

DIABETES SYMPTOMS AND COMPLICATIONS

DIABETES SERIES: PART II



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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. Common symptoms of diabetes mellitus is/are

- a. weight loss.
- b. unusually low blood glucose levels.
- c. infrequent urination.
- d. All of the above

2. True or False: Fluctuation in a patient's weight is a common symptom of possible diabetes mellitus.

- a. True
- b. False

3. Polyuria is described as

- a. significant weight loss.
- b. excessive production of urine.
- c. an elevated feeling of thirst.
- d. None of the above

4. High glucose level will _____ the risk of having eye problems.

- a. have no effect on
- b. decrease
- c. increase
- d. minimize

5. What is ketoacidosis?

- a. An increase in blood acids known as ketones
- b. An increase in urine production
- c. A decrease in blood acid production
- d. Difficulty in breathing

Introduction

Diabetes mellitus is often not recognized as a medical condition when a patient is first evaluated for symptoms. One of the primary reasons for this unawareness is due to the subtle symptomology that can occur and the fact that the patient's symptoms do not appear very dangerous. It is important that patients be diagnosed during the initial onset of diabetes to avoid serious complications in the future. The symptoms of diabetes, if present, can be very elusive and outwardly harmless, especially in a patient with diabetes mellitus type II. The risks associated with diabetes increase if the disease goes undetected as complications may still occur even if there are no noticeable symptoms.

Common Symptoms Of Diabetes

Recognizing the possible symptoms of diabetes is the first step toward helping patients lower their risk of complications associated with diabetes and to live a healthier life. This section discusses the common symptoms of diabetes mellitus.^{1-3,6-9}

Weight Loss

Fluctuation in a patient's weight is a common symptom of possible diabetes mellitus. Weight loss may be caused by a patient's constant need to urinate. Frequent urination may lead to a loss of sugar. The loss of sugar in turn will lead to a loss of calories due to the kidneys having to work to eliminate the excess sugar.

It is also possible for the patient to experience constant hunger; this occurs when glucose is unable to enter the cells to be used as energy. Since the glucose is unable to enter the cells, the body reacts in a way consistent with

starvation. The protein in the muscles is broken down as an alternate source of energy. This combination will lead to the patient losing weight at a very fast rate, especially in a patient that has diabetes mellitus type I.

Unintentional weight loss is more commonly seen in patients with type I diabetes. Concurrently, the kidneys work extra hard in an effort to get rid of excessive sugar in the blood. This leads to a loss of calories and to kidney damage. It is often a misconception that weight loss is always good for the body and is healthy. This is only true if an individual is intentionally losing weight by changing the diet or through exercise. This weight loss is beneficial to the cholesterol level, the heart and blood pressure. Additionally, weight lost in an intentional, beneficial way reduces insulin resistance and enhances insulin blood levels to act at the molecular and whole body level. The decrease in insulin resistance will help glucose metabolism at the cellular level. When body cells become resistant to insulin, higher than normal levels of blood glucose will occur. This is generally what occurs in a patient that has type II diabetes.

While intentional weight loss is beneficial to a diabetic patient, type II in particular, unintentional weight loss is not so beneficial. Quite often, when a patient is first diagnosed with diabetes it is usually during a visit to a medical clinician for inexplicable weight loss. While this weight loss may be linked to diabetes, the patient should also be checked for other medical conditions, such as thyroid disease and cancer. If a patient is not trying to lose weight intentionally (such as, the patient has not been exercising or dieting to lose weight for health reasons but losing weight at a rapid rate) it may be linked to diabetes mellitus. The patient should be thoroughly evaluated at that time.

Polyuria

Excessive urine production or polyuria is often seen in a patient with uncontrolled diabetes mellitus. Polyuria is diagnosed when a patient passes 2.5 to 3 liters of urine over a 24-hour period. It is essentially a function of the kidneys attempting to filter some of the glucose that is in the blood stream. It would be wasteful for glucose to be flushed out of the system through urination, so this filtered glucose is reabsorbed into the bloodstream once again by the kidneys. Once the level of glucose that can be reabsorbed is reached, some of the glucose will then be flushed out in the urine. In some cases this may be considered a good thing. In those cases where the blood glucose level is pathologically too high, the loss of glucose through the urine will lower it. The estimated threshold for this in an individual (who is not pregnant) is approximately 10 mmol of glucose per liter. If this threshold is exceeded then it will be lost through urination.

The excess glucose that is excreted in the urine will be a trigger for more urine to be produced. This occurs because glucose is considered to be a very powerful osmolyte. Like urea and sodium, glucose is able to stimulate water to flow after it. This means that when the glucose level in the urine exceeds a normal amount, excess water will be present as well. This causes polyuria to occur. Polyuria may also occur along with polydipsia even though one may occur without the presence of the other.

Polydipsia

Polydipsia is the term used for excessive thirst that an individual may experience with uncontrolled diabetes mellitus. It is common for polydipsia to be either the cause or the effect of polyuria.

Polydipsia is an abnormal symptom, which occurs in a patient that has diabetes mellitus during the initial onset of the disease. Polydipsia will also occur in those patients that have already been diagnosed with diabetes and are being treated but who refuse to take their medication or are not being treated with the adequate dosage. There are a number of other abnormal conditions along with polydipsia, such as hypokalemia that may occur during a hemorrhage where the blood volume is decreased or other conditions that deplete the body's water volume. Polydipsia will normally also transpire as a result of osmotic diuresis as well as possibly being caused by diabetes insipidus, which is known as *tasteless* diabetes.

Since polydipsia is associated with a constant and excessive thirst, it will also occur in conjunction with either a temporary or extended dryness of the mouth. In a non-diabetic individual, it is not unusual to be thirsty at several intervals during a day. It is very important for a person to have several intakes of water daily, as water is vital for survival. Water is a key element in many bodily processes, such as aiding in the regulation of the body temperature as well as assisting in the removal of waste. On the other hand, if an individual is experiencing a degree of thirst that is unusual or feels the need to drink more after just having had a drink, then this may be a sign that something is not right. If this occurs over a period of time without relief then it is advised that the patient be tested.

Though an increase in thirst may be associated with fluid loss, such as normally occurs following exercise or as a result of an acute illness, thirst may also be due to an increase in the blood sugar levels of patients diagnosed with diabetes mellitus; and, is suggestive of the need for further investigation in those undiagnosed with the disease. Patients that have already been diagnosed with diabetes mellitus and have access to equipment

for testing the blood glucose level should pay close attention to when they are experiencing an intense and persistent feeling of thirst. In these cases, it is common for an increase in the blood sugar level to occur. Those patients that have no access to equipment to test the glucose level should be advised to seek the assistance of a health clinician for excessive, prolonged thirst.

It is important for a patient to be able to recognize the signs of polydipsia. A normal individual would experience occasional thirst and not assume that feeling thirsty is due to polydipsia. There are markers that have been established as a method of better recognizing polydipsia. If a patient has been experiencing an excessive amount of persistent and unexplained thirst, even after having already consuming an adequate amount of liquid, then the patient has polydipsia. A patient may also be determined to have polydipsia if more than 5 liters of urine is being excreted daily. For a patient that has diabetes mellitus, seeking medical attention should be advised for prolonged thirst, such as for several days. In a case where there is no prior diagnosis of diabetes mellitus, medical attention should also be sought, as excessive thirst may be a symptom of the initial onset of the disease. This is particularly important when polydipsia is also accompanied by other symptoms of diabetes mellitus such as polyphagia and polyuria.

Polyphagia

A common symptom that will be experienced by a diabetic patient is polyphagia. Polyphagia is often referred to as *hyperphagia*. This term describes the feeling of excessive hunger or an unusually large appetite. The expression was derived from the Greek word *poly*, which means *very much*, and *phago*, which means *eat*. As it pertains to medicine, polyphagia describes the feeling of extreme levels of hunger and an abnormal amount of solid intake by mouth. Polyphagia will be seen in the very early stages of

diabetic ketoacidosis. It must be noted, however, that as insulin deficiency begins to increase, the appetite will simultaneously decrease as ketoacidosis develops.

Polyphagia is known to be one of the three main symptoms, the other two symptoms being polyuria and polydipsia as explained previously that is observed in a patient with diabetes mellitus. The increase in a normal individual's level of hunger and appetite usually occurs as a response to strenuous exercise or after rigorous exercise. In polyphagia, however, this increase in appetite may occur as a result of stress, depression or anxiety.

In a patient with uncontrolled diabetes mellitus, the blood glucose levels may be unusually high. This abnormally high level of blood glucose or hyperglycemia inhibits glucose from entering the cells, which may be a result of insulin resistance or a lack of insulin. Food that has been eaten will not be available as energy. Due to the inability to convert food into energy, an individual will lack energy, which will be a trigger for increased hunger.

When a very high glucose level causes hunger in a diabetic patient, consuming food will only be a means of increasing the blood glucose levels further. This will be the beginning of a vicious cycle, as the duration of the hunger will only be lengthened. When a diabetic patient experiences hunger due to an increase in the blood glucose level, it is advised that the patient participate in some sort of exercise. This exercise may be as simple as walking because it will help to decrease the blood sugar levels. On the other hand, an unusual low level of blood glucose or *hypoglycemia* may also cause increase in appetite.

When the blood glucose level falls below 4 mmol/l, an automatic physiological response occurs with the release of glucose previously stored in the liver. This is a natural response of the body to raise the blood glucose to its normal level. Patients that have diabetes mellitus, which is being treated with medications such as insulin or sulfonylureas are at risk of developing a more severe form of hypoglycemia than typically encountered. This severe form of diabetes should be given immediate attention and treated by consuming something sugary as soon as hypoglycemia is recognized.

A patient that has diabetes mellitus should be prepared to recognize the signs associated with polyphagia. The primary indicator of polyphagia is an excessive hunger that is not diminished by simply eating an increased amount of food or by eating more often than one would normally eat. A patient that is experiencing an increase in hunger should be advised to seek medical attention in order to receive a proper diagnosis. This will help to determine whether the polyphagia is related to diabetes mellitus or another medical condition.

Vision Impairment

The symptoms of diabetes may oftentimes include the vision. An increased blood sugar level will draw fluid from the tissues; this will include the lens of the eyes. This will affect the ability of the patient to focus. If this is left untreated, diabetes mellitus may enable the formation of new blood vessels in the retina, which is the posterior section of the eye and cause damage to the vessels already present. In most patients with diabetes, the early changes will not have an extensive effect on the vision but if this problem continues untreated over a period, then vision loss or blindness may occur. A patient that has been diagnosed with diabetes mellitus should be advised to make frequent visits to an eye specialist in order to diagnose and treat any

eye problems that may arise. When glucose levels increase to a level that is too high, the risk of having vision and eye issues will also increase. The leading cause of blindness in adults between 20 to 74 years of age has been discovered to be diabetes mellitus.

Oftentimes, blurred vision may be associated with high blood sugar levels in a patient that has diabetes. This will come on unexpectedly and rapidly. As the blood sugar levels rise in the patient, the lens of the eye will swell which will cause an impairment of the vision. In order for this problem to be corrected, the patient's blood sugar level should be brought back to the target level. In some cases, the vision is not completely corrected until a full three months after the problem is initially addressed. The patient's vision will then return to normal. The main eye problems that are associated with patients that have diabetes mellitus are cataracts, retinopathy and glaucoma.

A cataract condition involves fogging over a normally clear eye lens. The lens of the eye, similar to that of a camera, helps with vision and focus. Cataracts may affect individuals that do not have diabetes mellitus, but is seen in those with diabetes at a much higher rate and earlier age as well. The condition may also progress at a more rapid rate in those patients with diabetes than in those without it. A patient that is developing or has a cataract will have an area of the eye lens with a cloudy effect. This clouding of the lens will impair the vision by inhibiting the ability to focus on light. In the early stages of the symptom, the patient will experience glared or blurred vision. Cataracts may be corrected by means of surgery in which the affected lens is removed and is replaced by a man-made lens.

Another of the eye conditions that is generally associated with diabetes mellitus is glaucoma. This occurs when the fluid in the eyes is not able to drain properly. The lack of drainage will then cause excess pressure on the eye which may in turn cause damage of the nerves as well as affect the blood vessels of the eye, leading to impairment of the vision.

The most common form of glaucoma is open angle glaucoma. This may be treated by a decrease in the pressure on the eye by increasing the drainage of aqueous humor or by a decrease in the production of the fluid. There may be no signs of the condition in the initial stages but signs will show up in the latter stages after there is already extensive damage, and a significant loss of vision. Less commonly seen symptoms of this condition may include headaches, eye aches, watering eyes, loss of vision, blurred vision and halos around lights. In patients with diabetes mellitus, this may be treated through laser procedures, eye drops, medication or surgery. When there is an immediate need for drainage of aqueous drainage, the most effective treatments are surgery or laser procedures.

Individuals with diabetes mellitus should be advised to consult with an eye specialist occasionally for glaucoma screening. Additionally, a less common form of glaucoma known as *neovascular* glaucoma will also affect patients diagnosed with diabetes. In neovascular glaucoma there will be a growth of new blood vessels on the iris that occur. The new blood vessels will block the regular flow of eye fluid, which will cause an increase in eye pressure. This form of glaucoma is more difficult to treat but may be treated with laser surgery, which will decrease the blood vessels. The use of implants to assist in fluid drainage when glaucoma exists is one possible form of treatment, which has undergone continual medical research.

Diabetic Skin Conditions

Diabetes mellitus has the ability to affect all parts of the body, which may include the skin. A skin condition may be the first indicator that a patient has diabetes. In most cases of diabetes, a skin condition may be easily treated or prevented if caught in the beginning stages. There are some skin conditions that affect patients with diabetes mellitus that may affect other individuals; there will just be a higher prevalence rate among those with diabetes. The most common of skin conditions that occur with diabetes involve itching, fungal and bacterial infections. The skin conditions that are unique to those with diabetes mellitus include necrobiosis lipoidica diabetorum, diabetic dermopathy, eruptive xanthomatosis and diabetic blisters.

Bacterial Infections

There are several forms of bacterial infections that may occur in a patient that has diabetes. These bacterial infections manifest as boils, styes, carbuncles, folliculitis and infections of the nails. The inflamed tissues will appear swollen, hot, painful and red in appearance. These infections may be caused by a host of organisms; the most common of these being Staphylococcus bacteria (staph) that are more commonly seen in patients with diabetes than without.

In the past, when an individual with diabetes contracted a bacterial infection it could lead to death, more so in than in individuals without diabetes. In recent years, the occurrence of death from an infection is very rare due to improved blood sugar control and antibiotics. The occurrence of skin conditions in patients with diabetes is still higher than in individuals without the disease. Good skin care is a proven effective method of controlling bacterial infections in patients with diabetes.

Fungal Infections

The leading cause of fungal infections in patients with diabetes is *Candida albicans*. This is yeast like fungus, which may cause itchy rashes that may be moist and red, and surrounded by small scales and blisters. These infections will commonly occur in the folds of the skin, which are warm and moist. The areas are inclusive of the corners of the mouth, between the toes and the fingers, under the breasts, around the nails, in the armpits and groin as well as under the penis foreskin. The common forms of fungal infections include athlete's foot, jock itch rash, ringworm, and vaginal infections, often involving marked inflammation and itching.

Skin Itchiness

Diabetes is most often the cause of localized itching. This may be caused by a number of reasons, which will include dry skin, poor circulation and yeast infection. When the associated cause of itching is poor circulation, the part of the body most affected will be the lower areas of the legs. Itching may be treated in a patient through limiting the number of baths, using soaps that are mild and through the application of skin cream after taking a bath.

Acanthosis Nigricans

This is a condition that is uniquely associated with diabetes mellitus. In this acanthosis nigricans, brown or tanned areas will appear in the sides of the groin, neck or armpits. They will often times appear on the knees, hands and elbows as well. In most cases of the condition, the patient is noted to be overweight. In these cases, the best method of treatment is to lose weight or the application of cream to the affected area may also help.

Diabetic Dermopathy

This is another condition that will be found only in patients with diabetes mellitus and is the most common indicator of diabetes related to the skin. Diabetes may cause a change in small blood vessels. These changes will in turn cause problems with the skin. This is what is termed as diabetic dermopathy. This condition is light brown and scaly in its appearance. The patches may either be circular or oval and are often mistaken for age spots. The area most commonly affected by the condition is the anterior section of the legs though both legs may not be affected to the same degree. The patches are not painful, itchy and do not open.

Necrobiosis Lipoidica Diabeticorum

The changes in blood vessels may cause necrobiosis lipoidica diabeticorum, also known as NLD. NLD will appear as spots which are similar to diabetic dermopathy but are larger, deeper and fewer. This condition will appear as red, dull, raised areas in the initial stages but will in time take on a shiny, scar-like appearance with a violet outline. The blood vessels beneath the skin will become more visible. NLD may sometimes be itchy, painful and may also crack open. It is a very rare condition and will be mostly seen in adult females. If the sores are not open then there is no need for treatment. However, in the event that the sores open up, it should receive immediate medical attention.

Diabetic Blisters

Though this is rare, patients with diabetes mellitus may also break out in blisters. These blisters may appear on the hands, feet, backs of the fingers, toes, and at times the forearms or the legs. These sores will have the appearance of burn blisters. This condition will often occur in patients with

diabetic neuropathy (damage to the nerve fibers throughout the body, discussed in more depth later on). They will sometimes be large but will not be painful or red in appearance. These blisters will heal by themselves within a period of three weeks and often without a scar. They may be treated by regaining control of the blood sugar level.

Eruptive Xanthomatosis

A condition unique to patients that have uncontrolled diabetes mellitus is eruptive xanthomatosis. The condition will cause small, firm, yellow enlargements of the skin. Each of these enlargements will have a red border and may often itch. The most commonly affected areas associated with this condition are the legs, buttocks, arms, feet and hands. Young, male patients with diabetes mellitus type I are most frequently affected by this condition. Patients affected by this may also have high levels of fat and cholesterol in the blood. As with diabetic blisters, when the level of blood glucose is back under control the enlargements will disappear.

Digital Sclerosis

Patients with diabetes will experience what is known as digital sclerosis. This is the development of thick, waxy tight skin on the back area of the hands. There may also be a thickening of the skin of the toes and the forehead as well. The joints of the fingers may become stiff and the patient will experience some difficulty in moving them, as they would have normally done. On some occasions, though rare, the elbows, knees and ankles will also become stiff. This condition will appear in a third of the patients with diabetes mellitus type I. Bringing the blood sugar level under control is the treatment for this condition.

Disseminated Granuloma Annulare

In this disseminated granuloma annulare the patient will experience raised areas of the skin, which is circular or arc shaped. These rashes will most commonly appear on the ears or the fingers and may be red, reddish-brown or skin toned in its appearance. This condition may be treated with special medications, such as dapsone, retinoids, or niacinamides.

Abdominal Pain In The Diabetic Patient

There are various distinctive associations between diabetes and vomiting. Since there are an incomprehensible number of explanations for why a patient with diabetes mellitus could be experiencing vomiting, it is vital for the patient to seek medical help in order to confirm the true reason behind the advancing symptom. A possible serious cause of diabetes and vomiting is diabetic ketoacidosis, which has already been explained as a life-threatening condition brought on as a result of uncontrolled diabetes. Patients with long-standing diabetes could develop a disorder of *gastroparesis*, which involves delayed gastric propulsion and emptying. Another reason could be a reaction to medication that causes an individual with diabetes to experience nausea or vomiting.^{6,15-17,31-35}

The most dangerous connection between diabetes and vomiting happens when the underlying diabetes is uncontrolled and diabetic ketoacidosis develops. This advances when the levels of glucose are high, yet incomprehensibly the body cells do not have enough sugar since the insulin is not working correctly. Thus, the body begins to metabolize different substances for nourishment. Due to this fact, the blood becomes more acidic, and signs begin to appear such as vomiting, sickness, weakness, sleepiness, an increased level of thirst and an increased need to urinate. If it goes untreated, this condition may become deadly, therefore when the

combination of diabetes mellitus and vomiting is observed, DKA should be at the top of the diagnostic differential and ruled out.

Another link between diabetes and vomiting is a complication of diabetes mellitus, which is known as gastroparesis. Gastroparesis, which is also called delayed gastric emptying, is a medical condition comprised of a paresis (partial loss of movement) of the stomach, which will result in food staying in the stomach for a longer time than normal. Usually, the stomach contracts to move food down into the digestive tract for processing. The vagus nerve controls the stomach's contractions. Gastroparesis may happen as a result of the vagus nerve being damaged and the muscles of the stomach and intestines not working in their normal manner. Foods will then move gradually or quit traveling through the digestive tract.

Diabetes and chronically high levels of sugar in the blood can harm various parts of the body. Nerves are especially sensitive to being harmed by the elevated concentration of sugar. This also includes the nerves that help to facilitate the movements of the stomach. After experiencing nerve damage, the stomach will develop the ineffective emptying that is deemed gastroparesis. Patients experiencing this illness frequently have indicators of nausea vomiting and abdominal pain.

It is not uncommon for the connection between diabetes and vomiting to result from a reaction to medication. Metformin, which is usually one of the first medications endorsed for patients with type II diabetes, generally causes gastrointestinal irritation. Aside from the fact that Metformin more commonly causes intense stomach cramping and loose bowels, a few patients could also encounter vomiting as a side effect. Different medication inclusive of those in the *sulfonylurea* class of oral diabetes agents could

additionally cause nausea and vomiting in some patients. Since there are various distinctive explanations for patients with diabetes mellitus experiencing vomiting, it is critical for their medical clinician to be fully aware of the true cause behind the vomiting and closely follow up patients with these symptoms.

Patients with diabetes mellitus could develop vomiting because of other causes, such as, gastroenteritis, food poisoning, or different infections. When a patient with diabetes mellitus is unable to consume food, they should be advised to reduce the amount of insulin or different diabetic medication they are taking to prevent the development of low blood sugar.

Diabetic Ketoacidosis

Diabetic Ketoacidosis (DKA) is a very serious and life-threatening condition. This occurs in diabetic patients when the body begins to produce an increased level of blood acids known as *ketones*. This complication takes place when the patient's body is unable to produce an adequate amount of insulin. Without an adequate amount of insulin, the body is forced to break down fat as an alternate source of energy. When this process takes place, there will be a build-up of ketones in the blood stream that are toxic, and will lead to diabetic ketoacidosis if it remains untreated. DKA symptoms and complications are reviewed here.¹³⁻¹⁵

Untreated ketoacidosis will eventually lead to a diabetic coma, or even death. Diabetic ketoacidosis is a serious condition with potentially grave outcomes that requires rigorous life-saving interventions. Ketones are an indicator to individuals with diabetes mellitus that the blood sugar level is out of control. Large amounts of ketones have the ability to poison the body. The point at which levels get excessively high, a patient may advance the

ketoacidosis state. This condition may occur in any patient that has diabetes mellitus; however, it is uncommon in individuals with type II diabetes. The treatment of ketoacidosis will generally take place in a medical facility. A patient is able to prevent DKA, however, by taking heed to the cautionary signs and checking the urine and blood on a regular basis.

Indicators of Diabetic Ketoacidosis

Diabetic ketoacidosis is a condition that will advance gradually. In the cases where vomiting occurs, this life-threatening condition can build up in only a matter of a couple of hours. Early indicators of the condition include the following:

- Dehydration or an extremely dry mouth
- Increased frequency in urination
- High blood glucose levels
- Large amounts of ketones in the urine

Thereafter, other warning signs will appear:

- Frequently feeling tired
- Dry or flushed skin
- Nausea, vomiting, or stomach pains. (Vomiting may be a sign of numerous illnesses and not just DKA. In cases where nausea or vomiting remains constant for more than a couple of hours, a patient should be advised to seek medical attention).
- Trouble with breathing
- Fruity odor of the breath
- A hard time concentrating or uncertainty

Ketones are identifiable with a simple urine test strip, much like a blood testing strip. Clinicians should encourage patients with diabetes to check

their urine for ketones when the blood glucose is above 240 mg/dl. When a patient develops an illness, whether a minor cold or the flu, they should be advised to check for ketones every 4-6 hours; the patient should check every 4-6 hours to ensure that the blood glucose level is not above 240 mg/dl. Additionally, diabetic individuals should vigilantly pay attention to ketones when there are other associated indicators of diabetic ketoacidosis.

Abnormal Ketone Levels

Patients may be unaware of what ketone levels are medically considered at risk. It is important to educate the diabetic patient to seek medical assistance when ketone levels are at a moderate level after more than one test. The patient may then need to be guided on how to redo the test and what it is that they should be looking for.

Medical assistance should be obtained if the patient encounters any of these accompanying conditions:

- The urine tests demonstrate large amounts of ketones.
- The urine tests demonstrate large amounts of ketones and blood glucose concentration is high.
- The urine tests demonstrate large amounts of ketones and the patient has vomited more than twice in four hours.

High amounts of ketones occurring along with a high blood glucose level are an indicator that the patient's diabetes is out of control. There are three fundamental explanations behind a moderate to high level of ketones.

- Insufficient insulin:

There was an inadequate application of insulin. On the other hand, the body could require more insulin than regular as a result of illness.

- Insufficient food

When a patient is experiencing an illness, they will often not feel the need to consume any food. This will commonly trigger a response of high ketone levels. Large amounts may come from failure to have a meal.

- Insulin response (low blood glucose)

If testing shows high ketone levels in the morning, the patient may have had an insulin response of low blood sugar while asleep.

Kussmaul Breathing

Kussmaul breathing is a deep and toiled breathing with associated frequent recurrence, which is observed in patients with intense acidosis. It is considered to be a signal of hyperventilation. Kussmaul breathing was named after Adolph Kussmaul, the nineteenth century German doctor who initially noted it in patients with advanced diabetes (type I). He distributed his finding in a prototypal 1874 paper. The basis for Kussmaul breathing occurrences is respiratory compensation for a metabolic acidosis, most usually experienced by diabetics during diabetic ketoacidosis. Blood gases in a patient with Kussmaul breathing will demonstrate a low pCO₂ (carbon dioxide) in light of a constrained increased breathing (blowing out the carbon dioxide). The patient will experience an increased urge to inhale deeply, an *air craving*, and it shows up without much warning signals.

A metabolic acidosis soon results in hyperventilation; however, in the initial stages it tends to be quick and moderately shallow. Kussmaul breathing simultaneously increases in intensity as the acidosis develops to more extreme levels. In fact, Adolph Kussmaul initially identified this sort of

breathing as an indication of coma and impending death in patients with diabetes mellitus; breathing when metabolic acidosis was sufficiently intense that respiratory rate was reduced. The term Kussmaul respiration has also been adapted for when acidosis is less extreme, in which case breathing is slightly less rapid. It should be noted that Kussmaul breathing happens just in advanced phases of acidosis and is seldom reached.

In less extreme instances of acidosis, fast, shallow breathing is seen. Kussmaul breathing is quite profound. Some of the medical literature has alluded to any unusual breathing patterns in acidosis as being Kussmaul breathing, however, this is erroneous.

Acute And Chronic Diabetic Health Complications

The complications attached to diabetes mellitus will generally develop gradually, over a period of time. Patients with diabetes for a long time will have a higher risk of complication occurring, especially in cases where the blood sugar is less controlled. Diabetic patients are at a higher risk of developing serious health complications and even infections. The complications associated with diabetes mellitus may be disabling and in some severe cases life threatening. On a worldwide scale, more frequently in high-income countries, diabetes is one of the leading causes of cardiovascular disease, blindness, kidney failure and amputation. The health complications of diabetes mellitus fall under two main categories, *acute* and *chronic*, which are discussed in this section.^{14,15,36-58}

Acute Diabetic Ketoacidosis

Diabetic ketoacidosis as previously discussed is an intense, significant, life-threatening complication of diabetes mellitus that often occurs in an acute

crisis. DKA, while it generally occurs in patients with type I diabetes, is not unusual in a few patients with diabetes mellitus type II. DKA is a state of absolute or relative insulin deficiency aggravated by consequential hyperglycemia, dehydration, and acidosis ultimately resulting in an abnormal metabolism. The most common reasons for this are interruptions in insulin medication, causal infections, and new onset of diabetes mellitus. More specifically, DKA is the *acute state* of severely uncontrolled diabetes, which is associated with ketoacidosis.

This acute state will generally require the emergency treatment of insulin and intravenous fluids. In biochemical terms, DKA is defined as the increase in the serum concentration of the ketones, which is greater than 5 mEq/L, a blood glucose level, which is higher than 250 mg/dL and a blood pH less than 7.3. This is a complex metabolic state in which hyperglycemia, ketoacidosis, ketonemia and ketonuria will be characteristic. This will normally occur in the face of an absolute or a relative deficiency of insulin, which may be accompanied by a counter regulatory hormone increase. This type or imbalance in the hormones will act as an enhancer for hepatic gluconeogenesis, lipolysis and glycogenolysis.

Hepatic gluconeogenesis, glycogenolysis, which is secondary to a deficiency of insulin as well as counter regulatory hormone excess, will lead to a result of severe hyperglycemia. On the other hand, lipolysis will cause an increase in serum free fatty acids. The ketone bodies are produced from *acetyl coenzyme A* primarily in the mitochondria with hepatocytes when the use of carbohydrates is impaired due to a deficiency in insulin either relatively or absolutely. A high level of acetyl coenzyme A present in the cell will change the metabolic pathway of glucose, disrupting the normal physiology of the cell. The body prefers to take the *path of least resistance*, but abnormal

physiology takes precedence over this and forces the cell into an abnormal metabolic pathway, ultimately shifting the way macronutrients are used in the body. This is another consequence associated with insulin resistance or insulin deficiency. Common forms of ketones include acetone, acetoacetate and beta-hydroxybutyrate.

A progressive rise in the blood concentration of these acidic organic substances will, in its initial stages, lead to a state of ketonemia even though both extra and intracellular body buffers are able to limit the ketonemia in the early stages. When the ketones that have accumulated exceed the ability of the body to get rid of them, they will then overflow into the urine (ketonuria). If the occurrence of this is not addressed immediately, the greater increase in the organic acid will lead to ketoacidosis, which is clinical metabolic acidosis with an associated decrease in pH and bicarbonate serum levels.

In an acute crisis, when the body attempts to compensate for the acidotic conditions through respiration, there will be a resulting rapid shallow breathing, or Kussmaul breathing, as explained earlier. The ketones, more particularly beta-hydroxybutyrate, may induce nausea and vomiting that will in turn worsen loss of fluid and electrolytes, which exist in DKA. Acetone will also produce the fruity breath scent, which is attributed to ketotic patients. A lot of the underlying pathophysiological disorders of DKA in an acute or crisis situation may be directly measured by an intensivist clinician in an Intensive Care Unit setting and will require constant monitoring through the duration of treatment.

Hyperosmolar Hyperglycemic Nonketotic Syndrome

Hyperosmolar hyperglycemic nonketotic syndrome, also known as HHNS, is a severe condition that is associated with diabetes, and is mainly seen in elderly patients. This condition may occur in any patient with diabetes mellitus, either type I or type II that is not controlled efficiently. It will however be seen more regularly in those patients that have type II. When HHNS occurs, it is commonly brought on by another condition such as illness or an infection. When this condition occurs, the blood sugar level of the patient will rise and the body will attempt to eradicate the excess sugar by passing it through the urine.

There will be an increase in the level of urine that is produced initially causing an increased need to pass urine. However, in the latter stages, there will be a decrease in the urge to urinate and the urine will appear darker. There may also be an increase in thirst associated with the condition as well. If adequate amounts of liquid are not consumed, then the patient is at risk of becoming dehydrated. If HHNS is allowed to progress, the dehydration will lead to seizures, coma and eventually death. The development of HHNS may take weeks but knowing the warning signs of the condition may assist in preventative action before it leads to more grave circumstances. Warning signs include:

- Dry parched mouth
- Extreme thirst
- Loss of vision
- Warm skin that does not sweat
- Sleepiness
- Confusion
- Hallucinations
- High fever (over 101 degrees)

- Weakness of the body
- Blood sugar level (above 600 mg/dl)

An occurrence of HHNS is only brought on when diabetes mellitus is not controlled. The condition may be avoided if a patient's blood sugar level is checked on a regular basis. A patient may check the blood sugar level at several intervals during a day, for example before and after meals. Tissues that are more sensitive to insulin will take up more glucose during a meal when the rise in the glycemic level of ingested carbohydrates stimulates insulin secretion. The increase in the insulin level will reduce the glucagon that is released from the pancreatic islets and the ratio of plasma insulin to glucagon becomes relatively high.

In healthy individuals, when the ratio of insulin to glucagon is high, it will induce the storage of glucose as glycogen in the liver and muscle and as lipogenesis in adipocytes. A high level of insulin to glucagon ratio will also enhance amino acid intake of the muscle during meals. Between meals, there is no stimulation of insulin secretion therefore the insulin mediated glucagon reduction in the pancreatic islets will be halted. The glucagon levels will rise in the plasma and this will lead to a decrease in the plasma insulin to glucagon ratio. This decrease will consequentially lead to the breakdown of glycogen in the liver and in the muscles, also gluconeogenesis by the liver. These will both work to maintain the plasma glucose concentration in a range that is normal. The decrease in the insulin to glucagon ratio will also enable lipolysis as well as the formation of ketone bodies by the liver.

There are several tissues within the body that will utilize the glucose despite the level of the insulin to glucagon ratio. The tissues that are dependent on insulin include the brain and the kidneys. For patients that have a pre-

determined lack of insulin or a resistance to insulin, a physiological stress factor such as an acute illness will only work to further the net reduction of insulin circulation. The basic mechanism of HHNS is a relative or absolute reduction in the effective circulation of insulin. It is important to note that patients with HHNS are not like those with DKA, as they do not develop severe ketoacidosis; however, the reason for this is unknown.

In the face of HHNS, if the renal water loss is not made up for by the intake of oral fluids, then dehydration will lead to hypovolemia. Hypovolemic conditions are associated with hypotension, which then leads to an impairment of tissue perfusion. The ultimate result of this hyperglycemic process will be coma if severe electrolyte disturbances result in accordance with hypotension. If a condition leading to an increase in the loss of water occurs, for example diarrhea or a case of severe burns, then there will be an acceleration of hyperosmolarity and hypotension.

In the presence of a severely dehydrated and hyperosmolar state, there will be a huge stimulation of the renin-angiotensin-aldosterone system caused by the hypotension. When this occurs, it will ultimately lead to renal shutdown. Oliguria will prohibit the further excretion of glucose from the kidneys in an effort to conserve the levels being circulated but will intensify hyperglycemia.

Cardiovascular Disease

There is a very direct relationship between diabetes mellitus and the chronic occurrence of cardiovascular disease. Studies have been carried out over the course of the past few decades that have shown that there is a two- to four-fold increase in the incidence of heart disease for patients that had diabetes than in patients that do not have the disease. Adult females that have

diabetes have an even greater risk of developing heart disease in comparison to women of the same or similar ages that do not have diabetes mellitus.

The most frequent cause of death in both male and females with diabetes is cardiovascular disease, which may result from heart attack or stroke. There is also the factor of poor circulation in the legs, which is a very large component of cardiovascular disease. This may lead to foot ulcers and even amputations. There have been several advances that have been made in the past 20 years in the treatment of heart disease, which has served to increase the odds of surviving heart attacks and strokes. However, with the rate of diabetes mellitus cases steadily increasing, the new cases of cardiovascular disease and complications have also made a steady rise. Patients with diabetes are at a distinct disadvantage in terms of improvement after a heart attack, which is lower than half of the general populace.

Diabetes mellitus has been deemed the strongest risk factor associated with incidents of heart disease. It may not just be credited to only high blood glucose; rather, to a combination of interacting mechanisms. In patients with diabetes, the blood vessels are more vulnerable to other risk factors namely high cholesterol, smoking and high blood pressure. These risks factors have been observed, either alone or combined, in more than 90% of patients. There have been studies done that have proven there is a hastening of the chance of premature heart disease by 10 years when smoking is involved. The increased susceptibility could be due to the long-term effects of an inadequate control of the blood sugar levels in the body or it may also be as a result of other cell damage, which may be related to diabetes.

It has also been observed that when obesity, inactivity and poor blood glucose control are factored in, there is an increased chance of high blood pressure as well as abnormalities in the blood lipids occurring. Research is continuously being undertaken in order to identify the role of additional risk factors. It has been observed that patients that have diabetes mellitus have an elevated level of low-grade inflammation of the arterial lining. This process will initiate the changes in the blood vessels that will ultimately end in heart disease. The tests that are to be used to access this inflammation such as the C-reactive protein are being further evaluated.

The increase in the risk of heart disease is often seen years prior to the diagnosis of diabetes mellitus. Since there is a chance that more than 60 million adults in the U.S. alone are at risk of developing diabetes, the only way for cardiovascular disease rates to be decreased is to prevent the incidents of diabetes itself. It is possible to identify those individuals that have an increased risk for diabetes. A National Institute of Health (NIH) sponsored study, the Diabetes Prevention Program as well as other studies carried out, have shown that when weight is modestly reduced as well as engaging in thirty minutes of exercise five days a week it can enable a reduction in the development of type II diabetes over a three year period by over fifty percent. Additionally, those patients that are at risk of developing diabetes or those that have pre-diabetes as well as those already diagnosed with the disease, regularly have abnormalities in the lipid levels and blood sugar levels which may be detected and treated to prevent cardiovascular disease.

A patient at risk of diabetes or that has diabetes may apply lifestyle changes that will act as preventatives for cardiovascular disease. These vital changes are the termination of smoking and the controlling of weight. In the past

decade, a worldwide survey has been carried out and the result has shown that the control of LDL, which is referred to as the bad cholesterol, and of blood pressure is also important in preventing the occurrences of cardiovascular disease by thirty to fifty percent.

It has been a recommendation of the American Diabetes Association (ADA) as well as the American Heart Association (AHA) that the target LDL cholesterol in adults that have diabetes be less than 100 mg/dl. For patients that have heart disease, the desirable level of LDL cholesterol is no more than 70 mg/dl. In patients that have diabetes mellitus, the target blood pressure is less than 130/80. The attainment of this blood pressure will require the intake of one or more medications for some patients with diabetes. There are safe and effective medications that may assist diabetic patients in meeting their lipid and blood pressure goals.

Renal Failure

The kidneys are organs that consist of millions of tiny blood vessels that act as filters. The role of these blood vessels is to ensure the removal of waste products from the blood. There are occasions whereby the filtering system will be unable to do its job. This damage may be caused by diabetes, which will cause the kidneys to fail. The kidneys will therefore lose their ability to filter out waste products, ultimately resulting in kidney disease.

It is important to understand how diabetes causes kidney disease. When the protein that is taken into the body upon the consumption of food is digested, there will be a production of waste products. The blood vessels of the kidney act as filters, which are made possible by the tiny gaps that they have. As the blood flows through these blood vessels, tiny molecules such as waste products will squeeze through the gaps as well. The waste products that

squeeze through will then become part of the urine. The products considered useful, such as protein and red blood cells, are too large to pass through the gaps and will therefore remain in the blood. When a patient has diabetes mellitus, this may cause damage to this delicate system. When there is a high level of blood glucose then the kidney will filter too much blood. The kidneys will, over a period of time, begin to leak useful protein to be lost through urination, a condition termed as *microalbuminuria*.

When there is an early diagnosis of kidney disease, during microalbuminuria, there are several treatments that may be done to prevent the disease from becoming worse. When *large amounts* of protein are in the urine, this is known as *macroalbuminuria*. When the kidney disease is diagnosed with this condition then end-stage renal disease or ESRD will generally follow. Over time, as the kidneys gradually lose their ability to filter waste, they become overworked. They will eventually fail and this renal failure is very serious. A patient that has end stage renal disease will need a kidney transplant or need to have the blood filtered through dialysis.

Not all patients that have diabetes mellitus will develop kidney disease. Certain individuals with diabetes are more at risk of having a co-occurring renal condition. The factors that increase the likelihood of developing the disease include blood sugar control and blood pressure, as well as genetics. When diabetes is kept under control, and blood pressure as well, it decreases the chance of developing kidney disease.

The symptoms of kidney disease are important to know and to educate the patient about as part of their treatment plan. Since the kidneys will work extra hard in order to compensate for the failing capillaries, there will be no symptoms of kidney disease until there is almost no function left in the

kidney. There are no symptoms or indicators that are specific to kidney disease.

The first indicator of kidney disease is usually a buildup of fluid. The other symptoms that may come are poor appetite, loss of sleep, weakness, difficulty concentrating and upset stomach. Regular checkups for protein in the urine, waste products in the blood, blood pressure and other complications of diabetes are necessary in the patient treatment plan.

Prevention of kidney disease is also a necessary part of the patient treatment and education plan. The best way of preventing the development of diabetic kidney disease is by keeping the blood sugar levels within the prescribed range. The risk of microalbuminuria has been found to possibly reduce by one-third through the upkeep of tight blood sugar control. For patients that already have microalbuminuria, the risk may be cut in half. The treatment for kidney disease is multifactorial, depending on the stage and severity of the disease.

Self-care

The most essential treatment for kidney disease is good control of the blood glucose level and blood pressure. The rate of progression for the disease is significantly affected by blood pressure; and, the disease may become worse by a small rise in blood pressure. Avoiding the consumption of alcohol and tobacco, eating less salt, exercising and losing weight, may lower the blood pressure.

Medication Management

When self-care methods do not work effectively, there are particular medications that may be used to lower the blood pressure. Though are a

number of blood pressure medications, not all are suited for every patient with diabetes mellitus. There are specific drugs that may cause a rise in the blood pressure as well as mask the symptoms associated with low blood sugar.

A recommended medication for diabetic patients to help control high blood pressure falls into the category of the ACE inhibitors. These medications are suggested for patients with diabetes, blood pressure and kidney disease.

Dialysis

Dialysis is necessary once the kidneys fail. At this point, a patient is faced with the decision of continuing with dialysis or getting a kidney transplant. A team will assist in the making of this decision. This team should consist of a diabetes educator, medical clinician and medical specialist (*i.e.*, nephrologist), kidney transplant surgeon, psychologist and social worker.

Retinopathy

Retinopathy is a diabetes complication that affects the eyes. The retina is the innermost of the three tunics of the eye. It is comprised of a group of specialized cells that are able to convert light into images as it passes through the lens. The nerve in the eye, which is known as the optic nerve, will then transmit the information to the brain. Diabetic retinopathy is one of the blood vessel related complications of diabetes mellitus. The eye problem that is associated with diabetes is caused by damage of the small vessels and is referred to as a microvascular complication. Damage to the eyes, same as with the kidney and nerves, are all put into the category of microvascular complications. By contrast, larger blood vessel damage is

known as macrovascular complications such as occur with heart disease and stroke.

It has been shown that the disease processes that fall under the category of microvascular complications are related to high blood sugar. By maintaining good control of the blood sugar, a patient with diabetes mellitus is able to reduce the risk of developing eye problems. In industrialized nations, diabetic retinopathy has been found to be the leading cause of irreversible blindness. The duration of diabetes is the greatest risk for developing retinopathy. The longer a patient has lived with diabetes mellitus, the greater the risk of developing a serious eye problem. If retinopathy is not treated in the initial stages or is not discovered, it may lead to blindness. Patients that have diabetes mellitus type I will rarely develop retinopathy before reaching puberty. In adults, the development of retinopathy is not commonly seen before a period of five years from the time of disease onset. The risk of retinopathy increases with the time of having diabetes.

Effective control of the blood sugar levels has a significant role in reducing the patient's risk of developing retinopathy. In a large study of patients with type I diabetes, it was observed that patients that have controlled blood sugar levels, with the assistance of insulin pump or multiple injections of daily insulin, were 50 to 75% less likely to develop retinopathy, nephropathy or neuropathy. Patients with type II diabetes will commonly have indications of eye problems from the time a diagnosis of diabetes is made. Often, blurry vision and the thought of corrective reading glasses are confused with the first sign of uncontrolled blood sugar levels. When diabetic neuropathy is diagnosed, the control of blood pressure, blood cholesterol and blood sugar are essential in the slowing of the progression of retinopathy and other eye problems. Types of retinopathy in diabetes are outlined below.

Proliferative Retinopathy

There is a growth of new blood vessels at the back of the eye. Since retinopathy is a microvascular complication of diabetes, this form of retinopathy will develop due to a lack of oxygen going to the eye caused by vascular disease. The vessels in the eye will become thinned and will begin to remodel.

Background Retinopathy

There are incidences of blood vessel damage with no problems with vision arising. This form of retinopathy is known as background retinopathy. It is vital that a patient with diabetes carefully manages the disease at this stage in order to prevent this form of retinopathy from advancing to a more serious form of the disease.

Maculopathy

In this form of retinopathy, the patient has developed damage in a critical area known as the macula. This area is very important to vision. Due to this fact, there will be a significant reduction in vision in this type of retinopathy.

Managing Vision Risk Factors

It is important that a patient is aware of the vision risk factors that may harm the eye blood vessels. In order for the advancement of new vessel formation in the orbit of the eye to be stopped, there has to be cholesterol management, blood pressure control, smoking has to stop, and there needs to be tight control of the blood sugar levels. The fragile vessels may bleed and this will lead to an eventual clot in the orbit of the eye. This will cause scarring and detachment of the retina, which will in turn lead to irreversible loss of vision. Diabetic retinopathy may be treated with laser procedures and

surgeries as well. For patients with diabetes mellitus that used laser therapy to burn the fragile vessels in the early stages of retinopathy, there was an observed 50% reduction in vision loss. An annual eye exam can assist in the prevention of retinopathy in diabetes patients.

For pregnant women with diabetes, there should be an extensive eye examination in the first trimester. Checkups should be done during the course of the pregnancy in order to avoid the development of serious eye problems. Women with gestational diabetes however are not generally considered at risk of developing retinopathy.

Neuropathy

Diabetic neuropathies are a group of nerve disorders, which are caused by diabetes mellitus. Over a period of time, patients that have diabetes mellitus may develop nerve damage throughout the entire body. Some patients that have nerve damage have no real indicators that there is indeed nerve damage occurring. On the other hand, there are patients that may experience pain, tingling sensations and a numbness of the legs, feet, hands and arms.

Nerve damage may occur in any organ system of the body, inclusive of the sex organs, digestive tract and the heart. Some form of neuropathy is observed in 60 to 70% of patients that have diabetes mellitus. Nerve problems may develop in any patient that has diabetes but will be more prevalent according to age and the duration of the disease in the patient. Neuropathy is most commonly seen in those patients that have had diabetes for a period of twenty-five years or more. Diabetic neuropathies are also more prevalent in those patients that have more difficulty in maintaining a controlled glucose level, have a high level of blood fat, are overweight or

have high blood pressure. Types of diabetic neuropathy are classified as autonomic, peripheral, focal and proximal. Each of these types will affect different parts of the body in different ways.

Autonomic Neuropathy

Autonomic neuropathy will cause changes in the bladder and bowel functions, sexual response, digestion and perspiration. This may also affect the nerves of the heart, eyes, lungs and those that control blood pressure. Autonomic neuropathy may also cause hypoglycemia unawareness, which is a condition where patients are no longer able to experience the symptoms of low blood glucose levels.

Peripheral Neuropathy

Peripheral neuropathy is the most common of the neuropathies and will cause pain or a loss of feeling in the hands, arms, feet, toes and legs.

Focal Neuropathy

Focal neuropathy will result in the sudden weakness of a single nerve or a group of nerves. This will lead to a weakness of the muscles or pain. This may affect any nerve in the body.

Proximal Neuropathy

Proximal neuropathy will cause a pain in the hips, buttocks or thighs and will lead to weakness in the legs. For each type of diabetic neuropathy, there may be different causes. There is research being done to determine the effects of prolonged exposure to high blood glucose on nerve damage. Nerve damage may be due to a combination of a variety of factors, as highlighted below.

- Neurovascular factors which lead to the damage of the blood vessels that transport oxygen and nutrients to the nerves.
- Mechanical injuries to the nerves such as carpal tunnel syndrome.
- Metabolic factors, which include a long duration of diabetes, high blood glucose, low levels of insulin and unusual blood fat levels.
- Inherited traits that will increase the vulnerability to nerve disease.
- Lifestyle factors such as alcohol consumption and smoking.
- Autoimmune factors which will cause inflammation of the nerves.

The symptoms of diabetic neuropathies will be dependent on the type of neuropathy as well as which nerve is affected. Some patients will experience nerve damage and have no symptoms at all. In other patients, the first symptom to appear is usually numbness, tingling or pain in the feet. The symptoms will generally be mild in the initial stages and most nerve damage will take years to develop. Very mild cases tend to go undetected for a long time. Symptoms may involve the motor, autonomic or involuntary nervous and sensory systems. In a lot of patients, more particularly those with focal neuropathy, the onset of pain may be very sudden and often times severe.

The symptoms associated with nerve damage include the following:

- Wasting of the muscles of the feet and hands
- Diarrhea and constipation
- Dizziness and faintness caused by a drop in blood pressure after periods of standing and sitting
- Nausea, vomiting or indigestion
- Tingling, pain or numbness of the arms, hands, fingers, feet, toes and legs
- Difficulty with urination
- Weakness
- Vaginal dryness

- Erectile dysfunction

Symptoms that may not be due to neuropathy but may accompany it are depression and loss of weight (such as associated with gastroparesis and vomiting).

Cognitive Dysfunction In Diabetes

Patients with diabetes mellitus type I may have a slower mental speed and a deterioration of mental flexibility that is referred to as cognitive dysfunction. In these cases however, memory and learning ability are preserved. The intensity of the cognitive dysfunction may span from mild to moderate however even in the mild cases, there may be a hindrance to everyday activities. This should be expected to occur and it may present significant problems in situations that demand more cognitive output.^{9,15,55-58}

Those patients that have diabetes mellitus type I have been observed on a repeated basis to display modest deficits on an extensive range of neuropsychological tests in comparison to individuals that do not have diabetes mellitus that were tested. The results of the different neuropsychological studies were varied as to the domains that were affected and the level of severity of the cognitive deterioration that was reported.

In some studies, it was observed and reported that there were impairments on those tests that called for problem solving skills. On the other hand, however, other studies observed and reported deficits in learning and memory, psychomotor efficiency, visuospatial abilities as well as no difference at all. This variation in results may be due to the difference in the patient characteristics and the psychometric paradigms that were utilized. As

a result, the exact nature and patterns of cognitive dysfunction is still not clear.

There are a few complications that are thought to be associated with cognitive dysfunction in patients that have diabetes mellitus type II. These associated complications are chronic hyperglycemia, the resultant occurrence of the diabetes complications as well as the repeated episodes of hypoglycemia. The extent of the level of contribution that is made by these complications of diabetes to cognitive deficit is yet to be established.

Recent research studies focused on individuals with diabetes that experience worsening cognitive performance suggests possible value to several adjunctive therapies in addition to the administration of oral medication, such as Metformin, and insulin for glucose control. It is important that clinicians offer patients with diabetes ongoing education and options to help protect and maintain good cognitive performance and quality of life during the course of their disease. In addition to considerations, such as the patient's age, gender, mental health and education/literacy level, B-12 and other vitamin supplementation may be offered with the goal to improve cognitive performance.

The care of individuals with type 2 diabetes warrants ongoing and continuous close monitoring and follow-up to ensure that the latest health information and best course of care to help manage diabetes is being offered to patients as well as to their families. For those in the older adult and geriatric population, co-occurring health conditions factor into how well patients respond to diabetes treatment. This was discussed earlier in the study; however, one condition that can particularly complicate the medical

diagnosis and treatment plan of diabetes is being further studied, which is the co-occurring condition of Alzheimer's disease.

Type 2 diabetes mellitus and Alzheimer disease (AD) are considered major public health burdens as the age of the general population rapidly rises. While research has identified that type 2-diabetes is a risk factor for cognitive impairment, there are also neurobiological changes uniquely associated with Alzheimer's disease that should be considered. A neurology specialist may be consulted on the differential diagnosis and determination of cause, prognosis and treatment of cognitive decline in individuals with diabetes.

Early recognition of cognitive decline in individuals with diabetes is key to disease management. Clear clinical guidelines that include helpful screening tools to determine changes in cognitive functioning are helpful to all members of the care team, including family members involved in the patient's health management at home. There are several approaches that have been suggested in the medical literature aimed at helping clinicians identify changes in a diabetic patient's ability to focus, concentrate and to recall short and long-term events; the following is a concise overview of tools that health clinicians can utilize in a brief screening exam for cognitive decline.

Benton Temporal Orientation Test

The Benton Temporal Orientation Test (BTOT) involves asking the patient relevant questions to assess his/her orientation to the month, date, year and time of day. It uses a graduated scoring system that reflects the degree of error made in the patient's response. If the patient fails to respond or says *I don't know* in response to a question then the examiner encourages them to

guess. The higher the score the greater the cognitive impairment; the highest error is indicated by a score of 113.

Enhanced Cued Recall Test

The Enhance Cued Recall Test allows the examiner to ask the patient to recall 16 items presented pictorially on four individual cards with semantic cues to best describe the objects. If the patient cannot recall any of the items, then the examiner provides the appropriate cues to remind him/her of the items. This is a helpful test to distinguish between Alzheimer's disease and normal aging memory deficits. The total number of items remembered in both the uncued and cued recall is used to score the patient's responses; 16 is the maximum score and lower scores are suggestive of cognitive impairment.

Clock Drawing Test

Visuospatial ability is tested in the Clock Drawing Test. The patient is asked to draw a handless clock, showing all the numbers on it, and then asked to draw the clock hands, *i.e.*, at 20 minutes before 4. There is a maximum score of 7 (normal cognition) and anything lower represents cognitive impairment.

Verbal Fluency Test

In the Verbal Fluency Test a patient is asked to name as many members of a particular category, *i.e.*, "animals", in a 1-minute period. The number of appropriate items named is used to determine the total score; and, the maximum score is 45 with lower scores indicative of reduced verbal fluency.

The mental screening tests mentioned above comprise helpful tools during

patient follow-up visits that aid in the evaluation of cognitive functioning in the setting of diabetes. Cognitive functioning and early detection of decline is a key role of primary health clinicians caring for diabetic patients. It is an important part of the overall health picture of the patient, which includes their ability to process information. Additionally, the effects of patients' cognitive functioning also include their ability to stay active, follow healthy lifestyle choices, and to participate or partner in the successful management of diabetes.

Summary

Patients with diabetes mellitus do not often recognize the symptoms of the disease prior to a diagnosis. This is mainly due to the nature of most symptoms of diabetes, which do not appear harmful. The complications of diabetes mellitus on the other hand are more dangerous and may be life threatening in those cases that are severe. The longer a patient has had the disease, the higher the risk of developing complications.

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1. Common symptoms of diabetes mellitus is/are

- a. weight loss.
- b. unusually low blood glucose levels.
- c. infrequent urination.
- d. All of the above

2. True or False: Fluctuation in a patient's weight is a common symptom of possible diabetes mellitus.

- a. True
- b. False

3. Polyuria is described as

- a. significant weight loss.
- b. excessive production of urine.
- c. an elevated feeling of thirst.
- d. None of the above

4. High glucose level will _____ the risk of having eye problems.

- a. have no effect on
- b. decrease
- c. increase
- d. minimize

5. What is diabetic ketoacidosis?

- a. An increase in blood acids known as ketones
- b. An increase in urine production
- c. A decrease in blood acid production
- d. Difficulty in breathing

6. Kussmaul breathing is best described as

- a. hyperventilation.
- b. lightheadedness.
- c. wheezing.
- d. a deep and toiled breathing.

7. True or False: The risks associated with diabetes increase if the disease goes undetected but complications do not occur so long as there are no noticeable symptoms.

- a. True
- b. False

8. Diabetic ketoacidosis is most commonly seen in patients with

- a. diabetes mellitus type II
- b. gestational diabetes
- c. pre-diabetes
- d. diabetes mellitus type I

9. Hyperosmolar hyperglycemic nonketotic syndrome is most commonly observed in

- a. prepubescent diabetes patients.
- b. adolescent diabetes patients.
- c. elderly diabetes patients.
- d. diabetes patients ages 25-35.

10. Retinopathy is a complication, which is associated with diabetes mellitus that affects the

- a. skin.
- b. nerves.
- c. brain.
- d. eyes.

11. Cognitive deficit in patients with diabetes mellitus type I are described as

- a. having a slower mental speed.
- b. losing memory and learning ability.
- c. intense depression.
- d. All of the above

12. Polydipsia is the term used to describe the feeling of

- a. excessive urination.
- b. uncontrolled diabetes.
- c. excessive thirst.
- d. excessive hunger.

- 13. True or False: Polydipsia may be the cause or the effect of polyuria.**
- a. True
 - b. False
- 14. Polyphagia is present in the very early stages of diabetic ketoacidosis; however, as _____ begins to increase, the appetite will simultaneously decrease as ketoacidosis develops.**
- a. cholesterol levels
 - b. insulin levels
 - c. the deficiency of insulin
 - d. cell glucose levels
- 15. Hyperglycemia inhibits glucose from entering cells, which may**
- a. cause an increase in energy.
 - b. be a result of insulin resistance or a lack of insulin.
 - c. be a result of increased insulin levels.
 - d. result in weight gain.
- 16. When the fluid in the eyes are not able to drain properly, the patient may develop**
- a. retinopathy.
 - b. glaucoma.
 - c. polydipsia.
 - d. cataracts.
- 17. The growth of new blood vessels on the iris is a condition known as**
- a. retinopathy.
 - b. hyperglycemia.
 - c. neovascular glaucoma.
 - d. cataracts.

18. Which of the following skin conditions is unique to patients with diabetes mellitus?

- a. eruptive xanthomatosis.
- b. diabetic ketoacidosis.
- c. fungal infections.
- d. itching.

19. _____ is a skin condition that causes small, firm, yellow enlargements of the skin.

- a. Digital sclerosis
- b. Disseminated granuloma annulare
- c. Diabetic blisters
- d. Eruptive xanthomatosis

20. True or False: Diabetic blisters are common in patients with diabetes mellitus.

- a. True
- b. False

21. _____ is the development of thick, waxy tight skin on the back area of the hands.

- a. Digital sclerosis
- b. Disseminated granuloma annulare
- c. Diabetic blisters
- d. Eruptive xanthomatosis

22. Diabetic blisters are known to

- a. be large and painful.
- b. often leave scars when they heal.
- c. have the appearance of burn blisters.
- d. All of the above

23. A serious, potentially life-threatening condition that may be present with diabetes and vomiting is

- a. gastroparesis.
- b. delayed gastric emptying.
- c. diabetic ketoacidosis.
- d. disseminated granuloma annulare.

24. Patients with hyperosmolar hyperglycemic nonketotic syndrome (HHNS)

- a. develop severe ketoacidosis.
- b. develop delayed gastric emptying.
- c. more often have type II diabetes.
- d. have a reduced circulation of insulin.

25. True or False: Without an adequate amount of insulin, the body is forced to break down fat as an alternate source of energy.

- a. True
- b. False

CORRECT ANSWERS:

1. Common symptoms of diabetes mellitus is/are

- a. weight loss.

"Fluctuations in a patient's weight are a common symptom of possible diabetes mellitus.... A common symptom that will be experienced by a patient that has diabetes mellitus is polyphagia.... In a patient that has diabetes mellitus that is not controlled, the blood glucose levels may be unusually high."

2. True or False: Fluctuation in a patient's weight is a common symptom of possible diabetes mellitus.

- a. True

"Fluctuation in a patient's weight is a common symptom of possible diabetes mellitus."

3. Polyuria is described as

- b. excessive production of urine.

"Excessive urine production or polyuria is often seen in a patient with uncontrolled diabetes mellitus."

4. High glucose level will _____ the risk of having eye problems.

- c. increase

"It has been shown that the disease processes that fall under the category of microvascular complications are related to a high blood sugar level. By maintaining good control of the blood sugar, a patient with diabetes mellitus is able to reduce the risk of developing eye problems."

5. What is diabetic ketoacidosis?

- a. An increase in blood acids known as ketones

“Diabetic Ketoacidosis (DKA) is a very serious and life-threatening condition. This occurs in diabetic patients when the body begins to produce an increased level of blood acids known as ketones.”

6. Kussmaul breathing is best described as

- d. a deep and toiled breathing.

“Kussmaul breathing is a deep and toiled breathing with associated frequent recurrence, which is observed in patients with intense acidosis. It is considered to be a signal of hyperventilation.”

7. True or False: The risks associated with diabetes increase if the disease goes undetected but complications do not occur so long as there are no noticeable symptoms.

- b. False

“The risks associated with diabetes increase if the disease goes undetected as complications may still occur even if there are no noticeable symptoms.”

8. Diabetic ketoacidosis is most commonly seen in patients with:

- d. diabetes mellitus type I

“Diabetic ketoacidosis (DKA), discussed earlier, is an intense, significant, life-threatening complexity of diabetes mellitus that often occurs in an acute crisis. DKA, while it generally occurs in patients with type I diabetes, is not unusual in a few patients with diabetes mellitus type II.”

9. Hyperosmolar hyperglycemic nonketotic syndrome is most commonly observed in

c. elderly diabetes patients.

"Hyperosmolar hyperglycemic nonketotic syndrome, also known as HHNS, is a severe condition that is associated with diabetes, and is mainly seen in elderly patients."

10. Retinopathy is a complication, which is associated with diabetes mellitus that affects the

d. eyes.

"Diabetic retinopathy is a diabetes complication that affects the eyes."

11. Cognitive deficit in patients with diabetes mellitus type I are described as

a. having a slower mental speed.

"Patients with diabetes mellitus type I have a slower mental speed and a deterioration of mental flexibility that is referred to as cognitive dysfunction. In these cases however, memory and learning ability are preserved."

12. Polydipsia is the term used to describe the feeling of

c. excessive thirst.

"Polydipsia is the term used to describe the feeling of excessive thirst that an individual may experience, i.e., a patient with uncontrolled diabetes mellitus."

13. True or False: Polydipsia may be the cause or the effect of polyuria.

a. True

"It is common for polydipsia to be either the cause or the effect of polyuria."

14. Polyphagia is present in the very early stages of diabetic ketoacidosis; however, as _____ begins to increase, the appetite will simultaneously decrease as ketoacidosis develops.

c. the deficiency of insulin

"Polyphagia will be seen in the very early stages of diabetic ketoacidosis. It must be noted, however, that as the deficiency of insulin begins to increase, the appetite will simultaneously decrease as ketoacidosis develops."

15. Hyperglycemia inhibits glucose from entering cells, which may

b. be a result of insulin resistance or a lack of insulin.

"In a patient that has diabetes mellitus that is not controlled, the blood glucose levels may be unusually high. This abnormally high level of blood glucose is known as hyperglycemia and it inhibits the glucose from being able to enter the cells, which may be a result of insulin resistance or a lack of insulin. The body will therefore be unable to convert the food that has been eaten into energy."

16. When the fluid in the eyes are not able to drain properly, the patient may develop

b. glaucoma.

"Another of the eye conditions that is generally associated with diabetes mellitus is glaucoma. This occurs when the fluid, which is in the eyes, is not able to drain properly."

17. The growth of new blood vessels on the iris is a condition known as

c. neovascular glaucoma.

"... a less common form of glaucoma known as neovascular glaucoma will also affect patients diagnosed with diabetes. In neovascular glaucoma there will be a growth of new blood vessels on the iris that occur in this condition."

18. Which of the following skin conditions is unique to patients with diabetes mellitus?

a. eruptive xanthomatosis.

"The most common of skin conditions that occur with diabetes involve itching, fungal and bacterial infections. The skin conditions that are unique to those with diabetes mellitus include necrobiosis lipoidica diabetorum, diabetic dermopathy, eruptive xanthomatosis and diabetic blisters."

19. _____ is a skin condition that causes small, firm, yellow enlargements of the skin.

d. Eruptive xanthomatosis

"Eruptive xanthomatosis ... is a condition unique to patients that have uncontrolled diabetes mellitus. The condition will cause small, firm, yellow enlargements of the skin."

20. True or False: Diabetic blisters are common in patients with diabetes mellitus.

b. False

"Diabetic blisters: Though this is rare, patients with diabetes mellitus may also break out in blisters. These blisters may appear on the hands, feet, backs of the fingers, toes, and at times the forearms or the legs."

21. _____ is the development of thick, waxy tight skin on the back area of the hands.

a. Digital sclerosis

"Patients with diabetes will experience what is known as digital sclerosis. This is the development of thick, waxy tight skin on the back area of the hands."

22. Diabetic blisters are known to

- c. have the appearance of burn blisters.

"Diabetic blisters ... have the appearance of burn blisters.... They will sometimes be large but will not be painful or red in appearance. These blisters will heal by themselves within a period of three weeks and often without a scar."

23. A serious, potentially life-threatening condition that may be present with diabetes and vomiting is

- c. diabetic ketoacidosis.

"A possible serious cause of diabetes and vomiting is diabetic ketoacidosis, which, as explained already, is a life-threatening condition that is brought on as a result of uncontrolled diabetes."

24. Patients with hyperosmolar hyperglycemic nonketotic syndrome (HHNS)

- d. have a reduced circulation of insulin.

"Hyperosmolar hyperglycemic nonketotic syndrome, also known as HHNS, is ... seen more regularly in those patients that have type II.... The basic mechanism of HHNS is a relative or absolute reduction in the effective circulation of insulin. It is important to note that patients with HHNS are not like those with DKA, as they do not develop severe ketoacidosis; however, the reason for this is unknown."

25. True or False: Without an adequate amount of insulin, the body is forced to break down fat as an alternate source of energy.

- a. True

"Without an adequate amount of insulin, the body is forced to break down fat as an alternate source of energy."

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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