel for the aqueous humor remains open) is 1.4 times more likely in diabetics. The prevalence of this disease increases with age and duration of diagnosis.

Kidney Disease (ADA, 2017)

Kidney disease is a serious complication of DM and damage may go undetected during the initial stages of the disease. The pathophysiology of renal disease is more clearly understood in Type 1 than Type 2.

Diabetic Nephropathy

Thickening of the glomerular basement membrane can occur early after the diagnosis of diabetes. Laboratory evidence of damage generally appears after 10 years and is accelerated by hypertension in individuals with Type 1. This life-threatening complication is the leading cause of end-stage renal disease (ESRD). Approximately 40 percent of Type 1 diabetics with a diagnosis of 20+ years develop this complication. 5 to 10 percent of Type 2 diabetics are affected with diabetic nephropathy. The first sign of diabetic nephropathy may be protein present in urine.

Other signs and symptoms include:

- High blood pressure
- Weight gain
- Fatigue
- Feeling ill

African Americans with diabetes are at least two times more likely to develop ESRD than Caucasians. Treatment(s) for diabetic nephropathy resulting in kidney failure include, hemodialysis, peritoneal dialysis and kidney transplants. Because this condition proceeds more rapidly in diabetic patients, strict monitoring and treatment of hypertension and frequent renal function measurements should be instituted.

Diabetic Neuropathy (ADA, 2017)

25 percent of all diabetics have some form of neuropathy.

Common symptoms of diabetic neuropathy include:

- Loss of sensation
- Pain
- Tingling
- Weakness
- Autonomic dysfunction

Peripheral Neuropathy (distal symmetrical polyneuropathy) affects the hands, feet and legs. This is the most common of the three major types of diabetic neuropathy. Feet are the most vulnerable to this disorder and should be checked carefully for any cuts, abrasions, sores or infection. Peripheral neuropathy can cause infection to go unnoticed leading to foot ulcers, which may ultimately, result in amputation.

Autonomic Neuropathy

This disorder affects many internal organs and systems:

- Heart (orthostatic hypotension)
- Urinary (defective perception of bladder filling and emptying)
- Genital (impotence or decreased vaginal lubrication)
- Gastrointestinal (constipation, diarrhea, and incontinence)

Focal Neuropathy (Mononeuropathy)

Considered an uncommon disorder in diabetics, this neuropathy may occur after acute blockage of a blood vessel supplying nerves. It may affect both sensory and motor nerves and is generally seen in older populations. Unlike peripheral neuropathy, it only affects one side of the body. Carpal tunnel syndrome is the most common focal neuropathy that people with diabetes experience.

Macrovascular Disease (ADA, 2017)

In this disease, medium to large size vessels become blocked (atherosclerosis) or vessel walls thicken (arteriosclerosis) reducing or blocking the flow of blood. These vessels supply blood to the legs (peripheral vascular disease), brain (cerebral vascular disease) heart (coronary vascular disease). Cardiovascular disease is the leading cause of illness and death among all diabetics. In diabetics, cardiovascular disease is more likely to occur earlier in life and is more often fatal than in non-diabetics. Risk of heart disease may also be greater in Type 1 diabetics. Several risk factors, obesity, cholesterol level, inactivity, hyperinsulinemia combined with diabetes put an individual more at risk for developing cardiovascular disease.

Diabetics can reduce their risk of cardiovascular disease through:

- Controlling blood pressure
- Reduction of LDL and triglyecride levels
- Improved glycemic control (potentially raising the concentration of HDL cholesterol)
- Controlling weight
- Physical Activity
- Smoking Cessation

The Dental Patient with Diabetes

Oral Complications

Commonly seen oral conditions in individuals with DM include:

- Dental caries
- Periodontitis
- Xerostomia
- Candidiasis
- Burning mouth
- Enlargement of the parotid gland
- Oral neuropathies
- Altered taste perception

Dental Caries

Individuals who do not exhibit good glycemic control often experience an increased rate of dental caries. This is due to increased glucose levels in saliva and crevicular fluid. However, controlled diabetics may show a normal or reduced incidence of dental caries due to better glucose control, reduced carbohydrate consumption, better oral hygiene

practices and frequent dental appointments (Loe and Genco, 1995) (Low, 1993) (Ludstorm, Mordes, Rossini, 1997).

Periodontitis

Often referred to as “the sixth complication of diabetes", (Ludstrom,, Mordes, Rossini, 1997) periodontitis is the most common oral complication of diabetes. Studies (Loe, 1993) suggest that there is a higher prevalence of periodontal disease among diabetic individuals than in the general population. Similar studies (Lundstrom, Mordes, Rossini, 1997) found Pima Indians with Type 2 were 2.5 times more likely to have periodontal disease. A greater prevalence of periodontal disease among Type 1 diabetics has also been shown (Lundstrom, Mordes, Rossini, 1997). Severity of periodontal disease in Type 1 diabetics appears to be related to the duration of diabetes. In Type 1 diabetics who present with retinal changes, periodontal loss of attachment was greater than in those without any retinal alteration (Loe, 1993).

Factors identified as contributing to the development and severity of periodontal disease in diabetics include:

- Basement membrane and microvascular alteration.
- Collagen metabolism
- Differences in oral microflora

- Leukocyte function
- Age, duration of diabetes & oral hygiene

Research into the relationship between diabetes and periodontal disease is incomplete and not fully understood. Patients with poor glycemic control may have more calculus compared to nondiabetics with the same plaque control. There also appears to be a greater number of missing teeth and greater pocket depth associated with diabetic individuals (FDA, 2017).

Persons at Risk

Diabetic individuals with a long history of diabetes, other systemic complications, pregnancy, poorly controlled blood glucose levels and poor oral hygiene are at high risk for periodontal disease (Lundstrom, Mordes, Rossini, 1997). Clearly, many factors contribute to the prevalence and severity of periodontal disease in diabetic individuals.

Etiology and Pathogenesis of Factors Affecting Periodontal Disease Process in Diabetics

Basement Membrane and Microvascular Alteration Changes in the basement membrane and microvasculature are believed to be involved in the periodontal breakdown seen in diabetics. These changes include thickening of the basement membrane, narrowing of capillary lumen, and stasis in microcirculation. Similar to the changes seen in other body tissues, these events might lessen the amount of nutrients delivered and waste eliminated from the tissue resulting in a weakened host response to bacteria (Lundstrom, Mordes, Rossini, 1997) Maffie-Lee and Fitzgerals, 1995) (Med Sci, 1996).

Collagen Metabolism

Metabolism of collagen in diabetics is shown to be abnormal. The synthesis of collagen appears to be negatively affected by the presence of glucose. The impaired synthesis and increased breakdown of connective tissue seen in diabetics may account for rapid periodontal destruction. Decreased production by osteoblasts and fibroblasts has been demonstrated in experimentally induced diabetes. Crevicular fluid collagenase activity is also increased in diabetics but can be inhibited in vitro by tetracycline (FDA, 2017) (Lundstrom, Mordes, Rossini, 1997).

Microflora

Findings as to the similarity of microflora in diabetics versus nondiabetics vary. (36,37) Glucose levels present in oral fluids may alter the presence of some organisms. Organisms present in individuals with Type 1 appear to be composed of anaerobic vibrios Capnocytophaga and Actinobacillus actinomycetemcomitans. In Type 2

diabetics, microflora is similar to that found in adults without diabetes. (37) It is suggested that the severe periodontitis seen in diabetics is the result of a reduced host response to microorganisms that cause periodontitis rather than the type of microorganism present.

Polymorphonuclear Leukocyte Function/Immune Response

Defective polymorphonuclear leukocyte (PMN) function prevents a normal response to infection. This defect may be reversed with insulin therapy (FDA, 2017) (Lundstrom, Mordes, Rossini, 1997). Delayed and incomplete wound healing and susceptibility to infection increases the likelihood of developing periodontal disease (FDA, 2017).

Age, Duration & Oral Hygiene

Prevalence of periodontal disease increases with age. More importantly, the increased duration of diabetes places the individual at a greater risk for onset and increased severity of periodontal disease. There is a relationship between good oral hygiene and a diminished severity of periodontal disease in individuals with diabetes (Lundstrom, Mordes, Rossini, 1997). Diabetic patients with gum disease should be brought in for recalls every 3-4 months in order to help curtail any problems that may be occurring.

Other Oral Complications

Xerostomia, Candidiasis, Burning Mouth Syndrome, Oral Neuropathies and Enlargement of the Parotid Gland

Complaints of xerostomia are common among diabetics. A Methodist Healthcare System study assessing salivary gland function in diabetics, individuals with IGT and a control group found no significant difference in salivary output. The study excluded individuals taking medication. It has been postulated that other diseases or medication use may influence diminished salivary flow. Individuals with poor glycemic control may also experience dry mouth, possibly due to hypovolemia. Xerostomia may predispose diabetic individuals to oral candidiasis (Lundstrom, Mordes, Rossini, 1997) (Loe and Genco, 1995) (MHCS, 1996).

High glucose levels in saliva might be a risk factor for developing candidiasis. (MWDCC, 1996). However, the development of oral candidiasis is most likely multifactoral. Smoking and the continuous wearing of a denture will also promote a fungal infection in the diabetic patient (Lundstrom, Mordes, Rossini, 1997). Another oral symptom common among diabetics is burning mouth syndrome. Burning mouth syndrome may be best characterized as a burning pain, typically involving the tongue. A relationship between burning mouth syndrome and oral candidiasis has been suggested

but is inconclusive (MWDCC, 1996) (NIDDKD, 1995). Burning mouth syndrome and altered taste perception may occur in response to xerostomia or oral neuropathy (Low and Genco, 1995) Oral neuropathies are considered rare and symptoms can include tingling, numbness, and burning sensation and taste alteration. These conditions could be the presenting symptoms at a dental appointment in a diagnosed and/or undiagnosed diabetic (Lunstrom, Mordes, Rossini, 1997).

Parotid gland enlargement is a possible presenting symptom in an undiagnosed diabetic. The etiology for parotid gland enlargement is unknown and believed to affect 10-25% of patients with poor glycemic control (Loe, 1993) (Lundstrom, Mordes, Rossini, 1997).

Other oral conditions seen in individuals with diabetes include (Loe, 1993) (Lundstrom, Mordes, Rossini, 1997) NIDDKD, 1995):

- Erosive lichen planus
- Palatal ulcers
- Necrotizing cellulitis
- Sialosis
- Sialorrhoea

Treatment of Periodontal Disease

Treatment of periodontal disease in controlled diabetics is similar to that of nondiabetics. Therapy efforts should be targeted toward eliminating infection and the prevention of further destruction. Dentists should consult with the patient's physician regarding the periodontal status of the diabetic individual. The presence of periodontal infection may increase insulin resistance and glucose levels in a previously stable patient (FDA, 2017) (Lundstrom, Mordes, Rossini, 1997).

Steps in the treatment of periodontal disease in diabetics include, but are not limited to:

- Thorough oral hygiene assessment and education/instruction as to improved plaque control techniques
- Tobacco cessation/nutrition counseling
- Scaling and root planing as needed
- Smoothing or replacement of defective restorations
- Surgical elimination of periodontal pockets (if indicated)
- Antibacterial rinses (Chlorhexidine digluconate/Peridex)
- Topical fluoride application (to inhibit dental caries)
- Prescription of antibiotics (not routinely recommended in controlled diabetic patients)
- Routine periodontal maintenance (increased recall frequency)

Routine therapy for other oral complications should be administered. Diabetics suffering from xerostomia should be counseled about tobacco use and alcohol consumption and the negative impact of high alcohol mouth rinses. Sugar-free candy, gum and water may help stimulate salivary flow and provide relief. Artificial saliva substitutes may also be prescribed. Compliant patients instructed in the timely removal of partials and dentures, and smoking cessation often resolve oral candidiasis infections, although persistent cases may require an antifungal prescription (e.g., clotrimazole and nystatin). Certain conditions may require referral to dental and/or medical specialists (Loe and Genco, 1995) (Loe, 1993) Lundstrom, Mordes, Ronnini, 1997) (MWDCC, 1996).

Dental Intervention, Education, and Treatment Planning

Dental health professionals are likely to encounter many diagnosed and undiagnosed diabetic individuals. Persons with diabetes often require more emergency dental care and should have frequent routine dental visits to help control oral complications associated with diabetes (Lundstrom, Mordes, Rossini, 1997).

Familiarity with oral signs and symptoms of diabetes combined with a thorough health history can assist in the diagnosis and treatment of dental needs. The health history should be designed to obtain information indicative of diabetes.

A general health history including the following might help identify an undiagnosed individual:

- Polyuria, polydypsia, polyphagia
- Unexplained weight loss or gain
- Tingling or numbness in hands or feet
- Burning or tingling sensation on tongue
- Unexplained fatigue
- Family history of diabetes
- Frequent infections
- Slow healing cuts or sores
- Blurred eyesight
- Dry itchy skin

During the oral assessment phase of the appointment, the dental health professional should be aware of oral conditions that may represent undiagnosed diabetes.

These conditions include:

- Periodontal disease
- Recurrent periodontal abscesses
- Oral candidiasis

- Burning sensation/altered taste perception
- Parotid gland enlargement
- Erosive lichen planus
- Necrotizing cellulitis
- Sialosis
- Sialorrhoea

If there is a question about the presence of diabetes, the dentist should request a blood glucose test. Medical consultation with the patient's physician is also suggested. Oral symptoms of diabetes may be present prior to extraoral symptoms; therefore screening for diabetes should not be delayed (NIDDKD, 1995).

In diagnosed diabetics, it might be useful to include the following supplemental information in the patient's health record:

- Year of diagnosis
- Type of diabetes
- Oral hypoglycemic agent (name, dose)
- Insulin (type, dose)
- Glucose monitoring (type and frequency)
- Date and result of last glycosated hemoglobin test
- Known complications resulting from diabetes
- Names and contact information of various specialists associated with management of patient's diabetes.
- Previous history of diabetic emergencies (hypoglycemia, diabetic ketoacidosis, hyperglycemic hyperosmolar nonketotic coma)

Education

Educating patients about diabetes and its complications is the responsibility of the entire dental team. Information as to risk factors, screening methods and potential complications should be readily available during the dental visit. Dental education should include the importance of glucose control, good oral hygiene, diet/exercise and regular dental visits.

Controlled Type 1 and Type 2 diabetics receive regular dental treatment. It is important, however, that the patient and doctor communicate about the patient's current condition and make sure that the diabetes is, in fact, controlled. Make sure the patient has taken their insulin that day. Inquiring as to recent blood glucose numbers may help in this regard. Appointments should be kept as short and a stress free as possible.

Knowledge of the type, duration and peak of the insulin being taken is useful to the dentist and hygienist in planning dental treatment (FDA, 2017) (Loe and Genco, 1995).

In persons with uncontrolled diabetes, dental procedures should not be initiated except for the immediate relief of pain or other emergency. If emergency surgery is necessary, the patient should be treated in a facility where they can easily be monitored, such as a hospital. Consultation with the physician prior to providing any dental therapy for these individuals is recommended (FDA, 2017) (Low and GEnco, 1995) (Lunstrom, Mordes, Rossini 1997).

The amount of stress the individual feels during the dental appointment can greatly affect the patient's ability to tolerate the procedure. Therefore, patients should not be kept waiting. Thorough explanations of dental procedures to be performed may also help to reduce stress.

It is better to plan for dental treatment during a time of high glucose and low insulin activity. Individuals with Type 1 generally do better if appointed in the morning after consuming a normal breakfast. This is due to something known as the Dawn Phenomenon. There is an elevation in circulating blood glucose in the morning due to breakdown of stored energy supplies in the pre-dawn hours. This is thought to be a response to the prolonged fasting that occurs overnight (Zagaria, 2003).

Patients should be instructed to maintain their currently prescribed drug regimen. Adjustments in diet and insulin therapy may be necessary if the patient undergoes significant dental treatment. It is important to maintain proper nutritional balance and patients should be instructed to eat following their dental appointment. Understanding the patient's drug regimen assists the dental professional in planning and scheduling dental treatment (FDA. 2017) (Lundstrom, Mordes, Rossini, 1997).

The use of local anesthesia is not contraindicated in diabetic patients. Local anesthesia should contain no more than 1:100,000 epinephrine. Avoidance of excessive amounts of epinephrine is necessary in order to prevent increased blood glucose levels (FDA, 2017) (Loe and Genco, 1995).

Alterations in food and drug intake should be considered when conscious sedation is necessary during dental treatment. Consultation with the physician is suggested prior to initiating dental treatment involving IV sedation.

If diabetic patients are to undergo emergency oral surgery or periodontal treatment, the use of prophylactic antibiotics should be considered. In controlled and uncontrolled diabetics, poor host response and delayed wound healing may prompt the use of antibiotics. However, the use of antibiotics is not generally necessary in controlled diabetic patients for routine procedures. Use of antibiotics in conjunction with dental treatment of diabetics is highly variable according to the patient's glycemic control. Administration, dose and selection of an antibiotic are usually the same as in nondiabetic patients. Doxycycline may be considered for use instead of tetracycline (if

tetracycline is indicated). Doxycycline is not metabolized in the kidney, which may be important if nephropathy is present. Avoid prescribing glucocorticosteroids (used to reduce post-surgical swelling) because they may cause undesirable elevations in blood glucose (ADA, 2017) (FDA, 2017) (Loe and Genco, 1995).

Successful Intervention of Diabetic Emergencies

Diabetic emergencies can and do occur in the dental office. Many factors can predispose an individual to a hypoglycemic or hyperglycemic episode. Dental professionals should be aware of emergency medical procedures necessary to manage a diabetic emergency. Patients with diagnosed diabetes mellitus should be encouraged to bring self-monitoring glucose devices and a carbohydrate liquid drink to their dental office (FDA, 2017). Dental professionals should discuss emergency management procedures with their diabetic patients during their initial visit and stay informed as to the patient's current therapeutic regimen.

Hypoglycemia

The most common acute diabetic emergency in the dental office is hypoglycemia (FDA, 2017). Most diabetics begin to have symptoms when the blood glucose level falls below 70mg/dL. Persons with longstanding type 1 diabetes may have decreased ability to sense impending hypoglycemia (Oliver and Tellervo, 1993).

Symptoms of hypoglycemia may include:

- Headache
- Hunger
- Moist skin
- Pallor
- Weakness
- Dizziness
- Anxiety
- Confusion

If left untreated these symptoms may progress to severe hypoglycemia, loss of consciousness leading to seizures and possible death (FDA, 2017) (Cherry-Pepper, Sorkin, et al 1992).

Hypoglycemic episodes may be experienced by individuals who (Cherry-Pepper, Sorkin, et al 1992):

- take insulin or oral diabetes medications
- follow an intensified insulin protocol (target glucose level near normal)
- have delayed or decreased food intake

- increase physical activity
- consume alcohol
- have long duration of diabetes
- have autonomic neuropathy

Prevention of hypoglycemia is best approached through patient education and self-monitoring of blood glucose levels. Documentation in the dental record regarding previous incidence of hypoglycemic episodes and current information regarding insulin/oral hypoglycemic agent therapy is also useful. After a hypoglycemic event occurs in the dental office, discussion of any precipitating factors may be helpful in preventing future episodes. Patient identification, such as an emergency medical bracelet, also helps to identify person as having diabetes.

Educating diabetics of the relationship between hypoglycemia and the risk factors for onset (see above list) can greatly reduce episodes of hypoglycemia. Patients may be aware of hypoglycemic symptomology before the dental professional. At this point, the diabetic individual may self-test for blood glucose level and/or eat something containing sugar. The dental professional should encourage diabetic patients to communicate changes in their condition that might signal onset of hypoglycemia.

If the individual is experiencing hypoglycemia they should consume 10 to15 grams of rapidly absorbable carbohydrates.

Examples include:

- 3 glucose tablets
- 4 oz. fruit juice
- 5-7 hard candies
- 8 oz. milk
- 1 tablespoon of sugar or sugar cube
- 4 oz. of a regular soft drink (not diet)
- cake icing

Repeated if necessary in fifteen minutes.

Symptoms may arise rapidly and it may become necessary for the dental professional to administer some form of oral carbohydrate (e.g., orange juice, and candy). If the patient is unconscious or unable to treat himself, the dentist can administer dextrose (50mL in 5% concentration) intravenously or Glucagon (see Appendix A) can be administered intramuscularly, intravenously or subcutaneously (See Table 5).

Table 5: Glucagon Dosage

Children < 3 years of age (< 20 kg)	0.5 mg.
Children ≥ 3 years of age and adults (≥ 20 kg)	1.0 mg.

At anytime during the episode when there is a rapid deterioration in the patient's status activation of the emergency alert system is necessary. Transportation to a hospital and consultation with the patient's physician is necessary. Patients experiencing hypoglycemia while taking hypoglycemic agents should be closely monitored at least 48 to 72 hours to prevent possible recurrence (Cherry-Pepper, Sorkin, et al, 1992) (FDA, 2017) (Loe and Genco, 1997) (Oliver and Tellervo, 1993).

Hyperglycemia

If left unchecked, chronic hyperglycemia can result in Diabetic Ketoacidosis (DKA) or Hyperglycemic Hyperosmolar Nonketotic Coma. These conditions develop over days, but will develop more quickly if the individual is concurrently suffering an illness or infection (Cherry-Pepper, Sorkin, et al, 1992).

Diabetic Ketoacidosis

DKA, as described previously results from an insulin deficiency. The decreased use of insulin prompts the release of fatty acids and the production of ketones by the liver.

Physical symptoms may include:

- Weak, rapid pulse
- Nausea, vomiting
- Thirst
- Deep difficult breathing
- Flushed and dry skin
- Abdominal pain
- Confusion
- Weakness

DKA may be the presenting symptom in individuals previously undiagnosed with Type 1. DKA is likely seen in Type 1 diabetics if they have not received enough insulin during times of illness. Type 2 diabetics may experience DKA if they are very ill and not able to eat sufficient calories. Other factors include overeating and physical inactivity. Annual incidence rates rage from 3 to 8 persons per 1,000. It is more common in Type 1 diabetics than in individuals diagnosed with Type 2. Mortality rates range from less than

5% to 14% (Cherry-Pepper, Sorkin, et al, 1992).

Prevention of DKA is possible by following prescribed daily therapeutic regimen. Frequent blood glucose monitoring can alert the diabetic to changes in blood glucose level.

Occurrence of DKA is likely when there is:

- Mismanagement of therapy (inappropriate cessation, or change in prescribed therapy)
- Failure to recognize symptoms,
- Low level of suspicion of DKA occurrence by health care professionals
- Concurrent illness (improper management of diabetes during periods of illness)

DKA usually occurs when blood glucose levels are over 240mg/dL. When the blood glucose is at this level, type 1 diabetics should consult their physician. Dental treatment should be deferred until the individual's hyperglycemia is under control. In later stages, patients suffering from DKA may present with rapid, deep respiration (Kussmaul's respiration) and acetone breath. Individuals should be transported immediately to the hospital for care and treatment. If this condition continues the patient will become increasingly ill, possibly resulting in diabetic coma (ADA, 2017) (Cherry-Pepper, Sorkin, et al, 1992) (Loe and Genco, 1997) (Oliver and Tellervo, 1993).

Because it may not be possible to differentiate between a hypoglycemic and hyperglycemic episode, treatment protocol should follow that of hypoglycemia. Patients with hypoglycemia decline more rapidly and the condition can become life threatening more quickly. If the diagnosis is incorrect administration of glucose will not significantly worsen an acute hyperglycemic episode (Loe and Genco, 1997).

Hyperglycemic Hyperosmolar Syndrome (HHS)

HHS accounts for 5-15 % of hospital admissions for diabetic coma. (49) Mortality rates are reported as high as 50% (Cherry-Pepper, Sorkin, et al, 1992) This disorder resembles DKA (dehydration, altered mental status) although blood glucose levels are much higher (up to 2000 mg/dL), Kussmaul respiration is rare, and there is the absence of ketosis. There is a reduction in the rate of glomerular filtration and glucose excretion (Cherry-Pepper, Sorkin, et al, 1992) (Patterson, 2005) (Rees, 1994).

HHS occurs mostly in diagnosed and undiagnosed Type 2 diabetics over the age of 60.

Conditions or events that precipitate HHS include (Cherry-Pepper, Sorkin, et al, 1992):

- History of Type 2 diabetes
- Chronic illness
- Acute illness (e.g. stroke, myocardial infarction)
- Mild renal insufficiency
- Lack normal thirst drive or access to water
- Drugs (diuretics, glucocorticoids)
- Surgery
- Dialysis
- Poor support system or lives in nursing home

Health care providers should be suspect of elderly patients demonstrating any of these precipitating factors. Individuals may exhibit central nervous system distress (e.g., hallucinations, focal or grand mal seizures). Early recognition of symptoms and timely intervention are key in preventing onset. Treatment is similar to that of DKA and consists of intravenous administration of fluids, electrolytes and insulin. The result of treatment may make the patient more sensitive to further insulin. Glucose control can be attained through a combination of diet, exercise and oral hypoglycemic agents or insulin. Patient education should include an understanding of the warning signs of onset of HHS and glucose monitoring techniques (Patterson, 2005) Rees, 1994).

Prevention and Treatment of DM

Prevention efforts should be aimed at educating populations as to their individual and group risk for onset of diabetes. Criteria (See Table 6) for testing undiagnosed individuals is as follows (Cherry-Pepper, Sorkin, et al, 1992):

Table 6: Criteria For Testing Undiagnosed Individuals

ƒ Test for DM for all individuals ≥ 45 years of age, especially if BMI ≥ 25. If normal, repeat at 3-year intervals. Test at younger age or more frequently if BMI ≥ 25 and have additional risk factors:	
vascular disease first degree relative with diabetes history of GDM HDL cholesterol ≤ 35 mg/dl pre-diabetes	habitual physical inactivity delivered baby > 9 pounds blood pressure ≥ $^{140}/_{90}$ triglyceride ≥ 250 mg/dl polycystic ovary syndrome
high risk ethnic population (African American, Latino, Native American, Asian American, Pacific Islanders)	

Once the diagnosis has been made treatment goals should be directed at controlling blood glucose levels and preventing complications associated with diabetes.

These efforts include:

- education,
- dietary management, weight loss (if applicable),
- physical activity,
- pharmaceutical intervention, and
- professional monitoring

Diet/Nutrition

The foundation of diabetic therapy is nutrition. Type 1 diabetics need the same amount of food that would normally be consumed if they did not have diabetes. Insulin amounts need to compliment the amount of food required to maintain a healthy weight. Type 1 diabetics should strive to be consistent in both the choice of food and the timing of meals. Individuals with Type 2 may need only dietary modification in order to control blood glucose levels (See Table 7) (Eisenbarth, 1986).

Table 7: Diabetic Diet Modification

Component	Goal
Calories	Sufficient to maintain reasonable weight
Protein	10 - 20% of total caloric intake
Fat	30% of total calories
Fiber	20 - 35 grams per day
Carbohydrates	Up to 55 - 60% of total calories (modest amount from refined sugars)

The American Diabetes Association recommends the following goals for nutritional therapy:

1. Restore blood glucose and optimal lipid levels.
2. Maintain normal growth rate in children and adolescents as well as the attaining and maintaining of reasonable body weight in adolescents and adults.
3. Provide adequate nutrition for pregnant women, the fetus and lactation.
4. Stay consistent in the timing of meals and snacks to prevent inordinate swings in blood glucose levels for people using exogenous insulin.
5. Determine a meal plan appropriate for the individuals' lifestyle and based on a diet history.
6. Manage weight of obese people with Type 2.
7. Improve the overall health of people with diabetes through optimal nutrition.

A dietician should be consulted to assist in tailoring nutrition concerns to the diverse needs of the individual. Dietary plans should be directed toward lifestyle and health status of the individual (ADA, 2017) (Bressler and Johnson, 1997) (Eisenbarth, 1986) (Lilly and Co, 1995).

In June of 2017, a long-term study at the University of Pennsylvania found, in consistent scientific research, that prolonged delayed eating will likely increase weight, insulin and cholesterol levels, and negatively affect fat metabolism, and hormonal markers implicated in heart disease, diabetes and other health problems.

> "We know from our sleep loss studies that when you're sleep deprived, it negatively affects weight and metabolism in part due to late-night eating, but now these early findings, which control for sleep, give a more comprehensive picture

of the benefits of eating earlier in the day," said Namni Goel, PhD, a research associate professor of psychology in Psychiatry in the division of Sleep and Chronobiology, and lead author of the ongoing study. "Eating later can promote a negative profile of weight, energy, and hormone markers -- such as higher glucose and insulin, which are implicated in diabetes, and cholesterol and triglycerides, which are linked with cardiovascular problems and other health conditions." (Science Daily June 2017)

Exercise

Exercise is also considered to be a fundamental treatment for diabetes. Exercise can be useful in lowering blood glucose levels and promoting general health in both Type 1 and Type 2. Exercise may benefit the Type 1 diabetic by lowering insulin requirements. Type 2 diabetics may be able to eliminate or reduce pharmacological interventions through diet and exercise modifications.

Type 1 diabetics should carefully check blood glucose levels prior to exercising to avoid the onset of hypoglycemia (if blood sugar is too low) or ketoacidosis (if blood sugar is too high). Individuals with Type 2 are at risk for cardiac problems, orthopedic injury and perhaps hypoglycemia. A regular exercise program instituted under the care of a physician can improve the health of all individuals with diabetes (ADA, 2017) (Cherry-Pepper, Sorkin, et al 1992) (Dorman, McCarthy, et al, 1995) (Lilly and Co, 1995).

Pharmacological Intervention

Insulin

Normally produced by the ß-cells of the pancreas, insulin assists in the diffusion of glucose into the cell. When there is no insulin (or relatively little) glucose cannot enter the cell and be converted into energy. For individuals who do not produce insulin, insulin injections are necessary to balance the amount of glucose in the blood. Insulin cannot be taken orally because stomach acid will destroy it before it is effective (ADA, 2017) (Cherry-Pepper, Sorkin, et al 1992) (Dorman, McCarthy, et al, 1995) (Lilly and Co, 1995) (Exp. Comm, 1997).

Persons with Type 1 must have insulin injections to live. Type 2 diabetics may take insulin if diet, exercise and/or oral hypoglycemics alone do not control blood sugar fluctuations. The amount and type of insulin will vary among individuals depending on sensitivity to insulin, activity level and lifestyle. 100 percent of Type 1 diabetics require insulin and approximately 35 percent of Type 2 diabetics require insulin.

There are many things to consider when choosing an insulin therapy:

- Source
- Pharmacodynamics
- Administration
- Method of Injection

Source

Original sources of insulin were either bovine or porcine. Today, there is a human source available. The human insulin source is available by through recombinant DNA techniques (a chemical process that makes it possible to produce unlimited amounts of insulin).

Table 8: Common Subcutaneous Insulin Pharmacodynamics

Action	Type	Onset	Peak	Duration
Rapid	Aspart (Novolog) Lispro (Humalog) Glulisine (Apridra)	0.25 hours	0.5 - 1.5 hours	3 - 6 hours
Short	Regular	30 minutes	2.5 - 5 hours	6 - 8 hours
Intermediate	NPH Lente	1 hour 2 hour	3 - 6 hours 4 - 8 hours	11 - 16 hours 12 - 18 hours
Long Acting	Ultralente Glargine (Lantus)	4 - 6 hours 1 - 2 hours	12 - 16 hours Peakless	Up to 36 hours 24 hours
Mixed Insulins Intermediate + Short Acting	70/30 70% NPH/ 30% Regular	30 minutes	1 - 4 hours	4 - 30 hours
	50/50 50% NPH/ 50% Regular	30 minutes	1 - 4 hours	4 - 15 hours
Intermediate + Rapid Acting	Humalog Mix 75/25 75% NPL / 25% Lispro	0.25 hours	0.5 - 6.5 hours dual peaks	24 hours
Intermediate + Rapid Acting	Novolog Mix 70/30 70% NPA / 30% Aspart	0.25 hours	1 - 4 hours dual peaks	24 hours

(ADA, 2017) (Oliver and Tellervo, 1993)

Administration

Most therapies utilize short and intermediate-acting agents delivered two times a day. Human insulin has a more rapid onset and is believed to be less immunogenic. Most individuals with type 1 diabetes may inject up to four times per day to achieve near normal glucose levels and prevent complications.

The amount of insulin needed varies according to an individual's age, food intake, weight, and activity level. It is important that the amount of insulin be coordinated with food intake and meal times. Illness, stress, and other medicines taken may also affect dosage levels.

Method of Injection

As stated previously, insulin cannot be delivered orally because stomach acids render it useless before any action can take place.

Current methods of insulin delivery include:

- Needle and syringe
- Insulin pump
- Insulin pen
- Jet injector

Worn outside the body, an insulin pump delivers a continuous supply of insulin through a tube that connects to a needle placed under the skin. This amount may be supplemented before meals depending on blood glucose levels.

An insulin pen is a device that stores replaceable insulin cartridges with a sterile, disposable needle. These devices eliminate the need to carry extra bottles and needles.

Using high pressure to expel the insulin through the skin, jet injectors do not require a needle. This is an expensive option for insulin delivery.

Jet Nebulizers are currently being researched as a method for delivering insulin. This method is best described as "inhaled" insulin. Thus far no significant adverse reactions have been noted but efficacy is questionable.

When injecting insulin it is important to choose the correct location. It is critical to rotate sites following a regular pattern. Uptake of insulin is fastest in the abdomen and slowest

from the buttocks. Repeated injections in the same area may cause delayed absorption. Quicker absorption of insulin can result from exercising (arms and legs) the area of injection.

Patients should be aware of the following information when purchasing insulin.

- Species (bovine, porcine, human)
- Brand Name (Humulin, lletin, etc.)
- Type (NPH, Regular, Lente, etc.)
- Concentration (U-100 is most common)

Oral Hypoglycemic Agents

When sufficient results cannot be obtained through diet and exercise regimens it may become necessary for Type 2 diabetics to take oral hypoglycemic agents aimed at lowering blood glucose levels (see Table 9) (Oliver and Tellervo, 1993).

The four major classifications of oral hypoglycemic agents, are secretagogues (sulfonylurea drugs, meglitinides and D-Phenylalanines) biguanides (Metformin), Thiazolidinediones (Actos and Avandia) and Glucosidase Inhibitors (Precose and Glyset) Secretagogues act by increasing pancreatic production of insulin. Metformin's main action is to reducing glucose production in the liver, the Thiazolidinediones decrease insulin resistance and the Glucosidase Inhibitors delay carbohydrate absorption (Oliver and Tellervo, 1993).

Secretagogues

Sulfonylureas have been the mainstays of oral hypoglycemic therapy for the past 40 years. Sulfonylureas help to increase the secretion of insulin but have no effect on insulin sensitivity. The main side effects of this class of agents is hypoglycemia and weight gain. Primary failure of this drug is due to insulin insufficiency. Secondary failure may include poor dosing, lack of physical activity and obesity (Cherry-Pepper, Sorkin, et al, 1992) (Lilly and Co, 1995) (Frantzis, Reeve and Brown, 1973) (Oliver and Tellervo, 1993).

The newer class of secretagogues includes Prandin and Starlix. These medications also stimulate pancreatic insulin release, but in contrast to the sulfonylureas, they start acting within 30 minutes and are cleared by the body within 3 to 4 hours. These drugs should be taken immediately prior to each meal. The main advantage of these medications is that there is more flexibility in timing of meals, less weight gain and hypoglycemia (Oliver and Tellervo, 1993).

Biguanides (Metformin)

Biguanides were banned in the United States during the 1970's because they were linked to lactic acidosis. A safer biguanide, metformin, has been released (brand name Glucophage) and the risk of lactic acidosis appears to be minimal. This drug works through decreasing the amount of glucose released from the liver. This drug may also aid in weight reduction and improvement of lipid profiles (Lilly and Co, 1995) (Frantzis, Reeve, Brown, 1973) (Gibson, Lamey, et al, 1990) (Harris, 1995).

Thiazolidinediones (Actos, Avandia)

Actos and Avandia work by increasing insulin sensitivity. They lower blood sugar through improvement of target cell response to insulin. Persons on these drugs need baseline liver function testing and should be monitored for any signs of hepatic problems. Patients should also be evaluated for any signs of edema or weight gain since they medications can increase fluid retention. These drugs should be used with caution in people with congestive heart failure or on insulin therapy (Lilly and Co, 1995) (Frantzis, Reeve, and Brown, 1973) (Gibson, Lamey, et al, 1990) (Harris, 1995) (Oliver and Tellervo, 1993).

Glucosidase Inhibitors (Precose, Glyset)

Precose and Glyset are used to control digestive enzymes, delaying the digestion of complex carbohydrates. This interference can prevent a dramatic rise in blood sugar after eating a meal (Frantzis, Reeve, and Brown, 1973) (Gibson, Lamey, et al, 1990) (Harris, 1995) (Oliver and Tellervo, 1993).

Combination Medications

To improve efficacy and simplify medications regimens, three of these diabetes drugs are now combined. These medications combine Metformin plus Glyburide or Glucotrol and met-formin plus Avandia (Oliver and Tellervo, 1993).

Table 9: Oral Hypoglycemic Agents

Class/Main Action	Name(s)	Daily Dose Range	Considerations
Sulfonylureas Stimulate sustained Insulin Release	Glyburide: (Micronase, DiaBeta) (Glynase) Glipizide: (Glucotrol*) (Glucotrol XL) Glimepiride (Amaryl)	 1.25 - 20 mg 0.75 - 12 mg 2.5 - 40mg 2.5 - 20 mg 1.0 - 8mg	All sulfonylureas can cause weight gain and hypoglycemia. *Glucotrol should be taken on empty stomach.
Meglitinides Stimulates insulin "burst"	Repaglinide (Prandin)	0.5 - 4 mg a.c. 16mg max daily dose	Take before each meal. Side effects may include hypoglycemia / wt gain.
D-Phenylalanine Stimulates rapid insulin "burst"	Nateglinide (Starlix)	60 - 120mg mg a.c.	Take before each meal. Side effects may include hypoglycemia / wt gain.
Biguanides Decrease hepatic glucose output	Metformin (Glucophage) Glucophage XR (extended release)	500 - 2500mg 500 - 2000mg once daily	Take caution if creat >1.4 women, >1.5 men, CHF on meds, >80 yrs, binge drinker, liver disease, during IV dye study
Thiazolidinediones "glitazones" Increase insulin sensitivity	Rosiglitazone (Avandia) Pioglitazone (Actos)	4 - 8 mg 15 - 45mg	Baseline liver labs. Can cause edema and weight gain. Caution in patients with heart failure or receiving insulin therapy.
Glucosidase Inhibitors Delay carb absorption	Acarbose (Precose) Miglitol (Glyset)	75 - 300mg based on wt.	Start w/ low dose, increase slowly to decrease GI effects. Caution with liver or kidney problems.
Combination Medications	Glucovance Avandamet Metaglip	*Combine the following medications:* Glucovance: metformin and glyburide Avandamet: rosiglitazone and metformin Metaglip: metformin and glipizide	

Diabetes Medications

It is important for Type 2 diabetics to know the following information regarding oral hypoglycemic medication:

- Name of drug
- Time taken
- Strength of tablets
- Number of tablets
- Dose

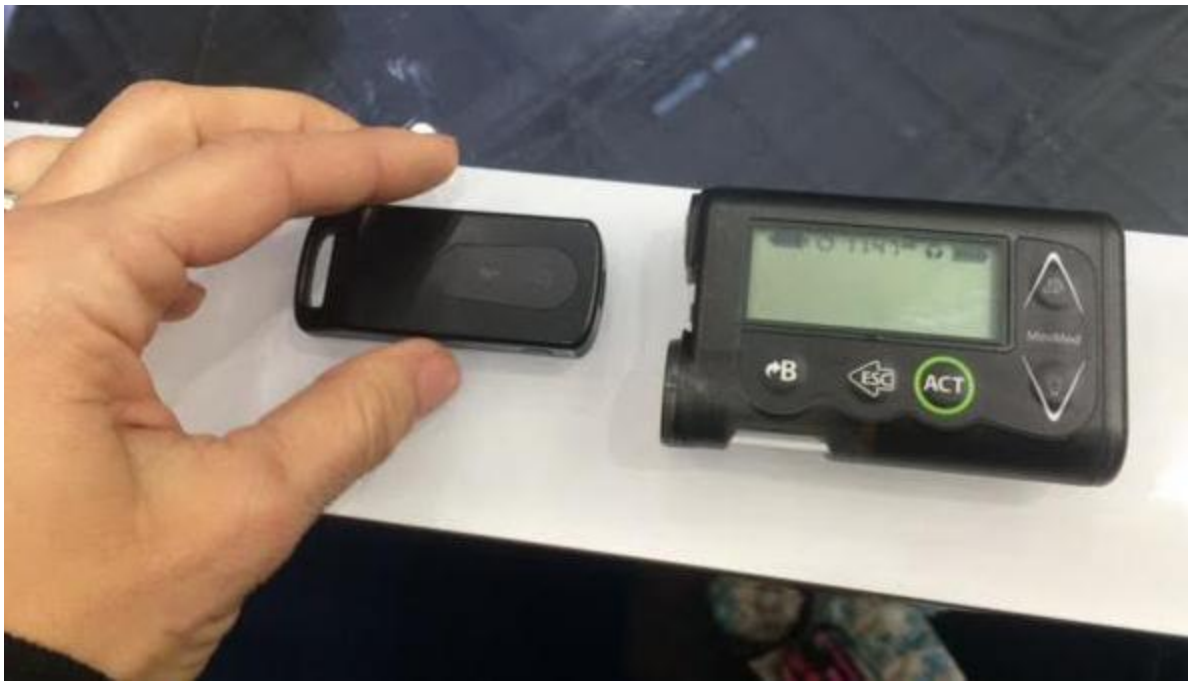
Research & Technological Updates in 2015-2017

In an online article, published on June 10, 2015 written by Amy Tenderich and Mike Hoskins, titled, *Tech Spotting at the ADA* [American Diabetes Association] Scientific Sessions 2015 Tendrich shares the following:

Medtronic

“Medtronic had a landmark weekend with four news announcements, catapulting the insulin pump and CGM company into the spotlight.

The company announced that it had gained FDA approval …of what it calls Minimed Connect, a new data-sharing system for its combo insulin pump and CGM. To use it, you need a small Uploader device that can be carried in the pocket or on a keychain, which transmits real-time data from a Paradigm Revel or 530G pump with Enlite CGM sensor to the Minimed CareLink system online. This is facilitated through a smartphone app (currently only available for iPhone, but Android is coming soon) that also delivers preset text messages to loved ones or parents for Highs or Lows.



Tied in with that, Medtronic announced that it is partnering with both Samsung and Glooko. What this means is that the system will soon beam data directly to Samsung smartwatches (using a Linux-based Tizen OS)… Soon Medtronic users will be able to view and share their data on the Glooko platform, which is huge -- especiallly for those who like the Medtronic devices but aren't fans of their proprietary software system, CareLink.

In (almost) bigger news, Medtronic announced that it is launching the first pivotal trial for its hybrid closed loop system (also referred to as the 670G), which is a pre-Artificial Pancreas that still requires some user intervention (i.e. not completely automated). This is BIG because it is the first-ever "pivotal trial" of closed loop technology conducted in the U.S. In reasearch, a "pivotal" trial is the final one providing evidence that a drug or device is ready for market. With this, Medtronic is paving the way for commercialization of an AP system soon!

…More details on the trial can be found at ClinicalTrials.gov (identifier: NCT01857973).

Of course, before the closed loop hybrid makes its way to market, we hope to see U.S. availabilty of the Minimed 640G, with its predictive glucose suspend feature and (finally) a new, more smartphone-ish design. It was launched outside the U.S. earlier this year, and the clinical trial needed for FDA review is underway.

The company also announced a partnership with BD (Becton Dickinson) to bring patients the new FlowSmart infusion set that will have a teensy catheter with extra side

port designed to improve insulin delivery and help prevent undetected occulusions. Interestingly, BD is the leading player in injection devices and needles but they've never before made an infusion set. The FlowSmart set announced last month will now be used in Medtronic pumps (and eventually closed loop systems) beginning in late 2017 or early 2018." (Healthline Online Resource, 2015)

In 2017, there has been incredible research leading to understanding markers to predict Type 1 diabetes in children. In a February 2017 online article titled, *An Early Signpost forTtype 1 Diabetes?* by Jennifer Couzin-Frankel, reveals astounding research, done by Ezio Bonifacio, a biologist at the Technische Universität Dresden in Germany, and his colleagues, which is able to determine preliminary markers in T cells found in infants and children which can lead to Type 1 diabetes.

Couzin-Frankel explains, "Type 1 diabetes hits when the body destroys insulin-producing cells in the pancreas. By the time people—many of them children—are diagnosed, most of those cells are gone. Forty thousand new type 1 diabetes cases are recorded each year in the United States, and the disease is on the rise for reasons not well understood. A dream for diabetes researchers is to treat kids earlier, when they are headed down the diabetes road but aren't yet there.

About 3 decades ago, scientists discovered a collection of signposts: antibodies directed at certain proteins in the body, including insulin. As they studied these children more intensively, they learned that those with two or more different kinds of these autoantibodies will eventually develop diabetes, though sometimes not for many years. Many clinical trials have since focused on trying to slow disease onset in these individuals.

But what happens before these autoantibodies arise? Ezio Bonifacio had the means to tackle this question. He and his colleagues had for years been following children since birth whose genetics and family history put them at increased risk. Beginning in 2000, the researchers began to collect and store blood cells from a subset of these children. Recently, technology had advanced to the point that scientists could analyze single cells in those samples.

'We decided that it was time to start to see if there was something happening at the level of the T cells,' Bonifacio says. Commonly referred to as the sentries of our immune system, T cells are the villains in diabetes. They for some reason go rogue, leading the attack on insulin-producing cells in the pancreas.

Bonifacio and his colleagues performed sophisticated analysis on T cells from 12 babies who didn't develop autoantibodies later—suggesting they were in the clear—and 16 babies who did. Probing the T cells in the lab, they saw that cells from the children who continued down the path toward type 1 diabetes were not normal. Essentially, when the

T cells were exposed to a substance called an antigen, which in this case could trigger a response against insulin-producing cells, some of those T cells got activated. This is a faint echo of what happens inside the body of someone developing diabetes: Their T cells are activated against cells in the pancreas much as they would be against a foreign invader, like a virus.

'These T cells have somehow already learnt to get halfway' toward becoming autoreactive cells, says Bonifacio, whose team reports its findings today in Science Translational Medicine.

Bonifacio cautions that the findings are still preliminary. For one, samples like these from infancy are rare, and thus the number of children whose T cells were studied is modest. For another, although the unusual T cell behavior was entirely absent in kids who didn't get autoantibodies later on, it was recorded in only about half who did.

Still, the work breaks ground by identifying likely signs of type 1 diabetes studies earlier than ever, says Kevan Herold, an endocrinologist at Yale University, who studies ways to prevent the condition. 'The value of this paper is that there's stuff that can be measured even before' the autoantibodies, agrees Gerald Nepom, director of the Immune Tolerance Network and former director of the Benaroya Research Institute in Seattle, Washington.

One central mystery is what's causing the changes in these cells so early in life. Bonifacio and others have looked exhaustively for environmental drivers of type 1 diabetes; although there have been hints of various influences, like certain infections, 'the punch line here is that the data's inconsistent' across all the studies, says Carla Greenbaum, who chairs Type 1 Diabetes TrialNet, which oversees type 1 diabetes treatment and prevention trials, and directs the diabetes program at the Benaroya Research Institute.

So diabetes experts like Greenbaum have their eyes on prevention. Bonifacio is co-leading a study called Pre-POINT-Early, which offers oral insulin to children between 6 months and 2 years old; results are expected sometime next year. An oral insulin prevention study by TrialNet, in people with autoantibodies, will be reported in June. Herold hopes to report data in the near future on a study of an antibody called anti-CD3; he has tested it in newly diagnosed patients and is now trying it as a preventive." (Couzin-Frankel, 2017)

Conclusion

"Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action or both" (Bruno, Merletti, et al, 1990). There is no known cure for diabetes mellitus. The new classification system

more accurately reflects improved understanding of the etiology and pathophysiology of this disease.

The four etiologic classifications are:

1) Type 1 diabetes mellitus
2) Type 2 diabetes mellitus
3) Other specific types
4) Gestational diabetes mellitus

The new upper limit of “normal” blood sugar level (100 mg/dL) is based on the level at which micro and macrovascular complications may arise. The provisional diagnostic fasting blood glucose level of ≥ 126mg/dL was determined in order to standardize results from different blood glucose testing methods.

Prevention efforts should be directed toward educating the general public as to risk factors associated with diabetes mellitus. Treatment goals are achieving metabolic control and preventing/minimizing complications.

Treatment may include diet and exercise modification, insulin and/or oral hypoglycemic drug therapy and professional monitoring of the disease by a variety of health care providers. Complications of diabetes mellitus can affect the eyes, kidneys, cardiovascular system, nervous system, and oral cavity. Acute complications of this disease are hypoglycemia and hyperglycemia (diabetic ketoacidosis, hyperglycemic hyperosmolar nonketotic syndrome).

Dental professionals should be aware of the etiology and pathogenesis of diabetes mellitus. Many individuals seen in the dental office are undiagnosed diabetics and may present with oral conditions indicating metabolic disturbance. The most common dental complication associated with diabetes is periodontal disease. Thorough health history taking and oral assessment is necessary to identify and manage diabetic individuals. The dental profession has an important role in helping diabetics control their disease. Dental visits provide an opportunity to educate the patient about maintaining oral health and overall diabetes management.

Diabetic emergencies occur during dental visits. Appropriate scheduling and treatment planning can help reduce the incidence of these emergencies. Communicating often with the patient, the patient’s physician and other professionals involved in diabetes management can be reassuring to both patient and practitioner. A clear understanding of the patient’s current therapeutic regimen and blood glucose level will allow the dental practitioner to respond quickly and accurately in an emergency situation.

Ultimately it is the responsibility of the patient to manage their diabetes. Dental professionals, who are knowledgeable about potential risk factors, complications and treatment modalities, are a valuable resource to the patient and the community.

Glossary

A1c Test (Glycosylated hemoglobin) A blood test that measures a person's average blood glucose (sugar) level for the 2- to 3-month period before the test.

Acute Happens for a limited period of time; abrupt onset; sharp, severe.

Adrenal Glands Two organs that sit on top of the kidneys and make and release hormones such as adrenaline (epinephrine). This and other hormones, including insulin, control the body's use of glucose (sugar).

Adrenocorticotropic Hormone Promote and maintains normal growth. Stimulates adrenal cortex to increase secretion of glucocorticoids. Increases blood glucose level.

Alpha Cell A type of cell in the pancreas (in areas called the islets of Langerhans). Alpha cells make and release a hormone called glucagon, which raises the level of glucose (sugar) in the blood.

Arteriosclerosis A group of diseases in which the walls of the arteries get thick and hard. In one type of arteriosclerosis, fat builds up inside the walls and slows the blood flow. These diseases often occur in people who have had diabetes for a long time.

Atherosclerosis One of many diseases in which fat builds up in the large- and medium- sized arteries. This buildup of fat may slow down or stop blood flow. This disease can happen to people who have had diabetes for a long time.

Autoantibodies The immune system makes an antibody against a normal body substance.

Autoimmune Disease Disorder of the body's immune system in which the immune system mistakenly attacks and destroys body tissue that it believes to be foreign. Insulin-dependent diabetes is an autoimmune disease because the immune system attacks and destroys the insulin-producing beta cells.

Autonomic Self-governing, independent

Autonomic Neuropathy A disease of the nerves affecting mostly the internal organs such as the bladder muscles, the cardiovascular system, the digestive tract, and the genital organs. These nerves are not under a person's conscious control and function automatically. Also called visceral neuropathy.

Background Retinopathy Early stage of diabetic retinopathy; usually does not impair vision. Also called "nonproliferative retinopathy."

Beta Cell A type of cell in the pancreas in areas called the islets of Langerhans. Beta cells make and release insulin, a hormone that controls the level of glucose (sugar) in the blood.

Blood Glucose The main sugar that the body makes from the three elements of food-proteins, fats, and carbohydrates-but mostly from carbohydrates. Glucose is the major source of energy for living cells and is carried to each cell through the bloodstream. However, the cells cannot use glucose without the help of insulin.

Blood Glucose Meter A machine that helps test how much glucose (sugar) is in the blood. A specially coated strip containing a fresh sample of blood is inserted in a machine, when then calculates the correct level of glucose in the blood sample and shows the result in a digital display. Some meters have a memory that can store results from multiple tests.

Borderline Diabetes A term no longer used. See: Pre diabetes and Impaired glucose tolerance.

Candidiasis Fungous infection caused by Candida albicans most commonly affecting the mucous membranes of the mouth, gastrointestinal tract and vagina.

C.D.E. (Certified Diabetes Educator) A health care professional who is qualified by the American Association of Diabetes Educators to teach people with diabetes how to manage their condition. The health care team for diabetes should include a diabetes educator, preferably a C.D.E.

Cataract Clouding of the lens of the eye. In people with diabetes, this condition is sometimes referred to as "sugar cataract."

Cerebrovascular Disease Damage to the blood vessels in the brain, resulting in a stroke. The blood vessels become blocked because of fat deposits or they become thick and hard, blocking the flow of blood to the brain. Sometimes, the blood vessels may burst, resulting in a hemorrhagic stroke. People with diabetes are at higher risk of cerebrovascular disease.

Chronic Present over a long period of time. Diabetes is an example of chronic disease.

Clotrimazole An antifungal agent used to treat candidiasis. Considered to be fungistatic.

Contraindication A condition that makes a treatment not helpful or even harmful.

Conventional Therapy A system of diabetes management practiced by most people with diabetes; the system consists of one or two insulin injections each day, daily self-monitoring of blood glucose, and a standard program of nutrition and exercise. The main objective in this form of treatment is to avoid very high and very low blood glucose (sugar).

Coronary Disease Damage to the heart. Not enough blood flows through the vessels because they are blocked with fat or have become thick and hard; this harms the muscles of the heart. People with diabetes are at a higher risk of coronary disease.

Coxsackie B4 Virus An agent that has been shown to damage the beta cells of the pancreas in lab tests. This virus may be one cause of Type 1 diabetes.

Creatinine A chemical found in the blood and passed in the urine. A test of the amount of creatinine in blood or in blood and urine shows if the kidney is working right or if it is diseased.

Crevicular Fluid A fluid secreted from the connective tissue through the epithelial lining of the sulcus or pocket. Amount increases with inflammation and is considered to be part of the host defense system.

Dextrose A simple sugar found in the blood. It is the body's main source of energy. Also called glucose.

Diabetes Control and Complications Trial (DCCT) A 10-year study (1983-1993) funded by the National Institute of Diabetes and Digestive and Kidney Diseases to assess the effects of intensive therapy on the long-term complications of diabetes.

Diabetes Insipidus A disease of the pituitary gland or kidney, not diabetes mellitus. Diabetes insipidus is often called "water diabetes" to set it apart from "sugar diabetes." The cause and treatment are not the same as for diabetes mellitus.

Diabetic Coma A severe emergency in which a person is not conscious because the blood glucose (sugar) is too low or too high.

Diabetic Ketoacidosis (DKA) Severe, out-of-control diabetes (high blood sugar) that needs emergency treatment.

Diabetic Retinopathy A disease of the small blood vessels of the retina of the eye. When retinopathy first starts, the tiny blood vessels in the retina become swollen, and they leak a little fluid into the center of the retina. The person's sight may be blurred. This condition is called background retinopathy.

Dietitian An expert in nutrition who helps people with special health needs plan the kinds and amounts of foods to eat. A registered dietitian (R.D.) has special

qualifications.

Doxycycline an antibiotic, tetracycline's.

Endocrinologist A doctor who treats people who have problems with their endocrine glands. Diabetes is an endocrine disorder.

End-Stage Renal Disease (ESRD) The final phase of kidney disease; treated by dialysis or kidney transplantation.

Epidemiology The study of a disease that deals with how many people have it, where they are, how many new cases develop, and how to control the disease.

Epinephrine One of the secretions of the adrenal glands. It helps the liver release glucose (sugar) and limit the release of insulin. It also makes the heart beat faster and can raise blood pressure; also called adrenaline.

Erosive Lichen Planus Usually appears on the cheek. Single or multiple lesions that look like a superficial ulcer surrounded by white lines.

Etiology The study of what causes a disease; also the cause or causes of a certain disease.

Fatty Acids A basic unit of fat. When insulin levels are too low or there is not enough glucose (sugar) to use for energy, the body burns fatty acids for energy. The body then makes ketone bodies, waste products that cause the acid level in the blood to become too high. This in turn may lead to ketoacidosis.

Focal and Grand Mal Seizures Commonly experienced by persons with chronic neurologic disorders. Involves part or all of the brain. Focal seizures do not necessarily result in impaired consciousness. Grand Mal seizures the person does experience a lack of consciousness.

Gestational Diabetes Mellitus (GDM) A type of diabetes mellitus that can occur when a woman is pregnant. In the second half of the pregnancy, the woman may have glucose (sugar) in the blood at a higher than normal level. However, when the pregnancy ends, the blood glucose levels return to normal in about 95 percent of all cases.

Glaucoma An eye disease associated with increased pressure within the eye. Glaucoma can damage the optic nerve and cause impaired vision and blindness.

Glomerular Filtration Rate Measure of the kidneys' ability to filter and remove waste products.

Glomeruli Network of tiny blood vessels in the kidneys where the blood is filtered and waste products are removed.

Glomerular Basement Membrane One of four layers composing glomerular capillaries, the basement membrane is composed of proteins and is negatively charged.

Glucagon A hormone that raises the level of glucose (sugar) in the blood. The alpha cells of the pancreas (in areas called the islets of Langerhans) make glucagon when the body needs to put more sugar into the blood. An injectable form of glucagon, which can be bought in a drug store, is sometimes used to treat insulin shock. The glucagon is injected and quickly raises blood glucose levels. See also: Alpha cell.

Glucocorticoids Hormones that influence food metabolism; secreted by the adrenal cortex. Raise blood glucose level.

Gluconeogenesis Formation of new glucose from proteins and fats. Chiefly occurs in the liver

Glucose A simple sugar found in the blood. It is the body's main source of energy; also known as dextrose.

Glucose Tolerance Test A test to see if a person has diabetes. The test is given in a lab or doctor's office in the morning before the person has eaten. A first sample of blood is taken from the person. Then the person drinks a liquid that has glucose (sugar) in it. After one hour, a second blood sample is drawn, and, after another hour, a third sample is taken. The object is to see how well the body deals with the glucose in the blood over time.

Glycemic Response The effect of different foods on blood glucose (sugar) levels over a period of time.

Glycogen A substance made up of sugars. It is stored in the liver and muscles and releases glucose (sugar) into the blood when needed by cells. Glycogen is the chief source of stored fuel in the body.

Glycogenesis The process by which glycogen is formed from glucose.

Glycogenelysis The breakdown of glycogen. In the liver this process results in free glucose that leaves the cell and enters the blood stream raising blood glucose levels.

Glycolysis Breakdown of glucose into pyruvic acid. Method of providing cells with energy when cellular oxygen levels are low or absent.

Glycosuria Having glucose (sugar) in the urine.

Hemoglobin A1C (A1c) The substance of red blood cells that carries oxygen to the cells and sometimes joins with glucose (sugar). Because the glucose stays attached for the life of the cell (about 2-3 months), a test to measure hemoglobin A1C shows what the person's average blood glucose level was for that period of time.

Hormone A chemical released by special cells to tell other cells what to do. For instance, insulin is a hormone made by the beta cells in the pancreas. When released, insulin tells other cells to use glucose (sugar) for energy.

Human Insulin Man-made insulins that are similar to insulin produced by your own body. Human insulin has been available since October 1982.

Hyperglycemia Too high a level of glucose (sugar) in the blood; a sign that diabetes is out of control. Many things can cause hyperglycemia. It occurs when the body does not have enough insulin or cannot use the insulin it does have to turn glucose into energy.

Hyperinsulinism Too high a level of insulin in the blood. This term most often refers to a condition in which the body produces too much insulin.

Hyperlipidemia Too high a level of fats (lipids) in the blood.

Hyperglycemic Hyperosmolar Syndrome A syndrome related to high levels of glucose (sugar) in the blood and requiring emergency treatment. The person may or may not have a previous history of diabetes. Ketones (acids) are usually not present in the urine.

Hypoglycemia Too low a level of glucose (sugar) in the blood. This occurs when a person with diabetes has injected too much insulin, eaten too little food, or has exercised without extra food.

Hypotension Low blood pressure or a sudden drop in blood pressure Idiopathic Cause is unknown.

Impaired Glucose Tolerance (IGT) Blood glucose (sugar) levels higher than normal but not high enough to be called diabetes. Also called pre diabetes

Incidence How often a disease occurs; the number of new cases of a disease among a certain group of people for a certain period of time.

Injection Putting liquid into the body with a needle and syringe. A person with diabetes injects insulin by putting the needle into the tissue under the skin (called subcutaneous). Other ways of giving medicine or nourishment by injection are to put the needle into a vein (intravenous) or into a muscle (intramuscular).

Insulin A hormone that helps the body use glucose (sugar) for energy. The beta cells of

the pancreas (in areas called the islets of Langerhans) make the insulin.

Insulin Reaction Too low a level of glucose (sugar) in the blood; also called hypoglycemia. This occurs when a person with diabetes has injected too much insulin, eaten too little food, or exercised without extra food.

Insulin Receptors Areas on the outer part of a cell that allow the cell to join or bind with insulin that is in the blood. When the cell and insulin bind together, the cell can take glucose (sugar) from the blood and use it for energy.

Insulin Resistance Many people with Type 2 produce enough insulin, but their bodies do not respond to the action of insulin. This may happen because the person is overweight and has too many fat cells, as people age, their body cells lose some of the ability to respond to insulin. Insulin resistance is also linked to high blood pressure and high levels of fat in the blood.

Insulin Shock A severe condition that occurs when the level of blood glucose (sugar) drops quickly.

Intensive Management A form of treatment for insulin-dependent diabetes in which the main objective is to keep blood glucose (sugar) levels as close to the normal range as possible.

Islets of Langerhans Special groups of cells in the pancreas. They make and secrete hormones that help the body break down and use food. Named after Paul Langerhans, the German scientist who discovered them.

Ketone Bodies Chemicals that the body makes when there is not enough insulin in the blood and it must break down fat for its energy.

Ketonuria Having ketone bodies in the urine; a warning sign of diabetic ketoacidosis (DKA).

Ketosis A condition of having ketone bodies build up in body tissues and fluids. The signs of ketosis are nausea, vomiting, and stomach pain. Ketosis can lead to ketoacidosis.

Kussmaul Breathing The rapid, deep, and labored breathing of people who have ketoacidosis or who are in a diabetic coma. Kussmaul breathing is named for Adolph Kussmaul, the 19th century German doctor who first noted it. Also called "air hunger."

Lancet A fine, sharp-pointed blade or needle for pricking the skin.

Macrosomia Abnormally large; in diabetes, refers to abnormally large babies that may be born to women with diabetes.

Macrovascular Disease A disease of the large blood vessels that sometimes occurs when a person has had diabetes for a long time.

Macular Edema A swelling (edema) in the macula, an area near the center of the retina of the eye that is responsible for fine or reading vision.

Metformin A drug currently being tested as a treatment for noninsulin-dependent diabetes; belongs to a class of drugs called biguanides.

Mg/dL Milligrams per deciliter. Term used to describe how much glucose (sugar) is in a specific amount of blood.

Microvascular Disease Disease of the smallest blood vessels that may occur when a person has had diabetes for a long time.

Mixed Dose Combining two kinds of insulin in one injection. A mixed dose commonly combines regular insulin, which is fast acting, with longer acting insulin such as NPH.

Morbidity Rate The sickness rate; the number of people who are sick or have a disease compared with the number who are well.

Mortality Rate The death rate; the number of people who die of a certain disease compared with the total number of people.

National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) One of

the 17 institutes that make up the National Institutes of Health, an agency of the Public Health Service.

Nephrologist A doctor who sees and treats people with kidney diseases.

Nephropathy Disease of the kidneys caused by damage to the small blood vessels or to the units in the kidneys that clean the blood.

Neurologist A doctor who sees and treats people with problems of the nervous system.

Neuropathy Disease of the nervous system.

Nonketotic Coma A type of coma caused by a lack of insulin.

NPH Insulin A type of insulin that is intermediate-acting.

Nystatin an antifungal drug.

Obesity When people have 20 percent (or more) extra body fat for their age, height, sex, and bone structure.

Oral Hypoglycemic Agents Pills or capsules that people take to lower the level of glucose (sugar) in the blood.

Pancreas An organ behind the lower part of the stomach that is about the size of a hand. It makes insulin and enzymes that help the body digest food.

Peak Action The time period when the effect of something is as strong as it can be such as when insulin in having the most effect on lowering the glucose (sugar) in the blood.

Periodontal Disease Chronic inflammatory condition characterized by loss of connective tissue, alveolar bone and the formation of pockets around diseased teeth.

Peripheral Neuropathy Nerve damage, usually affecting the feet and legs; causing pain, numbness, or a tingling feeling. Also called "somatic neuropathy" or "distal sensory polyneuropathy."

Peripheral Vascular Disease (PVD) Disease in the large blood vessels of the arms, legs, and feet.

Pima Indians of Arizona Pronounced “pee’-muh.” Reside with the Maricopa Indians on reservations near Phoenix, Arizona. (joint population ~16,1980). Linguistically related to the Papago Indians. Pima have the highest prevalence of Type 2 diabetes in the world.

Pituitary Gland An endocrine gland in the small, bony cavity at the base of the brain.

Polymorphonuclear leukocytes (PMNs) Also known as neutrophils. First white blood cells to appear after an injury. PMNs ingest and destroy agents, which cause disease.

Polydipsia A great thirst that lasts for long periods of time; a sign of diabetes.

Polyphagia Great hunger; a sign of diabetes. People with this great hunger often lose weight.

Polyuria Having to urinate often; a common sign of diabetes.

Postprandial Blood Glucose Blood taken 1-2 hours after eating to see the amount of glucose (sugar) in the blood.

Prevalence The number of people in a given group or population who are reported to have a disease.

Proliferative Retinopathy A disease of the small blood vessels of the retina of the eye.

Receptors Areas on the outer part of a cell that allow the cell to join or bind with insulin

that is in the blood.

Regular Insulin A type of insulin that is fast acting.

Renal A term that means having something to do with the kidneys.

Retina The center part of the back lining of the eye that senses light. It has many small blood vessels that are sometimes harmed when a person has had diabetes for a long time.

Retinopathy A disease of the small blood vessels in the retina of the eye.

Risk Factor Anything that raises the chance that a person will get a disease.

Self-Monitoring of Blood Glucose A way as person can test how much glucose (sugar) is in the blood. Also called home blood glucose monitoring.

Sialorrhea excessive drooling.

Sialosis painless enlargement of the parotid gland.

Split Dose Division of a prescribed daily dose of insulin into two or more injections given over the course of a day.

Sulfonylureas Pills or capsules that people take to lower the level of glucose (sugar) in the blood. See Oral hypoglycemic agents.

Symptom A sign of disease.

Syndrome A set of signs or a series of events occurring together that makes up a disease or health problem.

Syringe A device used to inject medications or other liquids into body tissues

Systemic A word used to describe conditions that affect the entire body

Tetracycline a broad-spectrum antibiotic.

Type 1 Diabetes Mellitus A chronic condition in which the pancreas makes no insulin because the beta cells have been destroyed. The body is then not able to use the glucose (blood sugar) for energy. Previous names for this condition include: “Insulin dependent diabetes mellitus,” "juvenile diabetes," "juvenile-onset diabetes," and "ketosis-prone diabetes, and “type I diabetes mellitus.”

Type 2 Diabetes Mellitus People with Type 2 diabetes produce some insulin, sometimes even large amounts. However, either their bodies do not produce

enough insulin or their body cells are resistant to the action of insulin. Previously used names for this condition include: "Noninsulin-dependent diabetes mellitus, "adult-onset diabetes," "maturity-onset diabetes," "ketosis-resistant diabetes," and "stable diabetes," and "type II diabetes mellitus."

Uncontrolled Diabetic Uncontrolled diabetes is a non-specific diagnosis, which indicates that the patient's blood sugar level is not kept within acceptable levels by his or her current treatment routine. In this report, this indicator only includes hospitalizations of patients whose principal diagnosis did not include a specified short-term complication of diabetes. It is unclear whether poor blood sugar control arises from poor quality medical care, non-compliance of patients, lack of education, or access to care problems.

Unit of Insulin The basic measure of insulin.

Urine Testing Checking urine to see if it contains glucose (sugar) and ketones

Vitrectomy Removing the gel from the center of the eyeball because it has blood and scar tissue in it that blocks sight. An eye surgeon replaces the clouded gel with a clear fluid.

Vitreous Humor The clear jelly (gel) that fills the center of the eye.

Xerostomia Dry mouth

References for Glossary

- Anthony, C.P., Thibodeau, G.A. & Prezbindowski, K.S. (1979). *Textbook of Anatomy and Physiology*. St. Louis, MO: C.V. Mosby Company.
- Bhaskar, S.N. (1981). *Synopsis of Oral Pathology* (6th ed.). St. Louis, MO: C.V. Mosby Company.
- *Grolier's Interactive Encyclopedia*. from http://www.grolier.com
- Löe, H. (1993). *Periodontal disease; The sixth complication of diabetes mellitus.*
- *Diabetes Care*, 16 (1), 332-334.
- National Institute of Diabetes and Digestive and Kidney Disease of the National Institutes of Health. (1994). *Diabetes dictionary*. Retrieved June 2017, from http://www.nih.gov
- Siegel, J. (1994). Diabetes mellitus. In L.C. Copestead (Ed.), *Perspectives on Pathophysiology*. Philadelphia, PA: W.B. Saunders Company, 826-845.
- Wilkins, E.M. (1982). *The Gingiva. In Clinical Practice of the Dental Hygienist* (5th ed.)

- Philadelphia, PA: Lea & Febiger.
  http://www.pharminfo.com/drugdg/db_mnu.html
  http://www.radiology.creighton.edu/Board%20review%20Notes%20Folder/sub-neuro- sub-salivary-text

Appendix A Diabetes Monitor

A1c and similar diabetes tests

Since the 1970's, diabetes researchers have developed several new laboratory tests that help in the evaluation of your blood sugar level. These tests are named A1c and fructosamine (fruk-TOES-ah-meen), and glycosylated protein (gly-COS-el-lay-ted PRO-teen). These tests are not substitutes for checking your blood sugar level at home. Your home blood sugar monitoring measures your blood sugar level at the very moment that the sample is obtained. These new tests give different information about your health, and add a new dimension to our ability to evaluate diabetes.

A1c: The A1c test was developed in the late 1970's. Other names that have been used to describe the same test are glycosylated hemoglobin, and hemoglobin A1c. This test gives information about your average blood sugar level during the past two or three months. The normal values for this test vary depending upon the lab, and you must look at the "normal range" or "reference range" that the lab uses to make sense of your result.1 If your A1c value is higher than the normal range, then we know that your average blood sugar has been elevated during the past two months. More importantly, if your recent A1c is lower than your previous value, then we know that you are now doing better than before!

Fructosamine: The fructosamine test has been developed more recently. Fructosamine is a term referring to the linking of blood sugar onto protein molecules in the bloodstream. Fructosamine levels have been shown to change more rapidly than glycohemoglobin. Your fructosamine value depends upon your average blood sugar level during the past three weeks. Therefore, it might be able to detect changes in diabetic control earlier than the glycohemoglobin.

The fructosamine test could be viewed as complementary to the glycohemoglobin, since the two tests are different reflections of diabetes control: glycohemoglobin looks back approximately eight weeks, and the fructosamine test looks back about three weeks.

Other tests: Other tests similar to the fructosamine test have been proposed; the glycosylated protein test is an example of another test that was suggested. Unfortunately, these newer tests are less reliable than originally hoped, and seems

unlikely that either the fructosamine test or the glycosylated protein test will ever become as widely used for monitoring diabetes as the glycohemoglobin level.

What to do: Therefore, to evaluate your diabetes control, you should arrange to get a A1c level measured approximately every three months. By using this test, together with your home blood sugar monitoring, you and your health care team will have a much better idea about how your diabetes is doing.

A1C laboratory tests are now standardized. In the past, the A1C test was not recommended for diagnosis of type 2 diabetes and prediabetes because the many different types of A1C tests could give varied results. The accuracy has been improved by the National Glycohemoglobin Standardization Program (NGSP), which developed standards for the A1C tests.

Appendix B Estimated Percentage of Adults with Diagnosed Diabetes, by Age and State, United States, data from 2014. Accessed June 2017:

Taken from: http://www.kff.org/other/state-indicator/adults-with-diabetes-by-age/

For Charts from website www.kff.org/other/state-indicator/adults-with-diabetes-by-age/ :

Location	Ages 18-44	Ages 45-64	Ages 65-74	Ages 75+	(Age-Adjusted)
United States [1]	**2.8%**	**13.2%**	**22.2%**	**21.2%**	**9.1%**
Alabama	4.8%	17.8%	24.2%	21.0%	11.8%
Alaska	1.8%	10.3%	21.3%	21.0%	7.6%
Arizona	2.8%	14.0%	21.7%	18.7%	9.1%
Arkansas	3.9%	17.9%	24.7%	22.7%	11.5%
California	2.9%	15.4%	21.5%	22.5%	9.9%
Colorado	2.2%	9.9%	16.2%	17.0%	6.9%
Connecticut	2.1%	11.5%	20.9%	20.0%	8.0%
Delaware	3.5%	13.2%	25.7%	20.5%	9.7%
District of Columbia	NR	14.8%	19.8%	24.4%	9.1%
Florida	2.9%	13.9%	22.7%	20.9%	9.4%
Georgia	2.8%	17.2%	26.7%	24.5%	11.0%
Hawaii	3.7%	12.8%	18.4%	18.4%	8.9%
Idaho	2.0%	10.0%	16.9%	18.3%	7.0%

Location	Ages 18-44	Ages 45-64	Ages 65-74	Ages 75+	(Age-Adjusted)
Illinois	2.4%	13.6%	23.5%	23.8%	9.4%
Indiana	3.1%	14.2%	22.2%	22.9%	9.7%
Iowa	2.6%	11.5%	22.1%	19.0%	8.3%
Kansas	3.0%	13.8%	22.2%	21.7%	9.5%
Kentucky	4.5%	16.1%	25.5%	22.9%	11.3%
Louisiana	3.0%	15.2%	27.1%	23.0%	10.4%
Maine	2.3%	11.6%	19.3%	17.1%	7.8%
Maryland	2.5%	13.2%	24.4%	21.1%	9.2%
Massachusetts	3.4%	11.6%	22.4%	19.0%	8.8%
Michigan	2.0%	13.1%	25.1%	21.8%	9.0%
Minnesota	2.4%	9.2%	18.3%	22.6%	7.5%
Nebraska	2.6%	12.7%	19.9%	17.4%	8.4%
Nevada	2.4%	11.8%	24.4%	22.7%	8.8%
New Hampshire	2.3%	11.1%	19.4%	19.4%	7.8%
New Jersey	2.6%	10.9%	24.2%	22.7%	8.6%
New Mexico	3.4%	15.3%	24.8%	22.9%	10.4%
New York	2.7%	13.0%	21.8%	23.8%	9.2%
North Carolina	3.2%	15.0%	22.0%	20.8%	9.8%
North Dakota	2.6%	11.3%	20.4%	17.4%	8.0%
Ohio	3.0%	15.5%	25.1%	22.6%	10.3%
Oklahoma	2.7%	18.0%	25.4%	22.3%	10.9%
Oregon	2.6%	10.4%	20.4%	20.9%	8.0%
Pennsylvania	2.6%	14.6%	23.5%	22.1%	9.6%
Rhode Island	2.0%	12.1%	21.8%	20.4%	8.3%
South Carolina	3.6%	16.1%	24.7%	22.2%	10.7%

South Dakota	2.9%	11.4%	18.9%	19.4%	8.2%
Tennessee	4.1%	17.8%	27.1%	21.5%	11.7%
Texas	3.2%	16.2%	26.9%	22.4%	10.8%
Utah	2.2%	10.5%	19.2%	19.7%	7.7%
Vermont	3.1%	8.3%	15.7%	17.6%	6.9%
Virginia	2.3%	12.5%	24.3%	22.4%	9.0%
Washington	2.5%	12.3%	18.9%	18.2%	8.2%
West Virginia	4.2%	17.9%	28.3%	23.5%	12.0%
Wisconsin	2.3%	11.0%	19.3%	21.2%	8.0%
Wyoming	3.1%	10.3%	17.6%	18.2%	7.8%
Guam	4.4%	17.6%	25.9%	21.2%	11.6%
Puerto Rico	3.5%	20.4%	35.6%	37.9%	14.2%
Virgin Islands	N/A	N/A	N/A	N/A	N/A

NOTES

State data based upon the BRFSS, an ongoing, state-based, random-digit-dialed telephone survey of noninstitutionalized civilian adults aged 18 years and older. Women who indicated that they had diabetes only during pregnancy were not included in these data.

Total adults diagnosed with diabetes by state have been age-adjusted to the U.S. population in 2000.

Sources

Centers for Disease Control and Prevention (CDC) National Diabetes Surveillance System Diabetes Atlas, accessed September 2016. Statistical analysis by CDC; data from the National Health Interview Survey (NHIS).

References

American Diabetes Association. www.diabetes.org/diabetes-basics/statistics. Accessed May 2017

American Diabetes Association. *Diabetes Care* 2016 Jan; 39(Supplement 1): S13-S22. https://doi.org/10.2337/dc16-S005. Accessed May 2017

American Diabetes Association. (1986). Nutritional recommendations and principles for individuals with diabetes mellitus. *Diabetes Care*. 10 (1), 126-32.

American Diabetes Association. *Genetics of diabetes*. Retrieved June 2017 from http://www.diabetes.org/c50e.html

American Diabetes Association. How lab tests show you have diabetes. *Diabetes Info*. Retrieved June 2017, from http://www.diabetes.org/ada/c20e.html

American Diabetes Association Clinical practice recommendations: Self- monitoring of blood glucose. *Diabetes Care*. S (62). Retrieved June 2017, from http://www.diabetes.org/DiabetesCare/Supplement/s62.htm.

American Diabetes Association*. Diabetes facts and figures*. Retrieved June 207, from http://www.diabetes.org/c20f.html

American Diabetes Association. *Making a difference; Type I diabetes research.* Retrieved June 2017, from http://www.diabetes.org/ada/restypl.html

American Diabetes Association. New recommendations to lower the diabetes diagnosis point. *Diabetes Care*. Retrieved June 2017, from http://www.diabetes.org/ada/mwclass.htm

American Diabetes Association. Oral diabetes medications. *Diabetes Info*. Retrieved June 2017, from http://www.diabetes.org/ada/c30c.html

American Diabetes Association. (2004). Clinical Practice Recommendations. Standards of medical care for patients with diabetes mellitus. *Diabetes Care.* 27(Sl), S15.

American Diabetes Association Clinical Practice Recommendations. (2004). Diagnosis and Classification of Diabetes Mellitus*. Diabetes Care*, 26 (S5). Retrieved June 2017, from http://www.diabetes.org/diabetescare/

American Diabetes Association Clinical Practice Recommendations. (2004). Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care*. 26(Sl), S5.

American Association of Diabetes Educators. (2003). A Core Curriculum for Diabetes Education (5th ed.). Chicago: AADE.

American Diabetes Treatment Centers of America. (1996). *Oral hypoglycemic maximum doses.* Diabetes Disease Management System. Diabetes Treatment Centers of America. Knoxville. Tennessee.

American Diabetes Association: Statistics about Diabetes. 2013. Last Edited: April 5, 2017 www.diabetes.org/diabetes-basics/statistics/#sthash.tqULootJ.dpuf Accessed June 2017

Anil, B.D.S., Remani, P., Vijayakumar, T., Hari, S. & Trivandrum, K.S. (1990). Cell-mediated and humoral immune responses in diabetic patients with periodontitis. *Oral Surgery Oral Medicine Oral Pathology*. 70, 44-48.

Anthony, C.P., Thibodeau, G.A. & Prezbindowski, K.S. (1979). Metabolism. *Textbook of Anatomy and Physiology*. St. Louis, MO: C.V. Mosby Company, 506-537.

Bell, G.I. *Molecular genetics of diabetes mellitus*. Retrieved June 2017, from http://www.hhmi.org/science/genetics/bell.htm

Bressler, R. & Johnson, D.G. (1997) Pharmacological regulation of blood glucose levels in non-insulin dependent diabetes mellitus. *Archives of Internal Medicine*. 157, 836-848.

Bruno, G., Merletti, F., Pisu, E., Pastore, G., Marengo, C. & Pagano, G. (1990). Incidence of IDDM during 1984-1986 in population aged less than 30 yr. Residents of Turin, Italy. *Diabetes Care*. 13 (10), 1051-1056.

Cherry-Pepper, G., Sorkin, J., Andres, R, Baum, B.J. and Ship, A. (1992). Salivary gland function and glucose metabolic status. *Journal of Gerontology: Medical Sciences*. 47 (4), M130-M134.

Centers for Disease Control and Prevention. *Cancer Prevention and Control: Diabetes*.2017; www.cdc.gov/diabetes/data/center/slides.html Accessed May 2017.

Cruickshanks, K.J., Jobim, L. F. & Lawler-Heavener, J. (1994). Ethnic differences in human leukocyte antigen markers of susceptibility to IDDM. *Diabetes Care*.17, 132-137.

Darwazeh, A.M.G., MacFarlan, T.W., McCuish, A. & Lamey, P.J. (1991). Mixed salivary glucose levels and candidal carriage in patients with diabetes mellitus. *Journal of Oral Pathology Medicine*. 20, 280-283.

Diabetes Control and Complications Trial. (1993). *New England Journal of Medicine*. 329, 977-86.

Diabetes in Control: News and Information for Medical Professionals. Jan 23, 2016. Accessed May 2017: www.diabetesincontrol.com/b-cell-centric-classification-of-diabetes/

Dorman, J.S., McCarthy, B.J., O'Leary, L.A. and Koehler, A.N. (1995). Risk factors for insulin dependent diabetes. In Diabetes in America (2nd ed., pp.165-178). National Institutes of Health. [On-line] Retrieved June 2017, http://diabetes-in-america.s-3.com/contents.htm.

Eisenbarth, G.S. (1986). Type I diabetes mellitus; A chronic autoimmune disease. *New England Journal of Medicine*. 314 (21), 1360-1368.

Eli Lilly and Company. (1995*). Blood sugar testing in Managing Your Diabetes*. Eli Lilly and Company. Indianapolis, Indiana, 59-66.

The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. (1997). Report of the expert committee on the diagnosis and classification of diabetes mellitus. *Diabetes Care*. 20 (7), 1193-1197.

FDA clears first glycated protein self-test for diabetes. Doctor's Guide to Medical and Other News. Retrieved June 2017, from http://www.pslgroup.com/dg/2ce42.htm

Frantzis, T.G., Reeve, C.M. and Brown, A.L. (1973). The ultrastructure of capillary basement membranes in the attached gingiva of diabetic and nondiabetic patients with periodontal disease. *Journal of Periodontology*. 42 (7), 406-411.

Gibson, J., Lamey, P.J., Lewis, M. & Frier, B. (1990). Oral manifestations of previously undiagnosed non-insulin dependent diabetes mellitus. *Journal of Oral Pathology Medicine.* 19, 284-287.

Harris, M.I. (1995). Summary. In Diabetes in America (2nd ed.). *National Institutes of Health*. Retrieved June 2017, from http://diabetes-in-america.s-1.com/contents.htm

Hoehns, B., Skelly, K. and Graber, M.A. (1997). Hematologic, electrolyte and metabolic disorders; Hyperglycemic-hyperosmolar nonketotic syndrome. *University of Iowa Family Practice Handbook*. Retrieved June 2017, from http://www.vh.org/Providers/ClinRef/FPHandbook/05.html

Holdren, R.S. & Patton, L.L. (1993). Oral conditions associated with diabetes mellitus. *Diabetes Spectrum*. 6 (1), 11-17.

Katz, P.P., Wirthlin, M.R., Szpunar, S.M., Selby, J.V. Sepe, S. J. and Showstack, J.A. (1991). Epidemiology and prevention of periodontal disease in individuals with diabetes. *Diabetes Care*. 14 (5), 375-385.

Knott, J.H. *Discovery and treatment of diabetes*. Retrieved June 2017, from http://www.napplisci.com/diabhist.html

Löe, H. and Genco, R.J. (1995). Oral complications in diabetes. In Diabetes in America (2nd ed.). *National Institutes of Health*. Retrieved June 2017, from http://diabetes-in-america.s-1.com/contents.htm

Löe, H. (1993). Periodontal disease; The sixth complication of diabetes mellitus. *Diabetes Care*. 16 (1), 32-334.

Lundstrom, R.E., Mordes, J.P. & Rossini, A.A. (1997). Complications. The Healing Handbook for Persons with Diabetes. Retrieved June 2017, from http://www.ummed.edu/dept/diabetes/handbook/chap12.htm#BLOOD_VESSELS

Lundstrom, R.E., Mordes, J.P. & Rossini, A.A. (1997). *Monitoring. The Healing*

Handbook for Persons with Diabetes. Retrieved June 2017, from http://www.ummed.edu/dept/diabetes/handbook/chap05.htm

Healthline Online Resource. Diabetes Mine: *Tech Spotting at the ADA Scientific Sessions* 2015 Written by Amy Tenderich and Mike Hoskins. Published on June 10, 2015 www.healthline.com/diabetesmine/overview-ada-scientific-sessions-2015#1. Accessed June 2017

Lundstrom, R.E., Mordes, J.P. & Rossini, A.A. (1997). *Oral medications. The Healing Handbook for Persons with Diabetes*. Retrieved June 2017, from http://www.ummed.edu/dept/diabetes/handbook/chap09.htm#Questions_and_Ans wers

Lundstrom, R.E., Mordes, J.P. & Rossini, A.A. (1997). *What is diabetes. The Healing Handbook for Persons with Diabetes*. Retrieved June 2017, from http://www.ummed.edu/dept/diabetes/handbook/chap01.htm#TypesofDiabetes

Maffie-Lee, J. and Fitzgerald, M. (1995). Pharmacological update diabetes management*. Journal of the American Academy of Nurse Practitioners*. 7 (12), 598-604.

Medical Sciences Bulletin. (1996). Focus on insulin. *Medical Sciences Bulletin*. [electronic version].

Methodist Healthcare System. (1996). *Diabetes mellitus*. Retrieved June 2017, from http://www.methodisthealth.com/health/diabetes/mellitus.htm

Midwest Diabetes Care Center. (1996). Glycohemoglobin and similar diabetes tests. *Diabetes Monitor*. Retrieved June 2017, from http://www.mdcc.com/ghb.htm

National Institute of Diabetes and Digestive and Kidney Disease of the National Institutes of Health. (1995). *Diabetes statistics*. Retrieved June 2017, from http://www.niddk.nih.gov/health/diabetes/pubs/dmstats/dmstats.htm

National Institute of Diabetes and Digestive and Kidney Disease of the National Institutes of Health. (1997). *Insulin-Dependent Diabetes.* NIH Publication. Retrieved June 2017, from http://www.niddk.nih.gov/health/diabetes/pubs/iddm1/iddm.htm

O'Hanlon-Nichols, T. (1996). Hyperglycemic hyperosmolar nonketotic syndrome; How to recognize and manage this diabetic emergency. *American Journal of Nursing*. Retrieved June 2017, from http://www.ajn.org/ajn/1996/6.3/a603038e.html

Oliver, R.C. and Tellervo, T. (1993). Periodontitis and tooth loss; Comparing diabetics with the general population. *Journal of the American Dental Association*. 124, 71-76.

Patterson, Dan. (2005). *Dental Care Guidelines for the Diabetic. Family Gentle Dental Care.* Retrieved June 2017, from http://www.dentalgentlecare.com/dentalcare_for_diabetics.htm

Rees, T.D. (1994). The diabetic dental patient. *Dental Clinics of North America*. 38 (3), 447-463.

Research on genetics and diabetes. (1997). Retrieved June 2017, from http://www.ncgr.org/gpi/odyssey/diabetes/degnes.html

Research, Science and Therapy Committee of The American Academy of Periodontology. (1996). Position paper; Diabetes and periodontal diseases. *Journal of Periodontology*. 67, 166-176.

Rewers, M. & Hamman, R.F. (1995). Risk factors for non-insulin dependent diabetes. In Diabetes in America (2nd ed.). *National Institutes of Health*. Retrieved June 2017, from http://diabetes-in-america.s-3.com/contents.htm

Sciencemag.org Online Source. February 22, 2017. *An early signpost for type 1 diabetes?* Jennifer Couzin-Frankel. DOI: 10.1126/science.aal0814 www.sciencemag.org/news/2017/02/early-signpost-type-1-diabetes. Accessed June 2017

Shlossman, M., Knowler, W.C., Pettitt, D.J. and Genco, R. J. (1990). Type 2 diabetes mellitus and periodontal disease*. Journal of the American Dental Association*. 121, 532-536.

Siegel, J. (1994). Diabetes mellitus. In L.C. Copestead (Ed.). *Perspectives on Pathophysiology*. Philadelphia, PA: W.B. Saunders Company, 826-845.

University of Pennsylvania School of Medicine. Timing meals later at night can cause weight gain and impair fat metabolism: Findings provide first experimental evidence of prolonged delayed eating versus daytime eating, showing that delayed eating can also raise insulin, fasting glucose, cholesterol, and triglyceride levels. *ScienceDaily*. *ScienceDaily, 2* Accessed: June 2017. www.sciencedaily.com/releases/2017/06/170602143816.htm.

Zagaria, Mary Ann. (2003). Drug-Induced Diabetes Mellitus. U.S. *Pharmacist*. www.uspharmacist.com/index.asp?show=article&page=8_1161.htm Retrieved June 2017.

Course Test: Diabetes Mellitus: Pathophysiology and Clinical Guidelines

1. Diabetes Mellitus can best be described as:

    a. an endocrine disorder resulting from an inadequate production or impaired use of insulin.
    b. a metabolic disorder primarily characterized by loss of protein in the urine.
    c. an endocrine disorder always resulting in blindness, kidney failure, and cardiovascular disease.
    d. an infectious disease process for which there is no cure.

2. Which of the following groups is considered to have the least risk of developing Type 2 diabetes?

    a. African-Americans
    b. Native Americans
    c. Hispanics
    d. Caucasians

3. The current upper limit of “normal” blood glucose level was chosen because:

    a. it is the point where vascular complications begin.
    b. it was necessary to diagnose more individuals.
    c. tests are most accurate at this level.
    d. OGTT and IFT are easily compared at this level.

4. Urine tests are a good measure of blood glucose levels.

    a. true
    b. false

5. A definitive diagnosis of diabetes can be based on:

    a. symptoms and a family history of diabetes
    b. symptoms of diabetes, a positive family history and a single glucose test.
    c. a single oral glucose test in persons with a family history of any type of diabetes.
    d. two consecutive glucose tests on subsequent days duplicating a positive result.

6. Self-monitoring of blood glucose (SMBG) allows individuals to:

    a. treat infections.
    b. ascertain the presence of ketones in the urine.
    c. make changes in insulin/diet/exercise therapy.
    d. diagnose diabetes.

7. An A1c test is likely to be recommended because:

    a. it accurately measures blood glucose levels over the past several months.
    b. it accurately measures blood glucose levels over the past several weeks.
    c. it is available over the counter.
    d. it is inexpensive.

8. Microvascular damage and high blood glucose can impair the body's infection fighting ability

    a. true
    b. false

9. The most common cause of death among individuals diagnosed with diabetes mellitus is:

    a. kidney failure
    b. stroke
    c. gangrene
    d. cardiovascular disease

10. The most common oral complication of diabetes is:

    a. glossitis.
    b. angular chelitis.
    c. dental caries.
    d. periodontitis.

11. The severity of periodontal disease seen in diabetics is most likely attributed to:

    a. geographic location and decreased ability to find specialty care.
    b. reduced host response to microorganisms and decreased ability to fight infection.
    c. specific microflora only found in diabetics.
    d. xerostomia, candidiasis, and burning mouth syndrome.

12. Dental treatment for a controlled diabetic patient should be altered in the following way(s):

    a. no vasoconstrictors used.
    b. appointments should be longer allowing the diabetic individual to relax.
    c. be referred to a physician prior to any dental treatment.
    d. be treated the same as a nondiabetic patient for routine dental procedures.

13. It is better to schedule a diabetic's dental appointment during:

    a. the lactose intolerance phase.
    b. high glucose and low insulin activity.
    c. low glucose and high insulin activity.
    d. second phase of the insulin regimen.

14. Doxycycline is a good choice for a diabetic because:

    a. diabetics need extra vitamin C.
    b. it is metabolized in the kidneys and not in the liver.
    c. it is less expensive than tetracycline.
    d. It is metabolized in the liver and not in the kidneys.

15. The most common acute diabetic emergency in the dental office is:

    a. hypoglycemia.
    b. glucagon overdose.
    c. retinal dystrophy.
    d. kidney failure.

16. Which of the following is not a symptom of hypoglycemia?

    a. headache
    b. confusion
    c. moist skin
    d. ketone production

17. An extreme acute complication arising from chronic hyperglycemia is :

    a. kidney disease
    b. blindness.
    c. neuropathy.
    d. hyperglycemic hyperosmolar syndrome

18. Diabetic Ketoacidosis:

    a. is sudden in onset.
    b. is a likely presenting symptom of an undiagnosed Type 1 diabetic.
    c. results from an insulin overdose.
    d. cannot be prevented.

19. When a dental practitioner is unsure of whether a diabetic emergency is related to hypoglycemia or hyperglycemia the best action to take is to:

    a. consult with the patient's physician.
    b. follow the protocol for hypoglycemia.
    c. reappoint the patient.
    d. place patient in an upright position and apply cool cloth to their forehead.

20. High ketone levels in the urine can predict the onset of Hyperglycemic Hyperosmolar Nonketotic Coma.

    a. true
    b. false

21. Primary diabetic treatment goals are:

    a. controlling blood glucose levels and preventing complications with the disease.
    b. controlling blood glucose levels and improving diet and exercise regimen.
    c. controlling blood glucose levels and maintaining desirable body weight.
    d. nutrition counseling and exercise

22. The five most important factors related to maintaining good blood glucose control include:

    a. eye exams, genetic counseling, insulin, education and regular dental visits.
    b. high protein diet, dental visits, exercise, diabetes medication and education.
    c. insulin, hospitalization, eye exams and a low sugar diet.
    d. education, diet, exercise, pharmaceutical intervention, and professional monitoring.

23. Oral diabetes medications are prescribed for Type 1 diabetics because they can produce insulin but cannot use it correctly.

    a. true
    b. false

24. A diabetic needs to get baseline liver test if they take:

    a. sufonylureas.
    b. biguanides
    c. thiazolidinediones
    d. insulin.

25. According to Appendix B, Adults in California with the highest percent of diagnosed diabetes fell into what age group:

    a. 18-44
    b. 45-64
    c. 65-74
    d. 75 or older