CHAPTER 3

DIABETES MELLITUS

3.1 INTRODUCTION

Diabetes Mellitus often simply referred to as diabetes, is the coercive effect of insulin on the glucose metabolism. Insulin is a hormone central to regulating carbohydrate and fat metabolism in the body. Insulin is produced from the islets of langerhans. In Latin the word Insula means-"island". Its concentration has wide spread effect throughout the body. When control of insulin levels fail, diabetes mellitus will result. As a consequence, insulin is used to treat some forms of diabetes mellitus. Not only insulin regulates the glucose in the blood but it is also responsible for lipid metabolism. Insulin secretion from beta-cells is principally regulated by plasma glucose levels. Increased uptake of glucose by pancreatic beta-cells leads to a concomitant increase in metabolism. One must understand that insulin is offered as medicine only when the above criteria are broken. Physicians will become familiar with other aspects of managing the patient with diabetes, including the importance of postprandial glucose control, diabetes self-management training etc.

Most of the food that is eaten is converted to glucose, or sugar which is used for energy. The pancreas secretes insulin which carries glucose into the cells of our bodies, which in turn produces energy for the perfect functioning of the body. When the patient’s have diabetes the body either doesn't make enough insulin or cannot use its own insulin as well as it should. This causes sugar to build up in the blood leading to complications like heart disease, stroke, and neuropathy, poor circulation leading to loss of limbs, blindness, kidney failure, nerve damage and death. The general symptoms of
diabetes include increased thirst, increased urination, weight loss, increased appetite, fatigue, nausea and or vomiting-blurred vision, slow-healing infections and impotence in men.

3.1.1 Causes of Diabetes

- **Hereditary or Inherited Traits:** It is strongly believed that due to some genes which passes from one generation to another, a person can inherit diabetes. It depends upon closeness of blood relationship as mother is diabetic, the risk is 2 to 3%, father is diabetic, the risk is more than the previous case and if both the parents are diabetic, the child has much greater risk for diabetes.

- **Age:** Increased age is a factor which gives more possibility than in younger age. This disease may occur at any age, but 80% of cases occur after 50 year, incidences increase with the age factor.

- **Poor Diet:** Improper nutrition, low protein and fiber intake, high intake of refined products are the expected reasons for developing diabetes.

- **Obesity and Fat Distribution:** Being overweight means increased insulin resistance that is if body fat is more than 30%, waist girth 35 inches in women or 40 inches in males.

- **Sedentary Lifestyle:** People with sedentary lifestyle are more prone to diabetes, when compared to those who exercise thrice a week, are at low risk of falling prey to diabetes.

- **Stress:** Either physical injury or emotional disturbance is frequently blamed as the initial cause of the disease. Any disturbance in
Corticosteroid or ACTH (Adrenocorticotropic hormone) therapy, may lead to clinical signs of the disease.

- **Drug Induced**: Clozapine (Clozaril), olanzapine (Zyprexa), risperidone (Risperdal), quetiapine (Seroquel) and ziprasidone (Geodon) are known to induce this lethal disease.

- **Infection**: Some of the strephylococci is supposed to be a responsible factor for infection in pancreas.

- **Sex**: Diabetes is commonly seen in elderly, especially males but, strongly in women and those with multiple pregnancy or suffering from (PCOS) Polycystic Ovarian Syndrome.

- **Hypertension**: It had been reported in many studies that there is a direct relation between high systolic pressure and diabetes.

- **Serum lipids and lipoproteins**: High triglyceride and cholesterol level in the blood is related to high blood sugars, in some cases it has been studied that risk is involved even with low HDL (High-density lipoprotein) levels in circulating blood.

### 3.1.2 Symptoms of Diabetes

High blood sugar levels can cause several symptoms, including:

- **Frequent urination**: Hormonal system commends the kidney to remove unwanted excess glucose in blood, in turn causes the diabetes sign of frequent urination. Kidney does filtering just as micro filters; so it not only filters glucose, but also other minerals, that are in the same size range, such as sodium and potassium salts.
- **Heavy thirst:** Hormonal system instructs to dilute the blood just to bring back normal glucose-level. So large amount of liquid is used to dilute the blood, also frequent urination causes dehydration, which in turn induces the diabetes symptom of heavy thirst.

- **Low energy:** Due to low or no insulin or improper utilization of insulin, the body is not able to utilize the glucose available in the blood. Also the kidney removes the excess glucose (to normalize the level) and other necessary salts from the body which is needed for the energy. So the body has low energy level and thus causes the diabetes sign of too much tired even after enough foods.

- **Blurred vision:** If there is low energy in the body then naturally the eye cannot be able to get enough nutrients, so the vision becomes dull causing the temporary diabetes symptom of blurred vision.

- **Hunger than usual:** Due to removal of minerals, the body feels tired (dehydrated) thus hormonal system stimulates the digestive system and induces diabetes sign of unusual hunger just to bring back necessary energy to the body system.

- **Sudden weight loss:** The food is digested, but not properly utilized and sent out as waste. So there is no storage of food inside the body and also the body is not nourished by the necessary nutrients. This causes the diabetes symptoms of sudden weight loss.

- **Dry and itching skin:** Glucose is necessary to nourish the skin, but improper utilization or shortage or no insulin and the skin is not able to get the needed nutrient. Thus the skin causes the diabetes signs of dry & itching skin.
- **Sores heal slowly**: Skin is not able to get enough nutrients, thus maintaining the healthy skin itself difficult. Dryness also becomes very difficult to heal any sores (skin damage need repair) in the skin. Also Endothelial Progenitor Cells (EPCs), which derive from bone marrow, normally travel to injured sites and are essential for the formation of blood vessels and wound healing. Many studies confirm that, the circulations of EPCs are low in diabetics, thus diabetes symptom of slow healing sores.

- **Losing sense or tingling in feet**: Blood vessels and nerves need “glucose-D” to maintain its health and normal function. Due to diabetes, blood vessels and nerves are not able to get enough nutrients to nourish it. Thus nerves normal functioning is affected, causing the diabetes sign of loss of sense or tingling in the extremities.

### 3.1.3 Diagnostic Tests

- **Urine Test**: A urine analysis may be used to look for glucose and ketones from the breakdown of fat. However, a urine test alone does not diagnose diabetes. The following blood glucose tests are used to diagnose diabetes.

- **Fasting Plasma Glucose Level (FPG) Test**: This test is done after 8-12 hours of fasting. The normal range of fasting blood glucose is <100 mg/dL. People with fasting glucose levels from 100-125 mg/dL are considered to have impaired fasting glucose. Patients with FPG >126 are considered to have diabetes mellitus.

- **Post Prandial Plasma Glucose Level (PPG) Test**: A blood sugar test taken after two hours of a meal is known as the post prandial glucose
test or PPG. The normal range for PPG is <140 mg/dL. People with fasting glucose levels from 140-200 mg/dL are considered to have impaired glucose tolerance. People with PPG >200 mg/dL are considered to have diabetes mellitus.

- **Oral Glucose Tolerance Test (OGTT):** This test is done to confirm the diagnosis in doubtful cases (i.e. cases were FPG and/or PPG are in the borderline range). In this test one has to drink 75 gm glucose (sugar) in water on empty stomach and blood sugar is to be tested after 2 hours. This test can be used to diagnose diabetes and pre-diabetes.

- **Hemoglobin A1c (HbA1c) Test:** HbA1c is a lab test that shows the average amount of sugar in the blood over 3 months. It shows how well the person is controlling the diabetes. The following are the results when the HbA1c is being used to diagnose diabetes:
  - Normal: Less than 5.7%
  - Pre-diabetes: 5.7% to 6.4%
  - Diabetes: 6.5% or higher

- **Random Plasma Glucose (RPG) Test:** This test measures the blood glucose level any time of day without regard to drinking or eating. This test is sometimes referred to as casual plasma glucose test.

### 3.1.4 Range of Diabetes Mellitus

The range of diabetes mellitus as suggested by Dr.P.S.Vasudevan (2007), in the book “Know Diabetes” is shown in Table 3.1. The IFG refers to Impaired Fasting Glucose and IGT refers to Impaired Glucose Tolerance.
Table 3.1 Range of Diabetes Mellitus

<table>
<thead>
<tr>
<th>Condition</th>
<th>Blood Sugar Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FPG</td>
</tr>
<tr>
<td>Normal</td>
<td>&lt; 100 mg/dL</td>
</tr>
<tr>
<td>“Pre-diabetic states”</td>
<td>100-125 mg/dL (IFG)</td>
</tr>
<tr>
<td>Diabetic Mellitus</td>
<td>&gt;126 mg/dL</td>
</tr>
</tbody>
</table>

3.1.5 Types of Diabetes

Classified based on the cause or mode of treatments, they are

- **Type 1 diabetes**-need insulin to maintain blood glucose level.
- **Type 2 diabetes**-insulin is not necessary, to normalize glucose level.
- **Gestational diabetes**-diabetes developed during pregnancy and mostly disappears after delivery.

3.1.5.1 Type 1 Diabetes

Diabetes also called as Insulin Dependent Diabetes Mellitus (IDDM), or Juvenile Onset Diabetes Mellitus commonly seen in children and young adults. In Type 1 diabetes, the pancreas undergoes an autoimmune attack by the body itself therefore; pancreas does not produce the hormone insulin. The body does not properly metabolize food resulting in high blood sugar (glucose) and the patient must rely on insulin shots. Type 1 disorder appears in people younger than age 40, usually from the ages 10 to 16. Type 1 diabetes is a lifelong (chronic) disease in which there are high levels of sugar (glucose) in the blood.
Causes

Type 1 diabetes is most often diagnosed in children, adolescents, or young adults. Insulin is a hormone produced by special cells, called beta cells, in the pancreas. The pancreas is found behind the stomach. Insulin is needed to move blood sugar (glucose) into cells, where it is stored and later used for energy. In Type 1 diabetes, beta cells produce little or no insulin. Without enough insulin, glucose builds up in the bloodstream instead of going into the cells. The body is unable to use this glucose for energy. This leads to the symptoms of Type 1 diabetes. The exact cause of Type 1 diabetes is unknown. It is an autoimmune disorder. An infection or some other trigger causes the body to mistakenly attack the cells in the pancreas that create insulin. This kind of disorder can be passed down through families.

Symptoms

These symptoms may be the first signs of Type 1 diabetes, or may occur when the blood sugar is high:

- Being very thirsty
- Feeling hungry
- Feeling tired or fatigued
- Having blurry eyesight
- Losing the feeling or feeling tingling in the feet
- Losing weight without trying and urinating more often

For other people, these warning symptoms may be the first signs of Type 1 diabetes, or they may happen when the blood sugar is very high:

- Deep, rapid breathing
- Dry skin and mouth
- Flushed face
- Fruity breath odor
- Nausea or vomiting, inability to keep down fluids
- Stomach pain

Low blood sugar (hypoglycemia) can develop quickly in people with diabetes who are taking insulin. Symptoms usually appear when the blood sugar level falls below 70 mg/dL. Then patient must be watched if he/she has the symptoms like
  - Headache
  - Hunger
  - Nervousness
  - Rapid heartbeat (palpitations)
  - Shaking
  - Sweating
  - Weakness

**Diet and Exercise**

People with Type 1 diabetes, should eat at about the same times each day and try to eat the same kinds of foods. This helps to prevent blood sugar from becoming too high or low. Regular exercise helps control the amount of sugar in the blood. It also helps burn extra calories and fat to reach a healthy weight.

**Treatment**

Since Type 1 diabetes can start quickly and the symptoms can be severe, people who have just been diagnosed may need to stay in the hospital. If the patient has just been diagnosed with Type 1 diabetes, the patient should probably have a check-up each week until the patients have good control over
their blood sugar. Health care provider will review the results of blood sugar monitoring and urine testing. As the disease gets more stable, patient will have fewer follow-up visits. Visiting the health care provider is very important so patient can monitor any long-term problems from diabetes.

**Prevention**

There is no way to prevent Type 1 diabetes. There is no screening test for Type 1 diabetes in people who have no symptoms. Patient must stay up-to-date with all of the vaccinations and get a flu shot every year in the fall.

**3.1.5.2 Type 2 Diabetes**

Diabetes is also called as Non-Insulin Dependent Diabetes Mellitus (NIDDM) or Adult Onset Diabetes Mellitus. Type 2 diabetes is the most common form of diabetes. In Type 2 diabetes, either the body does not produce enough insulin or the cells ignore the insulin. Type 2 disorder occurs mostly after age 40. Type 2 diabetes is a lifelong (chronic) disease in which there are high levels of sugar (glucose) in the blood.

**Causes**

Diabetes is caused by a problem in the way that the body makes or uses insulin. Insulin is needed to move blood sugar (glucose) into cells, where it is stored and later used for energy. When the patients have Type 2 diabetes their fat, liver, and muscle cells do not respond correctly to insulin. This is called insulin resistance. As a result, blood sugar does not get into these cells to be stored for energy. When sugar cannot enter cells, high levels of sugar build up in the blood. This is called hyperglycemia.
Type 2 diabetes usually occurs slowly over time. Most people with the disease are overweight when they are diagnosed. Increased fat makes it harder for patient’s body to use insulin the correct way. Type 2 diabetes can also develop in people who are thin. This is more common in the elderly. Family history and genes play a large role in Type 2 diabetes. Low activity level, poor diet, and excess body weight around the waist will increase the patient risk.

**Symptoms**

Often, people with Type 2 diabetes have no symptoms at first. They may not have symptoms for many years. The early symptoms of diabetes may include:

- Bladder, kidney, skin, or other infections that are more frequent or heal slowly
- Fatigue
- Hunger
- Increased thirst
- Increased urination

The first symptom may also be:

- Blurred vision
- Erectile dysfunction
- Pain or numbness in the feet or hands

**Diet and Exercise**

The patient must work closely with the doctor, nurse, and dietitian to learn how much fat, protein, and carbohydrates is needed in diet. The meal plans should fit the patient’s daily lifestyle and habits, and should try to
include foods that the patients like. Managing the weight and eating a well-balanced diet is important. Some people with Type 2 diabetes can stop taking medications after losing weight (although they still have diabetes). Very overweight patients whose diabetes is not well managed with diet and medicine are considered for bariatric (weight loss) surgery.

Treatment

The goal of treatment at first is to lower high blood glucose levels. The long-term goals of treatment are to prevent problems from diabetes. The main treatment for Type 2 diabetes is exercise and diet.

Prevention

The doctor may prescribe medications or other treatments to reduce the chances of developing eye disease, kidney disease, and other conditions that are more common in people with diabetes.

3.1.5.3 Gestational Diabetes

Diabetes can occur temporarily during Pregnancy called as Gestational Diabetes which is due to the hormonal changes and usually begins in the fifth or sixth month of pregnancy (between the 24th and 28th weeks). It usually resolves once the baby is born. 25-50% of women eventually develop diabetes later in life, especially in those who require insulin during pregnancy and those who are overweight after their delivery. Gestational diabetes usually starts halfway through the pregnancy. All pregnant women should receive an oral glucose tolerance test between the 24th and 28th week of pregnancy to screen for the condition. Women who have risk factors for gestational diabetes may have this test earlier in the pregnancy.
Causes

Pregnancy hormones can block insulin from doing its job. When this happens, glucose levels may increase in a pregnant woman's blood. Risk for gestational diabetes in women may be if they:

- Are older than 25 when pregnant and have a family history of diabetes
- Gave birth to a baby that weighed more than 9 pounds or had a birth defect
- Have sugar (glucose) in urine and have high blood pressure
- Have too much amniotic fluid
- Have had an unexplained miscarriage or stillbirth
- Were overweight before pregnancy

Symptoms

Usually there are no symptoms, or the symptoms are mild and not life threatening to the pregnant woman. Often, the blood sugar (glucose) level returns to normal after delivery. Symptoms may include:

- Blurred vision
- Fatigue
- Frequent infections, including those of the bladder, vagina, and skin
- Increased thirst
- Increased urination
- Nausea and vomiting
- Weight loss in spite of increased appetite
Treatment

The goals of treatment are to keep blood sugar (glucose) levels within normal limits during the pregnancy, and to make sure that the growing baby is healthy. The doctor closely checks both mother and baby throughout the pregnancy. Foetal monitoring to check the size and health of the foetus often includes ultrasound and nonstress tests.

- A nonstress test is a very simple, painless test for mother and baby. A machine that hears and displays the baby's heartbeat (electronic foetal monitor) is placed on mother’s abdomen. When the baby moves, the baby's heart rate normally increases 15-20 beats above its regular rate.
- Doctor can compare the pattern of the baby's heartbeat to movements and find out whether the baby is doing well. Doctor will look for increases in the baby's normal heart rate occurring within a certain period of time.

Diet and Exercise

The best way to improve the diet is by eating a variety of healthy foods. In general, diet should be moderate in fat and protein that provide controlled levels of carbohydrates through foods which include fruits, vegetables, and complex carbohydrates (such as bread, cereal, pasta, and rice). Pregnant women must cut back on foods that contain a lot of sugar, such as soft drinks, fruit juices, and pastries. Pregnant women will be asked to eat three small-to moderate-sized meals and one or more snacks each day. Meals and snacks must not be skipped. Keep the amount and types of food (carbohydrates, fats, and proteins) the same from day to day.
• Doctor or nurse will prescribe a daily prenatal vitamin. They may suggest the patient to take extra iron or calcium. A vegetarian mother must consult the doctor for their meal plan or on some other special diet.

• Remember that "eating for two" does not mean patient need to eat twice as many calories. Usually pregnant women need just 300 extra calories a day (such as a glass of milk, a banana, and 10 crackers).

If managing diet does not control blood sugar (glucose) levels, then they may be prescribed diabetes medicine by mouth or insulin therapy. Monitoring the blood sugar (glucose) levels during treatment is needed. Most women who develop gestational diabetes will not need diabetes medicines or insulin, but some will.

**Prevention**

Beginning prenatal care early and having regular prenatal visits helps improve the patient health and the health of the baby. Knowing the risk factors for gestational diabetes and having prenatal screening at 24-28 weeks into the pregnancy will help to detect gestational diabetes early. If pregnant women are overweight, decreasing body mass index (BMI) to a normal range before she gets pregnant will decrease the risk of developing gestational diabetes.

3.1.6 **Complications of Diabetes**

The complications of diabetes are many and can be very dire. The main reason for this is because diabetes causes problems with the nerves as well as problems with the flow of blood through the blood vessels that supply energy for every organ. These two problems affect every organ in the human body. So, when the blood glucose levels are not maintained because of
ineffective or poor self-care, this can trigger the problems with blood vessels and nerves. This in turn causes many complications of diabetes. These complications can be with the eyes, the heart, the kidneys, the feet and many other areas of the body. Because of the restricted blood flow when there is a problem or complication, the body is extremely slow to heal. Carelessness can cause body to begin to fall apart rapidly and lead to debilitating consequences and even death (Dr.A.K.Sethi 2006).

**Diabetic Neuropathy**

Nerve damage from diabetes is called diabetic neuropathy. It refers to the damage to the nerves which causes a person to be unable to feel any sensations such as the feeling of pain. Diabetes can attack certain nerves in the nervous system. They affect the nerves in a number of different ways but all seem to be somehow related to blood sugar levels which remain too high for a long period of time. Although nerve damage related to diabetes may be painful, in most cases it is not severe pain. Over time excess blood glucose can injure the walls of tiny blood vessels that nourish nerves, especially in the legs. Nerves send messages to and from the brain about pain, temperature and touch. They tell muscles when and how to move. They also control body systems that digest food and pass urine. If the person keeps the blood glucose levels on target, nerve damage can be prevented or delayed. Currently there is no treatment which can cure diabetic neuropathy. When a person has it, treatment can be done to keep the disease from becoming worse. The key to treat neuropathy is good management or control of diabetes and by maintaining a healthy weight.
Diabetic Retinopathy

Diabetic retinopathy is a very serious complication of the retina in the eye which often occurs in those who have diabetes. It is caused by changes in the blood vessels of the retina. In some people with diabetic retinopathy, blood vessels may swell and leak fluid. In other people, abnormal new blood vessels grow on the surface of the retina. The retina is the light-sensitive tissue at the back of the eye. A healthy retina is necessary for good vision. If a person has diabetic retinopathy, at first he/she may not notice changes to his/her vision. But, over time, diabetic retinopathy can get worse and cause vision loss. Diabetic retinopathy usually affects both eyes. To prevent these problems with the eye, it is important to have regular complete eye exams with an eye doctor. This includes having the eyes dilated so that the doctor is able to examine the blood vessels in the eye. It is also important in preventing diabetic retinopathy to manage the blood glucose levels daily. For a diabetic patient, this is a lifelong commitment to maintain and manage the chronic disease.

Skin and Mouth Conditions

Diabetes may leave you more susceptible to skin problems, including bacterial and fungal infections. Gum infections also may be a concern, especially if you have a history of poor dental hygiene.

Osteoporosis

Diabetes may lead to lower than normal bone mineral density, increasing your risk of osteoporosis.

Hearing Problems

Hearing impairments occur more often in people with diabetes.
Pregnancy Complications

High blood sugar levels can be dangerous for both the mother and the baby. The risk of miscarriage, stillbirth and birth defects are increased when diabetes isn't well controlled. For the mother, diabetes increases the risk of diabetic ketoacidosis, diabetic eye problems (retinopathy), pregnancy-induced high blood pressure and preeclampsia.

Diabetic Nephropathy

Diabetic nephropathy, also known as diabetic kidney disease, is one of the most common and most devastating complications of diabetes. It is a slow deterioration of the kidneys and kidney function which, in severe cases, can eventually result in kidney failure, also known as End-Stage Renal Disease, or ESRD. This failure, ESRD, is very serious. A person with ESRD needs to have a kidney transplant or to have the blood filtered by machine (dialysis). High blood pressure (hypertension) is considered the major factor in kidney problems developing in those persons with diabetes. A family history of hypertension as well as the presence of hypertension seems to increase the chance of developing kidney disease.

Diabetic nephropathy can be prevented by keeping the level of blood sugar under control. Very extreme management of diabetes can also decrease the risk of developing kidney disease or problems by 50%. This intense management includes testing levels of blood glucose frequently, basing the amount of insulin intake on exercise as well as diet, following a healthy diet as well as regular plan of exercise, and regular checkups with a doctor.
**Diabetic Heart Disease**

Diabetic heart disease or cardiovascular disease is one of the leading causes of deaths related to diabetes. A range of blood vessel system diseases that includes both stroke and heart attack is the major cause of death in people with diabetes. The two most common types of cardiovascular disease are coronary heart disease, caused by fatty deposits in the arteries that feed the heart, and hypertension, or high blood pressure. People with diabetes are two to four times more likely to have a stroke or heart attack than those without the disease. Chest pain is a common heart attack symptom. Since diabetes can impact the nerves, some people with diabetes have heart attacks without experiencing any pain at all. Making certain healthy lifestyle changes can reduce the risk of heart disease. Eating a heart-healthy diet, maintaining an optimal weight and sticking to a daily exercise routine will help to prevent diabetic heart disease.

**Diabetic Foot**

Diabetic Foot is a complex condition of the foot caused due to several concurrent complications of Diabetes. It finally leads to formation of wounds or ulcers in the affected legs which may not heal quickly or even require amputation of the affected part. The two important complications are Diabetic Neuropathy and Peripheral Vascular disease. Neuropathy affects the nerves carrying sensation of pain, touch and pressure from the feet to brain as well as supplying the blood vessels, increasing or decreasing blood flow in parts of the legs. Blood vessels may become constricted due to atherosclerosis and calcification leading to decreased blood flow to soles and other part of feet. Proper footcare is very essential for avoiding this devastating complication of diabetes. Choosing footwear is very important, shoes should be comfortable without any areas of excessive pressure, insoles or custom
made shoes should be used if there is any difficulty in finding adequate footwear. Feet should be inspected daily, if there are any cracks, wounds etc. they should be taken care of. A diabetologist or foot specialist must inspect the feet and conduct testing to ascertain the status of nerves. If foot infections do happen they require good nursing, cleaning and dressing preferably done in clean settings by a professional, rest and antibiotics are also helpful. Non healing wounds may be helped by Hyperbaric Oxygenation, in which the affected part is kept under pressurized oxygen, and this promotes healing. Blood Sugar should be strictly controlled in any infection.

3.2 SUMMARY

This chapter presents the causes, symptoms, types and complications of the diabetes mellitus. The quality of diagnosis of the diabetes disease totally depends on the clinical data, obtained through various diagnostic tests. Making a correct and accurate diagnosis is not easy for the medical experts as the clinical data contains huge amount of information. In the subsequent chapters the various techniques like neural network, fuzzy logic and genetic algorithm are used to diagnose the diabetic disease along with its types and complications more effectively.