DIABETES TYPES, DIAGNOSIS AND TREATMENT

DIABETES SERIES: PART I

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ABSTRACT

Current research has improved the medical knowledge and management of diabetes. Knowledge of the main and less common forms of diabetes mellitus, including associated risk factors, laboratory testing and screening, and diabetic treatment are necessary for clinicians to develop a comprehensive and thoughtful plan of patient care. The basics of insulin secretion and metabolism, medical management of insufficient insulin as well as lifestyle and prevention of diabetes are discussed.

Policy Statement

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Continuing Education Credit Designation

This educational activity is credited for 3 hours. Nurses may only claim credit commensurate with the credit awarded for completion of this course activity.

Statement of Learning Need

Health clinicians support patients that have diabetes to understand the nature and treatment of their disease. Knowledge of the current trends in diabetes research and medical management is important for clinicians to provide safe and appropriate communication, interventions and advocacy for the diabetic patient and their family. Educating diabetic individuals about the type of diet they should maintain as well as other lifestyle choices is integral to diabetic health and wellness.

Course Purpose

To provide health clinicians with knowledge of the main types of diabetes mellitus as well as the less common types in order to educate patients, families and peers about the right diabetic treatment and health choices.

Target Audience

Advanced Practice Registered Nurses and Registered Nurses

(Interdisciplinary Health Team Members, including Vocational Nurses and Medical Assistants may obtain a *Certificate of Completion*)

Course Author & Planning Team Conflict of Interest Disclosures

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Acknowledgement of Commercial Support

There is no commercial support for this course.

Please take time to complete a self-assessment of knowledge, on page 4, sample questions *before* reading the article.

Opportunity to complete a self-assessment of knowledge learned will be provided at the end of the course.

1. **When there is a need for energy, glycogen, stored in the liver, will be transformed to glucose by a process known as:**

   a. glucogenesis
   b. glycogeneolysis
   c. gluconeogenesis
   d. none of the above

2. **True or false. An A1c level found to be at 4.5% or higher after doing two separate tests indicates that the patient has diabetes.**

   a. True
   b. False

3. **Trans fatty acids are forms of processed fats that are:**

   a. found in a wide variety of processed foods
   b. produced through a process of hydrogenation or partial hydrogenation
   c. are initially unsaturated fat heated to a very high temperature and a nickel catalyst is then added
   d. all of the above

4. **True or False. Gestational diabetes mellitus is considered to be a treatable condition and those women that have an adequate control of their blood glucose levels will automatically decrease their risk of getting the condition.**

   a. True
   b. False

5. **After a baby with neonatal diabetes is born, the baby:**

   a. rapidly gains weight and grows at a faster rate as other babies
   b. may normalize in growth/development after appropriate therapy
   c. develops the same as any baby if the baby is male
   d. none of the above

Introduction

Three main types of diabetes mellitus are identified as type I, type II and gestational diabetes. Other types of diabetes are identified that are less common and may be confused with diabetes mellitus I and II, such as neonatal diabetes and maturity onset diabetes of the young (MODY), which involves ineffective insulin production or release from the pancreatic beta cells. Genetic mutations are defects understood to cause rare cases of diabetes. This course highlights the basics of insulin secretion and metabolism necessary for a full understanding of diabetes, the varied types of diabetes, and its medical management.

Overview Of Diabetes

Diabetes is considered to be a disorder of metabolism. Metabolism describes the manner in which food is digested by the body in order to enable growth and provide energy. Most of the food, which is consumed by a person, is then broken down into glucose. Glucose is a form of sugar in the blood and is the chief supply of fuel for the entire body. Subsequent to being digested, the glucose will pass into the bloodstream where it will then be utilized for growth and energy by the cells. In order for glucose to successfully enter the cells, a sufficient level of insulin has to be present. Insulin is a hormone, which is produced by the pancreas, a large gland located behind the stomach.[1-3,6]

When an individual consumes food the pancreas will automatically manufacture a sufficient level of insulin. Insulin will then be used to move glucose from the blood into the cells. Individuals that have diabetes do not have an adequate supply of insulin being produced by the pancreas; sometimes no insulin is being produced at all. In some instances, it is the

cells that are unable to respond accordingly to the insulin that is being produced. The glucose level in the blood will therefore rise. This excess of glucose in the blood will spill over into the urine and be passed out of the body during the excretion of urine. This emission of glucose from the body will cause the body to lose its primary source of fuel although the blood contains an increased level of glucose.

In order for there to be a full understanding of the exact nature, or pathophysiology, of diabetes mellitus (DM), there must first be a working knowledge of the fundamentals of carbohydrate metabolism, and insulin actions. Carbohydrates are broken down into glucose molecules in the gut postprandially, or after food have been consumed. Glucose is then absorbed directly into the bloodstream thereby elevating the level of blood glucose that was previously there. This increase in glycemia acts as a stimulant for the secretion of insulin from the beta cells found in the pancreas. For glucose to be allowed into most cells, insulin has to be present. The entry of glucose into cells throughout the body is facilitated by the binding of insulin to particular cell receptors whereby glucose is then used for the purpose of providing energy. Blood glucose levels are therefore decreased after being utilized by the cells coupled with the enhanced level of insulin, which is being secreted by the pancreas. The amount of insulin that is being secreted by the pancreas simultaneously decreases with the glucose level.[1-3,6]

Since the activity of blood glucose is greatly influenced by the production and secretion of insulin, if the insulin is somehow modified by disease then the actions of the blood glucose will be compromised as well. In situations where the level of insulin being manufactured decreases then the amount of glucose available to enter body cells will also decrease. This restraint on insulin production will result in high blood glucose levels, or hyperglycemia.

Similarly, if insulin is being secreted from the pancreas and is not utilized efficiently by the intended cells then the effect will be the same. On the other hand, if there is an increase in the amount of insulin that is secreted then the level of glucose in the blood may fall very low as a result. The simple explanation for such an occurrence is that a large amount of glucose enters the body tissue cells and leaves very little in the bloodstream.

After the consumption of a meal, the quantity of glucose that is readily accessible post carbohydrate breakdown often exceeds the amount of glucose that is required by the cells. This surplus of glucose is then sent to the liver to be stored as *glycogen* and remains there until there is a need for it. If there is a need for energy then glycogen, which is stored in the liver will be transformed to its previous state, *glucose*, by a process known as *glycogenolysis*. This will enable the elevation of the level of blood glucose and supply the required source of energy for the cells. There is also a process known as *gluconeogenesis* in which the liver manufactures glucose from fatty acids and amino acids. Both of these processes will serve as a means of increasing the level of blood glucose supply that is available for use.[4-5]

Glycemia is managed by a very complex series of interactions in the pancreas and liver, as well as the gastrointestinal tract. Although there are quite a number of hormones that may have an effect on glycemia, insulin is the only one of those hormones that has the ability to lower the level of blood glucose. All the other hormones namely the thyroid hormone, glucagon and growth hormones have quite the opposite effect on glycemia, by acting to increase the level of blood glucose.[4-6]

Insulin

Insulin, as previously alluded to, is a hormone that enables the absorption of glucose from blood cells by other body cells. The liver and the muscles are able to store glucose in order to inhibit the use of fat as a means of energy supply by the body. If there is little or no supply of insulin in the blood then the body cells will not take up the glucose that is there. This deprivation of glucose will compel the body to utilize the fat present as a source of energy. Not only does insulin act as a means of enabling cellular usage of glucose but it also acts as a control signal to a number of other body systems such as the intake of amino acid by the cells in the body.[1-3,6]

The insulin that is produced by the body is not identical across the board as it pertains to animals; the level of strength will fluctuate to a great extent. The insulin that is produced by pigs, known as porcine insulin, is the insulin that is considered to be the most similar to the insulin that is produced by human beings. Humans can receive insulin produced by other animals, although the advancements that have been made in genetic engineering has allowed for the synthetic production of human insulin.

Renal Threshold of Glucose

The renal threshold for blood glucose in a healthy human being matches the glucose concentration of plasma, which is 180 mg/dl.[7] However, there is a very wide span of variation in the renal threshold of different individuals. It is particularly important to note that the findings in human adults, more specifically those adults that have long standing diabetes, may display a significant increase in that threshold. This increase will result in the *underestimation* of the level of blood glucose. On the contrary, children as well as pregnant women may display an extremely low threshold, which will result in the opposite effect - an *overestimation* of the level of blood glucose.

Diabetes Mellitus Type I

Diabetes Mellitus type I, also termed T1DM, is the most common of the types of diabetes that prevails in children. Overall, T1DM is one of the most common of the chronic diseases that affect children. T1DM, formally referred to as juvenile diabetes or insulin dependent diabetes, is the form of diabetes mellitus that occurs as a result of the autoimmune destruction of the beta cells that produce insulin in the pancreas. From this decrease in insulin stems the increased level of glucose that is found in the blood and in the urine.[4-6,8,9]

Some very common symptoms that occur when glucose levels increase in the blood and urine are increased thirst (polydipsia), a frequency in urination (polyuria) and significant weight loss. If diabetes mellitus type I goes untreated for a long duration, the results may be fatal. However, the disease can be treated and controlled with supplemental insulin; the most common method of administering insulin for T1DM is by injection, which is done at intermittent intervals several times during the course of a day. There are other methods of administering injectable insulin however, for example insulin pumps may be used. In some cases, diabetic patients opt for undergoing transplant surgery during which an entire pancreas as well as pancreatic islet cells is transplanted as a potential cure.[8,9,11-13]

In order to differentiate between type I and type II diabetes, a test can be done. This form of testing is known as *autoantibody* testing. Autoantibody testing is successful mainly due to the fact that there is autoantibodies present in a patient with type I diabetes that is not present in a patient with type II diabetes. These autoantibodies which are only present in a patient with type I diabetes are islet cell autoantibodies, zinc transporter autoantibodies, insulinoma associated autoantibodies and glutamic acid

decarboxylase. The C-Peptide assay may also be used as well; this is used to measure the production of endogenous insulin.

The treatment of type I diabetes should be continued for the duration of the patient's life. Type I diabetes is a disease that will not pose a threat to an individual's normal daily activity. Although a patient is trained in the methods and techniques of managing the disease autonomously, there are some patients that may not find this to be an easy task. There are different complications that may arise from instances of both low blood sugar and high blood sugar. These are caused in both cases due to the non-physiological method by which the insulin is being replaced. The occurrence of low blood sugar may prompt seizures or unconsciousness, which will require emergency treatment. The occurrences of high blood sugar may lead to the feeling of intensified tiredness as well as it may be the cause of long term organ damage.[6,8-9]

When type I diabetes first makes its entrance it is usually a very abrupt one. The usual age for this to occur is generally before the age of 30. The disease can however be diagnosed at any age. Individuals that have type I diabetes are generally of a normal weight or somewhat thin in physique. A patient that has diabetes type I will be completely dependent on the administration of insulin in order to stay alive. This is due to the fact that there is no insulin being produced by the pancreas. Patients with this form of diabetes are left vulnerable to diabetic ketoacidosis. Since the pancreas is unable to produce any insulin, the glucose is not able to enter the cells and will therefore remain in the bloodstream. In an effort to meet the energy needs of the cells, *lipolysis* will occur, which is the breaking down of fat. This break down will result in a release of free fatty acids and glycerol.[8-10]

Glucose that is used by the cells is produced through the conversion of glycerol. Ketones come as a result of fatty acids being broken down and this will result in an increase in the level of ketone that is found in body fluids as well as it will cause a decrease in the hydrogen ion concentration, also known as pH. Ketones are then excreted in the urine along with a large amount of water. These factors, decreased pH and large degree of ketones in body fluids, as well as electrolyte loss and dehydration caused by an excessive amount of urination and modifications in the bicarbonate buffer system will result in diabetic ketoacidosis. If diabetic ketoacidosis, also known as DKA, is left untreated, it may result in coma or even death.[14,15]

It is not uncommon for patients to be first diagnosed with having type I diabetes after being admitted into the hospital with diabetic ketoacidosis. In instances where the patient is a known diabetic the onset of DKA may be brought on by infection or a period of stress. On a more common basis, DKA is generally an outcome of poor daily glycemia control. If a patient remains in a severely hyperglycemic state for a period of several days or longer, which would be caused by an inadequate amount of insulin that is being administered or on the contrary an excessive glucose intake, they will be susceptible to the development of DKA.[15]

Over the course of the past three decades, there has been a marked increase in the ability of medical scientists to more fully comprehend the exact nature of type I diabetes. This improvement in the level of understanding comes from a combination of the use of genetics, autoantibodies and metabolic markers unique to the disease. In the mid 1980's, there was the development of a model that was intended to integrate all three of these features. This model has been cited quite often since its inception. This model, which is representative of the natural history

of type I diabetes, implies that those individuals that are genetically vulnerable and have a fixed number of beta cells are open to exposure to a recognized environmental trigger which will encourage β-cell autoimmunity.[10,16]

The process identified above, having been marked by the growth of the islet reactive autoantibodies, indicates the escalation of the activated auto-reactive T cells that are capable of destroying the beta cells. This will inevitably result in advancing and foreseeable loss in the insulin secretory function. According to the model, type I diabetes is a disease that does not present itself until approximately 80% to 90% of the beta cells have been destroyed. In this model, as well, there is a very huge gap between the moment autoimmunity actually begins and the beginning of diabetes. Individuals that choose to study diabetes, in particular this form of diabetes, must acknowledge that the model has done a great deal of service in the past couple decades; it has undoubtedly provided guidance for those investigations that have played a great part in furthering the understanding of the natural history of the disease.[10,16]

In recent times, there has been some degree of modification to some of the aspects of the model as explained above in order to update it to the level of newer discoveries and knowledge. To provide a brief example, there is data that suggests that beta cells of the pancreas may very well persevere in some patients that suffer from type I diabetes; this simply means that the amounts of beta cells that are present do not reach zero (0) in a few patients that have type I diabetes. Also, it is being called into question just how much beta cell destruction is actually required in order for symptomatic onset to be seen. Recent studies have been suggesting that 40% to 50% beta cell viability may be present at the time that hyperglycemia occurs.

This aspect may very well be related to any factor such as physical activity, body max index, or age. [10,16]

The occurrence of the first signs of diabetes onset may be further explained by the fact that, although there is evidence of autoimmunity, the insulin secreting function is able to remain stable for a very long period of time in those patients that have type I diabetes. With that being determined, a loss of the first phase of the insulin response is very often followed by a phase of intolerance to glucose and then a period of what may be considered as clinically unspoken diabetes. The degree of loss of the beta cells in the pre-diabetic state has been, in recent times, an area of a great amount of debate. There are some who are suggesting that the symptomatic onset that is associated with type I diabetes may only occur once there is a period of deterioration in autoimmunity. There are two different categorizations of type I diabetes, which are further elaborated on below, including disease outcomes and potential complications.[6,10,15,16-19]

Immune-Mediated

The immune-mediated diabetes form of type I diabetes is also referred to as type IA diabetes. This form may be described as an autoimmune disorder which will cause the immune system of the human body to destroy, or make an attempt at destroying, the cells of the pancreas that are responsible for the production of insulin. Immune-mediated diabetes accounts for 5% to 10% of patients with diabetes and, as mentioned earlier, was known by the terms type I diabetes, juvenile onset diabetes and insulin dependent diabetes. This form occurs as a result of the cellular mediated autoimmune destruction of the beta cells that are found in the pancreas.

There are particular markers that can be seen for the immune destruction of the beta cells and these include autoantibodies to tyrosine phosphatases IA-2 and IA-2β, autoantibodies to insulin, islet cell autoantibodies and autoantibodies to glutamic acid decarboxylase. One, if not more of these autoantibodies will be present in approximately 85% to 90% of the patients at the initial detection of hyperglycemia. This disease also has strong HLA (human leukocyte antigen) associations, with a link to the DQA and DQB genes; it is also influenced somewhat by the DRB genes. The effect that these HLA-DR/DQ alleles have could be either a protective or an influencing one.

For the immune-mediated form of diabetes, the rate at which the beta cells are destroyed will vary widely. The rate may be seen to be very quick in some patients such as infants and children, while being very slow in other patients such as mainly in adults. At the very first onset of the disease, there are some patients, in particular adolescents and children that will present with ketoacidosis. Other patients may present with a modest level of fasting hyperglycemia that may very well quickly change to become a severe form of hyperglycemia as a result of emotional or physical stress, such as when an infection occurs or as a result of surgery.

Ketoacidosis may occur along with or separate from severe hyperglycemia in the instances explained above. In adults, more frequently than children, there may be a degree of beta cell function being retained to a level that is sufficient to prevent ketoacidosis in a person for quite a few years. These individuals will, in the long term, become highly dependent on insulin to ensure survival and have a heightened risk of ketoacidosis.

In the later stage of immune-mediated diabetes, there will be very little or no insulin being secreted at all, this will be quite evident given the low or in some cases undetectable levels of plasma C-peptide. This form of type I diabetes is most commonly seen during childhood or adolescence however it is not an uncommon occurrence for it to be seen at later stages in life, even up to 80 or 90 years of age. The autoimmune destruction of the beta cells have a wide variety of genetic predispositions and also has a level of relation to some environmental factors which yet remain to be properly defined.

Obesity is a risk factor associated with diabetes. Although it is rare for patients to be obese when they are first diagnosed with type 1 diabetes, it is not impossible for a patient to be obese when diagnosed with this form of diabetes. The patients that suffer from this form of diabetes also have a heightened risk of having quite a number of other autoimmune disorders such as Hashimoto's thyroiditis, Addison's disease, Graves' disease, autoimmune hepatitis, vitiligo, celiac sprue, pernicious anemia and myasthenia gravis.

Idiopathic

This is the term that is generally given to those very rare forms of diseases that have no established cause. There are some forms of type I diabetes that have no known etiologies whatsoever, which is to say that there is no known source of the disease. There are some patients who will present with evidence of permanent inadequacy of insulin secretion and will be evidenced to be prone to ketoacidosis as well but there is no sign of autoimmunity at all. Even though the number of patients with type I diabetes that will be placed in this category of the disease is a very small one, most of the patients who will fall in this group will be of Asian, Hispanic or African descent. For those patients that have this form of type I diabetes, there will

be episodes of ketoacidosis as well as an exhibition of a varying level of deficiency of insulin in the time that elapses between these episodes.

There is a very high inheritance rate for this form of diabetes and it is not HLA (human leukocyte antigen) associated. Also, a lack of immunological evidence for beta cell autoimmunity for idiopathic diabetes exists. Patients that variedly suffer from this form of diabetes will absolutely require or find it a necessity to rely upon insulin replacement therapy. This form of diabetes is referred to as *type IB diabetes* as well and will not give a positive result when the patient is tested for islet cell autoantibodies. Although the patients that suffer from idiopathic diabetes are considered to have a deficiency of insulin and are prone to experiencing emergency episodes of high blood sugar, the need for insulin will definitely fluctuate.

Testing And Diagnosing Diabetes Mellitus

As of the year 2009, there were three tests that were put forward as the recommended methods of testing for type 1 diabetes mellitus. The following organizations, the European Association for the Study of Diabetes, the American Diabetes association along with the International Diabetes Federation put forward recommendations for diabetes testing. The types of testing methods that were included in their recommendations are highlighted here.[6,14,16]

Fasting Blood Sugar Test

The fasting blood sugar test is taken after the patient has fasted over a period of a night. After the night of fast is complete, a sample of blood will be taken from the patient. After the patient is tested, the level of the fasting blood sugar will be the determinant of whether or not the patient has

diabetes. The measurement that expresses blood sugar values is milligrams per deciliter (mg/dl) or millimoles per liter (mmol/l).

A fasting blood sugar level that is lower than 100 mg/dl or 5.6 mmol/l is considered to be normal. A fasting blood sugar level that is in the range of 100 mg/dl to 125 mg/dl is considered to be pre-diabetes. If there is a result of 126 mg/dl or higher on two separate tests then the patient has diabetes.

Random Blood Sugar Test

Random blood sugar testing may be done anytime, at random. In this test, a blood sample is taken at an unplanned time. A diagnosis of diabetes is determined by this test if the patient exhibits a random blood sugar level of 200 mg/dl or more. No matter what food was consumed before the test was conducted, a result such as 200 mg/dl is a suggestion of diabetes. This is especially true in those cases where the patient also has symptoms such as frequent urination or extreme thirst, which are both symptoms of diabetes. In order to have a higher level of accuracy, it is advised that the test be done at two separate times.

Glycated Hemoglobin Test

The glycated hemoglobin (A1c) will give an indication of the average of the patient's blood sugar level over a course of two to three months. It is carried out by taking a measurement of the percentage of blood sugar that is attached to the hemoglobin, which is the oxygen-transporting protein that is found in red blood cells. The higher the patient's blood sugar level then the higher the amount of sugar that will be attached to the hemoglobin. It has been generally accepted that if the A1c level is found to be at 6.5% or higher after doing two separate tests, then this is an indication that the patient has

diabetes. The ADA had identified 5.7 to 6.4 percent, confirmed with a repeat A1c measurement, as increased risk for developing diabetes.

After an individual is diagnosed with DM type 1, there should also be blood tests run to check for the autoantibodies that are common in cases of type I diabetes. Utilization of these tests will be a great help in determining whether the patient has type I diabetes or type II diabetes. It is advised that the patient has regular checkups in order to efficiently and properly manage the diabetes. The patient must have periodic A1c testing done to monitor their levels.

Depending to the age of the patient along with a few other factors, the A1c target will vary somewhat. The American Diabetes Association (ADA) most recently recommended that the target A1c level be kept at below 7%. An A1c level of 7% will translate to approximately 154 mg/dl or 8.5 mmol/l. In comparison to daily blood sugar tests that the patient may be accustomed to regularly perform, the A1c test is better at pointing out how well the diabetes treatment is going and showing where the downfalls of the plan exist, if any. If there is an increase in the A1c levels then that is an indication that the insulin treatment, meal plan or both of these need to be adjusted. Along with the A1c tests, periodic blood and urine tests must also be given to the patient as a way of monitoring the cholesterol levels, kidney function, thyroid function and the liver function. The blood pressure must also be assessed and a check be done for the location where the blood should be tested and the insulin delivered.

Diabetes Mellitus Type II

Diabetes mellitus type II is a disorder of the metabolism that may be defined by the high level of blood glucose that exists from the point of view of insulin

resistance and comparative insulin deficiency. This form of diabetes mellitus was once known as adult onset diabetes mellitus (AODM) as well as noninsulin dependent diabetes mellitus (NIDDM). All that defines this type of diabetes can be stated to be in contrast to the type I form of the disease where there is complete deficiency in insulin, which comes as a result of the depletion of the cells in the pancreas. The common symptoms that are related to type II diabetes are an increased frequency in urination, an excessive felling of thirst and a constant need to eat. Of all the patients that suffer from diabetes, 90% of the population has type II diabetes with all of the other 10% of diabetes cases either suffering from type I diabetes or from gestational diabetes. This section highlights the risk factors, comorbidities and prevalence of diabetes (reported by the Centers for Disease Control and Prevention (CDC)).[8,9,14,16,25,59,60]

The main cause of type II diabetes is believed to be obesity for those patients that are genetically affected by the disease. In the initial stages of type II diabetes, it is monitored along with the recommendation to increase exercise as well as modify the patient's dietary practices. If both these strategies are applied and there is not an adequate decrease seen in the level of blood glucose, then there will be a need for medication, which may come in the forms of (injectable) insulin or (oral) metformin. For those patients that require to be medicated with insulin, there is usually a need for constant monitoring of the blood sugar level. There has been a marked increase seen in cases of diabetes type II that have emerged over the last fifty (50) years. This is corresponding to the comparative increase that may be seen in obesity cases as well.

Compared to the 5.5 million cases that were seen in the year 1980, there were 22 million patients that were suffering from diabetes as of the year

2014. The long-term complications that may come with the increase in blood sugar are stroke, heart disease, kidney failure (which will in some cases require dialysis), poor blood circulation in the limbs of the body (that may eventually lead to amputation) and diabetic retinopathy that will affect the eyesight. Unlike type I diabetes where patients will more often than not suffer the complication of ketoacidosis, this is rarely witnessed in patients with diabetes mellitus type II. Rather, those patients that suffer from type II diabetes are prone to having occurrences of nonketotic hyperosmolar coma.

For patients that suffer from type II diabetes, there is still a level of insulin production in the body, but the level of insulin production is not quite the required amount for the needs of the body especially when there is insulin resistance. In a very large amount of the cases, this means that the pancreas will produce a larger than normal level of insulin. A major defining feature of type II diabetes is the lowered sensitivity to insulin by the cells of the body. This occurs particularly more frequently in the muscle and fat cells.

Along with all the issues that will arise from this heightened degree of insulin resistance, the insulin that is being released from the pancreas may very well be defective or not of the expected high standard that it should be. As a matter of fact, patients with type II diabetes are known to see a steady decline in the production of insulin by the beta cells, which will then lead to a lessened degree of glucose control. Reduced glucose control is a major contributing factor leading to type II diabetic patients having to eventually undergo insulin therapy. There is also evidence that shows that, although there is escalation in the glucose level in type II diabetics, the liver will still produce more glucose through a process known as gluconeogenesis. This will compromise the level of control that there is for gluconeogenesis.

Despite the fact that this form of diabetes mellitus is generally seen in patients that are above the age of thirty, and the level of incidence seen increases with age, there are quite a number of patients that are being diagnosed with type II diabetes that are adolescents. In many of these cases that involve adolescent patients, the main contributing factors to the diagnosis of the disease are bad eating habits, a general lack of exercise as well as a higher than normal body weight. Even though there is a strong genetic constituent that will contribute to the development of this form of diabetes, there are also quite a few other factors that will facilitate the development of type II diabetes.

One of the main contributing factors that tends to co-occur with a genetic predisposition to develop type II diabetes is obesity. There is a direct link between the extent of the obesity that an individual suffers and the chances of also developing type II diabetes. This is a fact that applies to both adults and children alike. A projected estimate exists that the risk of an individual developing diabetes will double for every 20% increase in body weight that is acquired above that which is recommended.

Another contributing factor pertains to age; there is data that demonstrates that for every decade that an individual lives over the age or forty, there is a heightened incidence for diabetes. The number of cases of diabetes occurring in persons that are 65 years of age and older account for approximately 27% of the type II diabetic population.

There is also an increased risk to develop diabetes in patients that are of a particular ethnic group and where Type II DM is more commonly seen. When compared to the 7% prevalence found in patients that are non-Hispanic Caucasians, the prevalence that is seen in Asian Americans is at an

estimated figure of 8% whereas the prevalence in Hispanics is at 12%, 13% percent for African Americans and at an astonishing 20% to 50% in some Native American communities.

Diabetes mellitus type II is also known to be seen more frequently in those women that have a history of developing diabetes during their pregnancy or gestational diabetes.

The exact dynamics of the type II diabetes epidemic are changing at a rather rapid rate. Diabetes mellitus type II was once regarded as a disease unique to those of the West but has in recent years been noted to occur in every country of the world. This type of diabetes was also more frequently seen in patients that were more affluent but has made a transition to being more noted among socio-economically deprived groups as well. No longer a disease regarded as more prevalent in adults and almost never seen in children, diabetes mellitus type II is a disease that is now increasingly seen in children. This increase may be credited to the level of child obesity that is being witnessed in the pediatric population and most commonly among children of a particular ethnic group.

There is an estimated 285 million patients that are inflicted with type II diabetes, and this number is expected to increase significantly to a figure of 438 by the year 2030. An approximate two-thirds of all these estimated diabetic occurrences will be from low or middle-income countries. The figure for adults that have glucose intolerance will see an estimated increase to 472 million in the year 2030 from a figure of 344 million in 2010.

On a global scale, it is interesting to note that there was an estimated total health expenditure of 12% being credited to diabetes alone in 2010, which is

$376 billion; and, this expenditure is estimated to hit a figure of $490 billion in the year 2030. This increase in the prevalence of type II diabetes and all the health complications that are associated with it poses a unique threat in developing countries in terms of economic gain. Diabetes is a disease of epidemic proportion in developing countries with significant national health and economic implications. In quite a number of these developing countries, there is limited or virtually no infrastructure in place to care for individuals with diabetes; and, they are inadequately equipped to handle the epidemic of diabetes with which they are faced.

Type II Diabetes and Diet

The occurrence of type II diabetes was for a few decades seen mostly in the Western region of the globe. Cases of type II diabetes have in recent years been reported to increase across the entire globe, affecting people of many countries. This epidemic may be related to the increasing popularity of the Western Diet. Whereas in previous years many countries chose not to adapt to certain foods of the West, an acceptance of the diet is more widely seen in many regions of the developing world. Excess in the level of calorie intake per individual is one of the factors that contribute the most to the increasing rise in obesity and type II diabetes worldwide.

It has also been found that diet *quality* has its independent effects upon health as well. There has been research undertaken that has shown how the quality of fats and carbohydrates play a major role in the development of diabetes; all this being independent of other risks factors such as BMI (body mass index). There are a few dietary contributors to the increase in the risk of developing diabetes. Higher dietary glycemia load (GL), as well as trans fat, is a particular influence in the heightening of the risk of diabetes. There are also particular dietary factors that may play a part in the decrease of the

risk of diabetes. An individual that has a greater consumption of polyunsaturated fat and cereal fiber will have a lessened risk of developing diabetes.

A significant lower risk of diabetes has been associated an increase in whole grain intake by two servings a day. Conversely, there has been evidence to indicate that a higher level of consumption of sugar sweetened beverages will increase the risk of type II diabetes even after the effects of body weight have already been taken into consideration. Based on research and analysis that has been carried out, individuals that fall into a group of those with the highest level of sugar sweetened beverage consumption, which is approximately one to two servings a day, had a significantly greater risk of developing type II diabetes than those in the group with a lower level of intake.

There are quite a number of factors that may explain the undesirable effects that sugar sweetened beverages have on cardiometabolic risk. Along with a gain in weight, several other mechanisms such as dyslipidemia, chronic inflammation and an increase in insulin demand are all factors that contribute to the effects of sugar-sweetened beverages. The large quantities of rapidly absorbable carbohydrates, such as sucrose, that is found in sugar sweetened beverages will result in a higher level of dietary glycemia load that will lead to a very quick increase in both the blood glucose and insulin levels. This high glycemia load diet, which plays such a great part in increasing the insulin demand, may eventually lead to a breakdown of the beta cells in the pancreas over a period of time. This chain reaction highly contributes to the development of type II diabetes as well as cardiovascular disease.

The fructose that is derived from high fructose corn syrup and any sugar may also play a big part in the development of type II diabetes. Fructose is metabolized in the liver to lipid, which will then lead to an increase in dyslipidemia, insulin resistance and lipogenesis. This may also play a great part in promoting visceral adiposity. A recent study that was done to compare the relative effect on individuals obtaining one-fourth of their energy from the consumption of glucose (as opposed to fructose-sweetened beverages) showed that they had similar weight gain as those who consumed fructose-sweetened beverages. However, it was also found that only individuals consuming fructose-sweetened beverages experienced a significant increase in visceral adiposity.

There are many developing countries that are currently experiencing rapid economic and social changes associated with shifts in popular lifestyle and dietary habits. What these changes will lead to in these countries is over-nutrition. In Asia in particular, the traditional dietary practices are being quickly pushed aside and replaced by a western diet as the population adapts to a more industrialized and urbanized food environment. At the same time, there has been some level of inactivity as it relates to the environment. This is one of the factors that will contribute a great deal to the development of DM type II as it significantly increases body weight and central adiposity as well as contributes to decline in the level of physical activity.

With the high rate at which nutritional standards are changing, there are many countries that are faced with the very distinctive issue of having cases of both under-nutrition and over-nutrition. This issue of having to deal with both ends of the spectrum at once will eventually lead to the double burden of infectious and chronic diseases. There is data that was gathered from a

10-year survey, carried out by the Chinese National Nutrition Survey, which showed a noticeable increase in the amount of energy derived from the food consisting of animal products. Just as noticeable was the increase in the proportion of fat consumed.

Many countries around the world have undergone significant changes in their cultural dietary habits to more of a western diet. In India, there was a substantial increase over the course of two decades in national dietary changes; for example, the percentage of the energy that was obtained by food from animals made a marked increase. The majority of this increase was accredited to residents in urban areas who consumed 32% of energy from fat in relation to those residents of the rural areas who consumed 17%. Both forms of the ghee, vegetable and animal, that are utilized for the purpose of cooking, in India and in other South Asian countries, have a high trans fatty acid content.

One particular form of the vegetable ghee, which is known as Dalda, is a primary source of edible oil that can be found in India and has a trans fat level of 50%. Along with being one of the greatest contributors associated with cardiometabolic risk profiles and an increased risk of experiencing heart disease, trans fat intake also plays a part in the development of the resistance of insulin and chronic inflammation.

Along with the factors that have already posed a threat to developing societies, there has also been the introduction of certain dietary products from the Western diet, which is further elaborated upon below.

Processed Food

The processing of food greatly affects the glycemic index of foods. The more the food is processed the higher the degree of the glycemic response that it will produce. A majority of the types of foods that are being consumed today in the industrialized countries are being prepared by the method of processing them in a factory. The reason that these foods are being processed is to ensure that the food has a long shelf life. Some of the foods that are most commonly processed are cakes, pastries, bread and foods that are considered to be snack food. The methods that are being employed to process these foods are explosion puffing, instantization and extrusion cooking, which all require an extremely high temperature and pressure or that requires repeated wetting and drying. All these processes will have an effect on the digestibility of the starch found in the products, and compound the problem of a high glycemic index.

Processed products eaten on a continuous basis, over a period of time, will affect the blood sugar control system in the body. While these products are being processed, the fiber content of food is being changed from its natural prior state and important fatty acids are removed in an effort to increase the shelf life food. The accumulative effects of food processing will lead to a negative impact on the body as fiber has been proven by a number of studies to assist in the maintenance of proper blood sugar balance.

Along with the removal of fiber that is so important and also making alterations to fats and oils, there is a processed high fructose corn syrup that is added to such foods during the processing period. The main aspects of processed foods that cause the highest level of health concern in the standard Western diet are highlighted below.

Fiberless Food

Fiber is a very essential element of the human diet and when food is processed, this part of the food supply is lost. There are quite a few reasons why fiber is important a healthy diet but one of fiber's most important roles in the diet is to assist in maintaining the balance of insulin levels and the blood glucose levels in the body. In comparison to grain products that have been refined, whole grain products will generally be digested and absorbed at a very slow rate due to their physical make up as well as their high content of viscous fiber. These whole grain products will also extract a smaller postprandial glucose response that will therefore cause a lessened level of exertion upon the cells of the pancreas to meet the insulin demand.

The best sources for fiber may be found in whole foods such as legumes, fruits, nuts, seeds, whole grains and vegetables. An approximate 3/4th of the grains that are consumed in the Western diet are highly processed. The methods that may be employed to refine grain products during the food process are pressing, rolling and grinding. All of the aforementioned methods that are used will affect the glycemic index of the food and affect the blood sugar levels of the body. What these food-processing methods do is to damage the outer layer of the grains and compromise the chemical composition of the food starches, which affect the glycemic index of these processed foods.

High Fructose Corn Syrup

High fructose corn syrup only became popular in the 1970's. Fructose is a very sweet substance. It is sweeter than sucrose, which is also known as table sugar, and this allows the manufacturers of the processed foods to use a lesser amount of ingredients to sweeten the foods that are being

processed, and to increase manufacturing profits as well. In the average Western diet, the annual consumption of corn syrup is high. Although high fructose corn syrup in food may not significantly cause elevation of blood glucose after being consumed, the long term, constant use will have a major effect after a period of time.

When high fructose corn syrup is consumed, the liver will metabolize it. After it is metabolized, this high fructose corn syrup will be stored as fat in the liver. This is a direct contributor of obesity and an increase in the level of insulin resistance. Both of these will play a great part on the development of type II diabetes. Since the high fructose corn syrup plays such a major role in the promotion of increasing insulin resistance, it is also a major factor in the risk of diabetes mellitus type II.

Trans Fatty Acids

Trans fatty acids are a form of processed fat. These processed fats are not a product of nature but are rather a product of technology. Trans fatty acids may be found in a wide variety of processed foods such as candies, crackers, salad dressings, baked goods, potato chips, oils, margarine as well as an assortment of other snack foods. The process that is used to produce these fats is called hydrogenation or partial hydrogenation. These processed fats are initially unsaturated fat and these unsaturated fats are then heated to a very high temperature. After the fat is exposed to the high degree of heat, a nickel catalyst is then added to the heated fat. When this addition is made then hydrogen gas will be pumped into the heated fat and nickel catalyst mixture. When this process is done, it removes all of the fatty acids that are essential to a good diet and it also extends the life of such products on the shelf.

The trans fatty acids, which are found in these processed foods have been evidenced to have quite an effect on a patient that has diabetes mellitus type II. The trans fatty acids will decrease the response of the cell to the insulin. The effect that the trans fatty acid will really have on the body is that it will obstruct the proper function of the insulin receptor by making changes to fluidity of the lipid bilayer as well as other cellular membranes. The cells in the human body are essentially made up of healthy important fatty acids and when the artificial fats are used to replace these essential fats the body will then utilize the wrong type of fat as a means of maintaining and repairing the cells.

Gestational Diabetes

One the types of diabetes mellitus is gestational diabetes or GDM. Gestational diabetes is a condition that is unique to pregnant women, more particularly, pregnant woman that had no prior diagnosis of diabetes. These pregnant women will display a high blood glucose level during the pregnancy. This will generally occur at a higher rate while the woman is in her third trimester. GDM diagnosis and treatment is briefly reviewed here.[59,61,62]

A long-standing debate over the years has been whether or not an increase in blood glucose level during pregnancy is a normal, natural part of being pregnant. Gestational diabetes occurs when the insulin receptors are unable to function properly. This malfunctioning of the insulin receptors may be caused by pregnancy related factors. One of these factors may be the presence of human placental lactogen that will interfere with the insulin receptors that are already vulnerable. This will then cause a rise in the blood sugar to an inappropriately high level.

Gestational diabetes has a very small amount of symptoms. It is a common occurrence or diagnosis made during a routine screening exam of a women during pregnancy. When the screening is being done, the diagnostic lab tests will reveal a very high level of blood glucose. A 3 to 5 percentile of women are diagnosed with gestational diabetes throughout the course of their pregnancy. This is also dependent on the population in which the study was carried out. With these factors in mind, the condition may very well be one of natural influences.

As with any other conditions that may occur during pregnancy, gestational diabetes mellitus will also pose a degree of risk to the baby. Babies that are born to mothers with gestational diabetes that have been untreated will have a higher risk of problems in comparison to babies born to a mother without gestational diabetes. The baby may have problems such as a low blood sugar level and jaundice as well as appear large for their gestational age, which in most cases will lead to complications during the delivery of the baby. If gestational diabetes is left untreated, there is a heightened risk of the mother experiencing a seizure or a stillbirth.

Gestational diabetes mellitus is considered to be a treatable condition and those women that have an adequate control of their blood glucose levels will automatically decrease their risk of getting the condition. One of the primary points of focus when planning a strategy that will aid in the management of gestational diabetes mellitus is the diet. The food plan of the pregnant women is generally the very first recommendation for a good target that is made in regards to the management of gestational diabetes. Not only are the babies at a higher risk of having complications and problems but the women are at a high risk for future problems as well. If a woman has

gestational diabetes and it is not properly handled and monitored then the patient has a higher risk of developing type II diabetes later in life.

Despite the fact that cases of gestational diabetes are far and few between, there is a risk of developing latent autoimmune diabetes or type I diabetes during pregnancy as well. These cases are very rare, however. There is also an increase in the incidence of pre-eclampsia and Caesarian section.

Children that are born to mothers with unmanaged gestational diabetes are at increased risk of developing childhood obesity as they become older, and will also be prone to developing diabetes mellitus type II later on in life.

In most cases of gestational diabetes that occur it is possible for the patient to manage their blood glucose level independently. These patients are able to manage the blood glucose level by making modifications to their diet and at a moderate pace. There are a few cases however where the patient will require the aid of anti-diabetic drugs, which is inclusive of insulin.

Classification of Gestational Diabetes

The definition that was formerly given to gestational diabetes mellitus was that it was any amount of glucose intolerance that is recognized whether onset or first recognition during pregnancy. By making a broad definition such as this, there is room left to acknowledge the fact that the patient, having been diagnosed with the condition may have previously had diabetes mellitus but it was not yet diagnosed, or also that it may be a development that coincides with the pregnancy. The fact that the symptoms may subside after the pregnancy has run its course is of no relevance to the fact that the diagnosis was indeed made. The diagnosis of gestational diabetes is made

after there is noticeable glucose intolerance continuing beyond 24-28 weeks of gestation.

There is a classification of gestational diabetes mellitus that is known as the White classification so named for the physician, Priscilla White, who is known as a pioneer in the field of diabetes; particularly, diabetes in pregnant women. Priscilla White was a female physician in what was considered a man's world at the time when she was alive. Dr. White was the pioneer who did the research on the effect that different types of diabetes had on the perinatal outcome. This classification is commonly used as a tool to assess the risks of both the mother and the fetus.

The classification system that is used will categorize the condition into two groups. These two groups are utilized to separate, define and distinguish between gestational diabetes, type A and diabetes that was there before the patient got pregnant, pregestational diabetes. There is also a subdivision that occurs within these two groups as well, and this is done according to the level of risk that is posed and the management to be applied that is associated with the subgroup. The two subcategories of gestational diabetes are Type A1 and Type A2.

Type A1

In patients that are diagnosed with type A1 gestational diabetes there will be an abnormal oral glucose tolerance test (OGTT) but there will be a normal level of glucose in the blood during the period of fasting as well as two hours after meals. In these cases it is enough to make modifications to the patient's diet in order to control the level of the glucose.

Type A2

For the patients that fall into type A2 gestational diabetes there will also be an abnormal oral glucose tolerance test. The intensity of this will however be multiplied by the abnormal glucose levels that are experienced during the period of fasting as well as after meals. In these cases, there will be an elevated need for insulin or the assistance of other medication. The other group that is used to categorize the other cases of diabetes that is seen during pregnancy is the diabetes that existed before the pregnancy. This group is also divided into quite a number of subcategories. These subcategories include Type B – Type T, highlighted below.

Type B

The initial onset of type B gestational diabetes occurs at the age of twenty (20) or older and with a duration of less than ten year.

Type C

The initial onset of type C diabetes is at the age of ten (10) to nineteen (19) or with duration of ten to nineteen years.

Type D

The initial onset of type D diabetes is before the age of ten (10) or with duration greater than twenty years.

Type E

Type E is an evident type of diabetes mellitus that has hardened pelvic vessels.

Type F

Type F diabetes is defined by diabetic nephropathy.

Type R

Type R diabetes is defined by proliferative retinopathy.

Type RF

Type RF diabetes is defined by retinopathy and nephropathy.

Type H

Type H diabetes is defined by ischemic heart disease.

Type T

Type T diabetes is defined by prior kidney transplant. There is a greater level of risk that is associated with a patient that experienced the onset of the disease at an early age or has had the disease for a very long time. This is why there is a need for the subcategories of type B through to type D.

Pathophysiology of Gestational Diabetes

The exact mechanisms that are related to gestational diabetes are still yet to be discovered or determined. The marker that defines the condition, gestational diabetes mellitus is an increase in insulin resistance. It is believed that all of the hormones that are associated with pregnancy as well as quite a few other factors obstructs the activity of the insulin as it attempts to bind to the insulin receptors. This interference that is made by the pregnancy hormones and factors are assumed to occur at the point of the cell-signaling pathway that is behind the insulin receptor. It should be

recalled that the main aim of insulin is to allow for the entry of glucose into the cells; therefore, when there is increased insulin resistance, a corresponding reduction in the level of glucose that is able to enter the cells occurs. As a result of this reduced movement of the glucose into the cells, the glucose will be forced to remain in the bloodstream, when this happens the levels of the glucose will rise.

In order to overcome insulin resistance, an elevation in the amount of insulin will be required. In a pregnancy where the patient has gestational diabetes mellitus, there will be a production level of insulin that is 1.5 to 2.5 times the amount of insulin that is produced in a normal pregnancy.

In the second trimester of pregnancy, it is fairly common for an increase in insulin resistance to occur. This increase in insulin resistance will progress even further to a level which is more commonly seen in those patients that have type II diabetes that are not pregnant. This natural phenomenon that occurs in pregnant women takes place mainly due an effort by the body to secure a glucose supply for the fetus that is being carried by the mother.

Women suffering from gestational diabetes have an insulin resistance level that they are not able to balance with the increased level of beta cell production that is occurring in the pancreas. To an extent, placental hormones, and to a lesser degree fat deposits, that occur in women during pregnancy, seems to play a part in lessening the effects of insulin resistance during pregnancy. The main contributing factors are progesterone and cortisol, however, prolactin, the human placental lactogen and estradiol, also make a significant contribution to the lessening of insulin resistance as well.

Type II and Gestational Diabetes

There is no clear explanation that has been offered as to why some woman are not able to balance their insulin needs and eventually end up developing gestational diabetes mellitus. However, there are quite a few explanations that seek to clarify the phenomenon and these explanations are very much similar to those that are put forward for the development of type II diabetes.

Explanations that underpin gestational diabetes in terms of causative mechanisms and outcomes include single gene mutations, autoimmunity, obesity as well as a few other factors. Due to the fact that glucose passes across the placenta, through the process of diffusion made possible though GLUT3 carriers, a woman that has untreated gestational diabetes is continuously exposing the unborn child to a higher level of glucose. Though the insulin is not able to move across the placenta, the levels of insulin will eventually increase for the fetus.

The increase in insulin that the fetus is exposed to will also have a growth stimulating effect, as insulin is known to do. This excess in insulin will quite possibly lead to an excessive growth of the child and a very large body. After the child is born, the environment of high levels of glucose that was present in the womb will disappear but the child will be left with an ongoing high level of insulin production. The baby will also be left vulnerable to such conditions as low glucose levels and hyperglycemia.

For women that have experienced gestational diabetes during their pregnancy, the risk is significantly increased for a chance of developing type II diabetes later on in life. This development of type II diabetes will occur in approximately 40% of those women that had gestational diabetes during the course of their pregnancy. Type II diabetes will be most generally seen in

women in the first ten years after they have been diagnosed with gestational diabetes. In the presence of obesity, an estimated half of women with gestational diabetes will develop type II diabetes later on in life.

There are quite a number of efforts being undertaken to find out if women who have gestational diabetes may be treated using lifestyle modification as well as medication to reduce their chance of developing type II diabetes. The results obtained from these attempts are considered to be very promising and there will be further studies and research carried out in an effort to identify those patients that will be potentially able to respond to treatment.

Maturity Onset Diabetes Of The Young

One of the less commonly seen forms of diabetes is maturity onset diabetes of the young (MODY). This form of diabetes is caused by a mutation occurring in numerous different genes. MODY is considered a monogenic form of diabetes. Each of the genes that become mutated will have its own unique impact and will cause a slightly different type of diabetes.[8,63-65]

The most common forms of gene mutation that occurs in maturity onset diabetes of the young are HNF1α-MODY (MODY3) and GCK-MODY (MODY2). The mutations that occur in the HNF1A genes are the causes behind MODY3 while the cause of MODY2 is the mutations that occur in GCK genes. MODY is a very uncommon form of diabetes and cases are rarely seen. This is one of the primary reasons that it is often mistaken for type II diabetes. This mistake also occurs due to the fact that in both occurrences there is no need for insulin as a treatment, or, mostly not in the initial stages of the disease.

There are many differences that exist between MODY and diabetes mellitus type II. These differences are what separate the two conditions from being

mistaken for and diagnosed as the other. One of the most defining points for the two diseases is their genetic makeup. The nature of the predisposition in type II diabetes differs from that of MODY. While type II diabetes has no clear implications with the presence of many vulnerable genes, MODY is caused by a single gene mutation, making it a monogenic condition, which is inherited from an autosomal dominant trait.

The initial onset of diabetes mellitus will most commonly occur during the childhood years or during the adolescent years. The disease will generally be seen before the age of 25 even though the degree of intensity of the hyperglycemia will be very mild in a few cases and may be overlooked, much similar to cases of type II diabetes. It is not uncommon for MODY to be misdiagnosed in children as type I diabetes once there is a detection of hyperglycemia.

A diagnosis of MODY is generally made during late childhood, adolescence and even in early adulthood. There have been cases of the condition developing in some adults at 50 years of age. The accuracy of the diagnoses of this condition is not very high as MODY tends to be misdiagnosed as type I diabetes or type II diabetes. If an accurate diagnosis of MODY is made then this will alter the course of patient treatment. This would also assist in the identification of other members of the patient's family that also have maturity onset diabetes of the young.

The patients that have MODY will often display different symptoms, and have differences in their lab results that are unusual to those symptoms and with results typical of type I diabetes and type II diabetes. A couple signals of MODY are listed below.

- A patient that has been diagnosed as having type I diabetes displays negative blood testing for autoantibodies. This test is generally carried out at the time that the diabetes is initially diagnosed. The antibodies that will most commonly be tested for are insulin, ZnT8, islet cell or ICA and GAD65.

- A patient that has been diagnosed as having type I diabetes generates a considerable amount of insulin years after being diagnosed with diabetes mellitus type I. There will be detectable blood levels of insulin, proinsulin and C-peptide.

- A patient that has been diagnosed with having type II diabetes but is of a normal body weight or has no considerable amount of extra weight. This patient does not display any signs of being insulin resistant.

- A diabetes patient who belongs to a family that has seen three or more successive generations being diagnosed with diabetes mellitus.

- A diabetes patient that has stable of mildly elevated levels of blood sugar. This is often found accidentally during a check-up. MODY normally shows symptoms that are different from those that are considered normal for patients that have type I diabetes or type II diabetes.

MODY2 is caused by a mutation of a glucokinase enzyme that fails in its attempts to correctly sense the concentration of the glucose that is circulating. All of the MODY genes that are left will encode transcription factors. Very critical links are formed among HNF4A, TCF1, TCF2, and IPF-1 in the surge of transcription factor that are in control of the appropriate

expression of the beta cell genes, such as the glucose transporter known as GLUT 2 as well as insulin.

The mutations that occur in the genes listed above will likely cause a disruption in the development of the beta cells in the embryo and will most likely result in the dysfunction of the beta cells in the adult. The particular role that the proteins actually play in the pancreatic islets of the adult has just been revealed in recent years. MODY3 and MODY2 are identified to be the most common forms of MODY but still remain a very uncommon cause of diabetes.

Pathophysiology of MODY

The forms of MODY that have been recognized all stem from an ineffective level of insulin production or from an ineffective release from the pancreatic beta cells. Several of the defects that have been noted in MODY are mutations of the transcription genes. One form of MODY is stated to be a mutation of the glucokinase gene. For all the recognized forms of MODY it has been discovered that there is a varying amount of specific mutations all of which involve amino acid substitutions. In some of the cases seen, there is a marked difference of the activity level of the mutant gene products that play a role in the variations of the clinical features of diabetes. A couple of these variations are the age that onset occurs and the level of insulin deficiency that is seen in a particular individual.

Impaired Beta Cell Function And Types Of Diabetes

Mutations that occur in the mitochondrial DNA are a very rare cause of diabetes. The mitochondrial DNA is a molecule that has a circular shape and contains within it thirty-seven (37) genes that will be passed on from a

mother to her child. It is believed that the transfer of mitochondrial DNA from father to child does not occur at all. This is thought to be because after the fertilization has taken place, the egg that has been fertilized will destroy all traces of mitochondria that are taken from the sperm.

Conditions such as diabetes mellitus and loss of hearing are often associated with a point mutation of the mitochondrial DNA. This mutation will take place in the gene that is responsible for encoding tRNA leucine. This mutation in the gene will result in a substitution of the guanine for the adenine at position 3243. When this mutation tRNA Leu 3243 was initially identified as such it was seen in patients that had MELAS syndrome, which is mitochondrial myopathy, encephalopathy, lactic acidosis, and stroke-like syndrome. Diabetes is not associated to this syndrome in any way. This disassociation between the MELAS syndrome and diabetes has led to the belief the mitochondrial mutation may be conveyed as different phenotypes.

Neonatal Diabetes

Neonatal diabetes, which is also known as NDM is another form of diabetes that is considered to be monogenic. This form of diabetes occurs within the first six months of a baby's life and is a very rare condition. This condition is only diagnosed in one in 100,000 to 500,000 live births. Infants that are born with the condition are not able to produce an adequate amount of insulin and this lack of insulin will lead to an increase in the blood glucose.

Neonatal diabetes is often mistaken for diabetes mellitus type 1 and is often diagnosed as such. However, type I diabetes is not commonly seen within the first six months of life and occurs more commonly after the first six months. Approximately half the cases of neonatal diabetes that has been seen have been lifelong conditions. These cases have what is called

permanent neonatal diabetes mellitus, or PNDM. For the rest of patients that have neonatal diabetes, the condition only occurs for a brief period and will disappear during infancy. Though the condition passes it may reappear later on in life. This form of neonatal diabetes is known as transient neonatal diabetes mellitus, or TNDM.

The specific genes that are unique to the condition and are a cause of it have been identified. Some of the symptoms that may be seen when neonatal diabetes occurs are frequent urination, dehydration and thirst. Neonatal diabetes mellitus may be diagnosed by the discovery of an escalated level of glucose being found in either the blood or the urine.

In quite a few severe cases, an excess amount of acid in the body has been observed due to the lack of insulin. This lack of insulin and production of excess acid may result in ketoacidosis which can potentially be life threatening. In the womb, a fetus that has neonatal diabetes will not grow well and newborn that have the condition are considerably smaller than those at the same gestational age. This condition is known as intrauterine growth restriction. After a baby that has neonatal diabetes is born, it may not be able to gain weight but will still grow at the same rate as other babies of the same age as well as gender. If the appropriate therapy is applied then there will be normalization in the growth and development of the baby.

Pre-diabetes Risk Factors And Prevention

Pre-diabetes describes the state in which some of the diagnostic criteria for diabetes are met but not quite all of them. This is normally referred to as the midpoint or gray area between a normal blood sugar and a blood sugar that has reached diabetic proportions. A patient that is observed to have pre-diabetes has a very high risk of developing type II diabetes within a decade.

The development of pre-diabetes may be hindered by an adoption of a healthier lifestyle, which will involve an increase in physical activity as well as loss of weight. The pre-diabetes patient is also at an elevated risk of developing heart disease.

For a higher level of understanding about pre-diabetes, there must be some degree of comprehension about what pre-diabetes is and what pre-diabetes is not. Diabetes is considered as having a fasting plasma blood glucose that is at a level of 126 mg/dl or above having been tested on two different occasions. If a patient has symptoms that are unique to diabetes and opts to take a casual blood glucose test and the patient has a blood glucose that is 200 mg/dl or greater; and, after this person does a second test which shows the same high level of blood glucose, then it can be confirmed that the patient has diabetes.

On a general scale, an individual with a fasting plasma blood glucose of 100 -125 mg/dl is considered to have an impaired fasting glucose. If the patient is given an oral glucose tolerance test and after two hours has elapsed the blood glucose is 140 -199 mg/dl, then the patient has impaired glucose tolerance. If a patient is diagnosed with having any of the two, they are therefore considered to have pre-diabetes. In some cases, a medical clinician may misdiagnose a patient who has pre-diabetes, which stems from misinformation of the national guidelines to be used in the diagnosis of diabetes.

The individuals that are ideal candidates to be screened for pre-diabetes are those individuals that are 45 years old and over and are overweight; as well as those individuals that are overweight, under the age or 45 and have any of the risk factors listed below:

- The individual makes a habit of being inactive
- The individual has been identified before as having impaired fating glucose or impaired glucose tolerance.
- The individual has a family history of diabetes.
- The individual falls under the ethnic groups of Hispanic, Asian, Native American or African American.
- The individual has had gestational diabetes or has given birth to a child that had a weight of more than nine pounds.
- The individual has an increased blood pressure.
- The individual has a HDL cholesterol level of 35 mg/dl or lower.
- The individual has a triglyceride level of 250 mg/dl or higher.
- The individual has polycystic ovary syndrome.
- The individual has a history of vascular disease.

There are a few activities that a patient that has been diagnosed with pre-diabetes can do in an effort to reduce the risks of type II diabetes. The risk of developing type II diabetes may be significantly reduced if a patient has sustained modest body weight loss and has a moderate increase in physical activity such as walking for 30 minutes a day.

Summary

Diabetes mellitus is identified as type I, type II and gestational. Diabetes Mellitus type I, also termed T1DM, is the most common of the types of diabetes that prevails in children. Diabetes mellitus type II is a disorder of the metabolism that may be defined by the high level of blood glucose that exists from the point of view of insulin resistance and comparative insulin deficiency. Once known as adult onset diabetes mellitus (AODM) as well as noninsulin dependent diabetes mellitus (NIDDM), diabetes mellitus type II,

in contrast to type I with complete deficiency in insulin due to depletion of the cells in the pancreas, involves common symptoms of increased frequency in urination, an excessive feeling of thirst and a constant need to eat.

Ninety percent of the total U.S. population diagnosed with diabetes have type II diabetes while all of the other 10% of diabetes cases either suffer from type I diabetes or from gestational diabetes. Gestational diabetes mellitus is considered to be a treatable condition and those women that have adequate control of their blood glucose levels will automatically decrease their risk of getting the condition.

The main cause of type II diabetes is believed to be obesity for those patients that are genetically affected by the disease. In the initial stages of type II diabetes, an increase in exercise as well as modification in the patient's dietary practices are monitored. Lifestyle strategies such as diet and exercise are initial treatment strategies used to evaluate blood glucose levels before the need for medication is determined.

Medication may be prescribed in the forms of (injectable) insulin or (oral) metformin. Patients requiring treatment with injectable insulin usually need constant monitoring of the blood sugar level. The marked increase seen in cases of diabetes type II that have emerged over the last fifty years has been found to correspond to an increase in obesity cases.

Other types of diabetes raised in this course included those less common to diabetes mellitus type I and II, such as neonatal diabetes and maturity onset diabetes of the young (MODY). These diabetes types involve ineffective insulin production or release from the pancreatic beta cells. Genetic

mutations are defects understood to cause rare cases of diabetes. Current research has improved the medical knowledge and management of diabetes. Knowledge of the current research on the main and less common forms of diabetes mellitus is necessary for all health professionals to develop a comprehensive and thoughtful plan of care for those afflicted by the disease.

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1. **When there is a need for energy, glycogen, stored in the liver, will be transformed to glucose by a process known as:**

   a. glucogenesis
   b. glycogeneolysis
   c. gluconeogenesis
   d. none of the above

2. **The Glycated Hemoglobin (A1c) Test indicates the average of the patient's blood sugar level over:**

   a. two to three months
   b. two to three weeks
   c. one to two weeks
   d. 4 weeks

3. **True or false. An A1c level found to be at 4.5% or higher after doing two separate tests indicates that the patient has diabetes.**

   a. True
   b. False

4. **Trans fatty acids are forms of processed fats that are:**

   a. found in a wide variety of processed foods
   b. produced through a process of hydrogenation or partial hydrogenation
   c. are initially unsaturated fat heated to a very high temperature and a nickel catalyst is then added
   d. all of the above

5. **True of False. Gestational diabetes mellitus is considered to be a treatable condition and those women that have an adequate control of their blood glucose levels will automatically decrease their risk of getting the condition.**

   a. True
   b. False

6. Individuals consuming fructose-sweetened beverages experienced a significant increase in _____.

a. weight loss
b. ketoacidosis
c. visceral adiposity
d. renal failure

7. Pre-diabetes is a state between a normal blood sugar and one that has reached diabetic proportions, which has high risk of developing Type II diabetes in:

a. one decade
b. two decades
c. those reaching menopause
d. obese patients

8. Diabetes that existed before pregnancy is also divided into a number of sub-categories. Type D involves:

a. hardened pelvic vessels
b. initial onset before the age of ten or with duration greater than twenty years
c. diabetic nephropathy
d. proliferative retinopathy.

9. True or False. The mutations that occur in the HNF1A genes are the causes behind MODY3 while the cause of MODY2 is the mutations that occur in GCK genes.

a. True
b. False

10. After a baby with neonatal diabetes is born, the baby:

a. rapidly gains weight and grows at a faster rate as other babies
b. may normalize in growth/development after appropriate therapy
c. develops the same as any baby if the baby is male
d. none of the above

11. Placental hormones, and to a lesser degree fat deposits, that occur in women during pregnancy, seem to play a part in lessening the effects of insulin resistance during pregnancy. The main contributing factors are _____ and _____…

a. estrogen and progesterone
b. testosterone and progesterone
c. progesterone and cortisol
d. estrogen and cortisol

12. True or False. Trans fat intake plays a part in the development of the resistance of insulin but has *no effect* on issues of chronic inflammation.

a. True
b. False

13. The common symptoms that are related to type II diabetes are an increased frequency in urination, an excessive feeling of thirst and a constant need to eat.

a. increased frequency in urination
b. excessive feeling of thirst
c. constant need to eat
d. All of the above.

14. Of all the patients that suffer from diabetes, _____% of the population has type II diabetes.

a. 50
b. 75
c. 90
d. None of the above.

15. True or False. A diagnosis of maturity onset disease is generally made during the years of late childhood, during adolescence and even in early adulthood.

a. True
b. False

16. The fructose that is derived from high fructose corn syrup and any sugar may also play a big part in the development of type II diabetes. Fructose is

a. metabolized in the liver
b. metabolized to lipid
c. insulin resistance
d. All of the above

17. Fiber has an important role in the diet to

a. prevent colon infection
b. maintain the balance of insulin levels and blood glucose levels.
c. prevent gastroparesis
d. Both b and c above.

18. True or False. A patient is given an oral glucose tolerance test and after two hours the blood glucose is 95 -110 mg/dl, then the patient has impaired glucose tolerance.

a. True
b. False

19. Increase in glycemia acts as

a. a stimulant for the secretion of insulin from the beta cells
b. a stimulant for the secretion of insulin from the alpha cells
c. to reduce insulin release since sugar is in a form cells can use
d. Both b and c above.

20. Type F diabetes is defined by

a. diabetic retinopathy
b. diabetic neuropathy
c. diabetic nephropathy
d. diabetic ischemic heart disease

Correct Answers:

1. **When there is a need for energy, glycogen, stored in the liver, will be transformed to glucose by a process known as:**

   a. glucogenesis
   b. glycogeneolysis
   c. gluconeogenesis
   d. none of the above

   "*If there is a need for energy then glycogen, which is stored in the liver will be transformed to its previous state, glucose, by a process known as glycogenolysis*."

2. **The Glycated Hemoglobin (A1c) Test indicates the average of the patient's blood sugar level over:**

   a. two to three months
   b. two to three weeks
   c. one to two weeks
   d. 4 weeks

   "*The glycated hemoglobin (A1c) will give an indication of the average of the patient's blood sugar level over a course of two to three months*."

3. **True or false. An A1c level found to be at 4.5% or higher after doing two separate tests indicates that the patient has diabetes.**

   a. True
   b. False

   "*It has been generally accepted that if the A1c level is found to be at 6.5% or higher after doing two separate tests, then this is an indication that the patient has diabetes. The ADA had identified 5.7 to 6.4 percent, confirmed with a repeat A1c measurement, as increased risk for developing diabetes*…"

4. Trans fatty acids are forms of processed fats that are:

a. found in a wide variety of processed foods
b. produced through a process of hydrogenation or partial hydrogenation
c. are initially unsaturated fat heated to a very high temperature and a nickel catalyst is then added
d. all of the above

"*Trans fatty acids may be found in a wide variety of processed foods… The process that is used to produce these fats is called hydrogenation or partial hydrogenation. These processed fats are initially unsaturated fat and these unsaturated fats are then heated to a very high temperature. After the fat is exposed to the high degree of heat, a nickel catalyst is then added to the heated fat*."

5. True or False. Gestational diabetes mellitus is considered to be a treatable condition and those women that have an adequate control of their blood glucose levels will automatically decrease their risk of getting the condition.

a. True
b. False

"*Gestational diabetes mellitus is considered to be a treatable condition and those women that have an adequate control of their blood glucose levels will automatically decrease their risk of getting the condition*."

6. Individuals consuming fructose-sweetened beverages experienced a significant increase in _____.

a. weight loss
b. ketoacidosis
c. visceral adiposity
d. renal failure

"*Individuals consuming fructose-sweetened beverages experienced a significant increase in visceral adiposity*."

7. Pre-diabetes is a state between a normal blood sugar and one that has reached diabetic proportions, which has high risk of developing Type II diabetes in:

a. one decade
b. two decades
c. those reaching menopause
d. obese patients

"*A patient that is observed to have pre-diabetes has a very high risk of developing type II diabetes within a decade*."

8. Diabetes that existed before pregnancy is also divided into a number of sub-categories. Type D involves:

a. hardened pelvic vessels
b. initial onset before the age of ten (10) or with duration greater than twenty years
c. diabetic nephropathy
d. proliferative retinopathy.

"*The initial onset of type D diabetes is before the age of ten (10) or with duration greater than twenty years*."

9. True or False. The mutations that occur in the HNF1A genes are the causes behind MODY3 while the cause of MODY2 is the mutations that occur in GCK genes.

a. True
b. False

"*The mutations that occur in the HNF1A genes are the causes behind MODY3 while the cause of MODY2 is the mutations that occur in GCK genes*."

10. After a baby with neonatal diabetes is born, the baby:

a. rapidly gains weight and grows at a faster rate as other babies
b. may normalize in growth/development after appropriate therapy
c. develops the same as any baby if the baby is male
d. none of the above

"*After a baby that has neonatal diabetes is born, it may not be able to gain weight but will still grow at the same rate as other babies of the same age as well as sex. If the appropriate therapy is applied then*

there will be normalization in the growth and development of the baby."

11. Placental hormones, and to a lesser degree fat deposits, that occur in women during pregnancy, seem to play a part in lessening the effects of insulin resistance during pregnancy. The main contributing factors are _____ and _____…

a. estrogen and progesterone
b. testosterone and progesterone
c. progesterone and cortisol
d. estrogen and cortisol

"*To an extent, placental hormones, and to a lesser degree fat deposits, that occur in women during pregnancy, seems to play a part in lessening the effects of insulin resistance during the period of the pregnancy. The main contributing factors are progesterone and cortisol…*"

12. True or False. Trans fat intake plays a part in the development of the resistance of insulin but has *no effect* on issues of chronic inflammation.

a. True
b. False

"*Along with being one of the greatest contributors associated with cardiometabolic risk profiles and an increased risk of experiencing heart disease, trans fat intake also plays a part in the development of the resistance of insulin and chronic inflammation*."

13. The common symptoms that are related to type II diabetes are an

a. increased frequency in urination
b. excessive feeling of thirst
c. constant need to eat
d. All of the above.

"*The common symptoms that are related to type II diabetes are an increased frequency in urination, an excessive felling of thirst and a constant need to eat*."

14. Of all the patients that suffer from diabetes, _____% of the population has type II diabetes.

a. 50
b. 75
c. 90
d. None of the above.

"*Of all the patients that suffer from diabetes, 90% of the population has type II diabetes ...*"

15. True or False. A diagnosis of maturity onset disease is generally made during the years of late childhood, during adolescence and even in early adulthood.

a. True
b. False

"A diagnosis of maturity onset disease is generally made during the years of late childhood, during adolescence and even in early adulthood".

16. The fructose that is derived from high fructose corn syrup and any sugar may also play a big part in the development of type II diabetes. Fructose is

a. metabolized in the liver
b. metabolized to lipid
c. insulin resistance
d. All of the above

"*The fructose that is derived from high fructose corn syrup and any sugar may also play a big part in the development of type II diabetes. Fructose is metabolized in the liver to lipid, which will then lead to an increase in dyslipidemia, insulin resistance and lipogenesis*."

17. When educating diabetic patients, its important to emphasize that fiber has an important role in the diet to

a. prevent constipation.
b. maintain proper blood sugar balance.
c. prevent gastroparesis.
d. Both b and c above.

"*The accumulative effects of food processing will be a negative impact on the body as fiber has been proven by a number of studies to assist in the maintenance of proper blood sugar balance*."

18. True or False. A patient given an oral glucose tolerance test and after two hours shows a blood glucose of 95 -110 mg/dl may be evalutated to have impaired glucose tolerance.

a. True
b. False

"*If the patient is given an oral glucose tolerance test and after two hours has elapsed the blood glucose is 140 -199 mg/dl, then the patient has impaired glucose tolerance*."

19. Increase in glycemia acts as

a. a stimulant for the secretion of insulin from the beta cells
b. a stimulant for the secretion of insulin from the alpha cells
c. to reduce insulin release since sugar is in a form cells can use
d. Both b and c above.

"*This increase in glycemia acts as a stimulant for the secretion of insulin from the beta cells found in the pancreas. For glucose to be allowed into most cells, insulin has to be present*."

20. Type F diabetes is defined by

a. diabetic retinopathy
b. diabetic neuropathy
c. diabetic nephropathy
d. diabetic ischemic heart disease

"*Type F diabetes is defined by diabetic nephropathy*."

Here are the test questions and answers.

Test name: Diabetes Types, Diagnosis And Treatment, Diabetes Series: Part 1
Correct answers are in BOLD.

Question number 1: When there is a need for energy, glycogen, stored in the liver, will be transformed to glucose by a process known as:

a) glucogenesis
b) glycogeneolysis <-- your answer
c) gluconeogenesis
d) none of the above

Question number 2: The Glycated Hemoglobin (A1c) Test indicates the average of the patient's blood sugar level over:

a) two to three months <-- your answer
b) two to three weeks
c) one to two weeks
d) 4 weeks

Question number 3: True or false. An A1c level found to be at 4.5% or higher after doing two separate tests indicates that the patient has diabetes.

a) True
b) False <-- your answer

Question number 4: Trans fatty acids are forms of processed fats that are:

a) found in a wide variety of processed foods
b) produced through a process of hydrogenation or partial hydrogenation
c) are initially unsaturated fat heated to a very high temperature and a nickel catalyst is then added
d) all of the above <-- your answer

Question number 5: True of False. Gestational diabetes mellitus is considered to be a treatable condition and those women that have an adequate control of their blood glucose levels will automatically decrease their risk of getting the condition.

a) True <-- your answer
b) False

Question number 6: Individuals consuming fructose-sweetened beverages experienced a significant increase in _____.
a) weight loss
b) ketoacidosis
c) visceral adiposity <-- your answer
d) renal failure

Question number 7: Pre-diabetes is a state between a normal blood sugar and one that has reached diabetic proportions, which has high risk of developing Type II diabetes in:
a) one decade <-- your answer
b) two decades
c) those reaching menopause
d) obese patients

Question number 8: Diabetes that existed before pregnancy is also divided into a number of sub-categories. Type D involves:
a) hardened pelvic vessels
b) initial onset before the age of ten or with duration greater than twenty years <-- your answer
c) diabetic nephropathy
d) proliferative retinopathy.

Question number 9: True or False. The mutations that occur in the HNF1A genes are the causes behind MODY3 while the cause of MODY2 is the mutations that occur in GCK genes.
a) True <-- your answer
b) False

Question number 10: After a baby with neonatal diabetes is born, the baby:
a) rapidly gains weight and grows at a faster rate as other babies
b) may normalize in growth/development after appropriate therapy <-- your answer

c) develops the same as any baby if the baby is male
d) none of the above

Question number 11: Placental hormones, and to a lesser degree fat deposits, that occur in women during pregnancy, seem to play a part in lessening the effects of insulin resistance during pregnancy. The main contributing factors are _____ and _____...

a) estrogen and progesterone
b) testosterone and progesterone
c) progesterone and cortisol <-- your answer
d) estrogen and cortisol

Question number 12: True or False. Trans fat intake plays a part in the development of the resistance of insulin but has no effect on issues of chronic inflammation.

a) True
b) False <-- your answer

Question number 13: The common symptoms that are related to type II diabetes are an increased frequency in urination, an excessive feeling of thirst and a constant need to eat.

a) increased frequency in urination
b) excessive feeling of thirst
c) constant need to eat
d) All of the above. <-- your answer

Question number 14: Of all the patients that suffer from diabetes, _____% of the population has type II diabetes.

a) 50
b) 75
c) 90 <-- your answer
d) None of the above.

Question number 15: True or False. A diagnosis of maturity onset disease is generally made during the years of late childhood, during adolescence and even in early adulthood.

a) True <-- your answer

b) False

Question number 16: The fructose that is derived from high fructose corn syrup and any sugar may also play a big part in the development of type II diabetes. Fructose is

a) metabolized in the liver
b) metabolized to lipid
c) insulin resistance
d) All of the above <-- your answer

Question number 17: Fiber has an important role in the diet to

a) prevent colon infection
b) maintain the balance of insulin levels and blood glucose levels. <-- your answer
c) prevent gastroparesis
d) Both b and c above.

Question number 18: True or False. A patient is given an oral glucose tolerance test and after two hours the blood glucose is 95 -110 mg/dl, then the patient has impaired glucose tolerance.

a) True
b) False <-- your answer

Question number 19: Increase in glycemia acts as

a) a stimulant for the secretion of insulin from the beta cells <-- your answer
b) a stimulant for the secretion of insulin from the alpha cells
c) to reduce insulin release since sugar is in a form cells can use
d) Both b and c above.

Question number 20: Type F diabetes is defined by

a) diabetic retinopathy
b) diabetic neuropathy
c) diabetic nephropathy <-- your answer
d) diabetic ischemic heart disease

References Section

The References below include published works and in-text citations of published works that are intended as helpful material for your further reading.

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