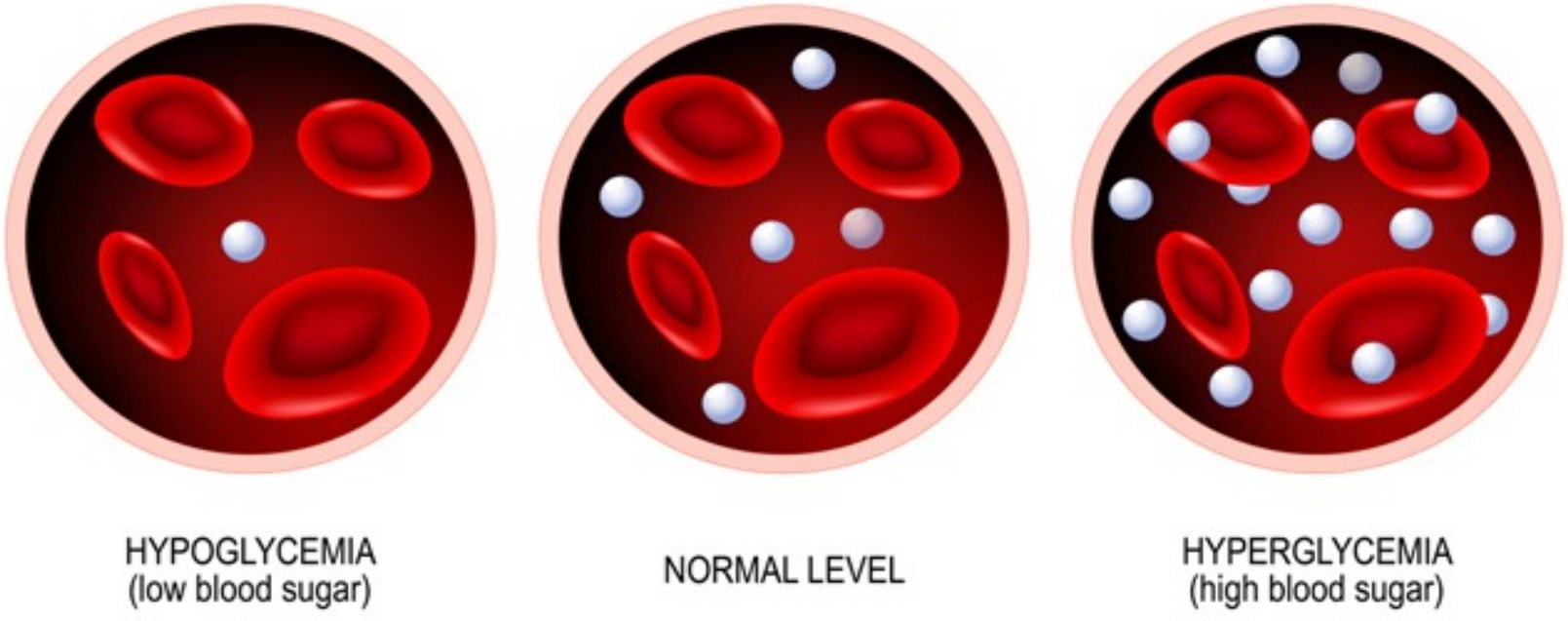
Management of Diabetes Mellitus

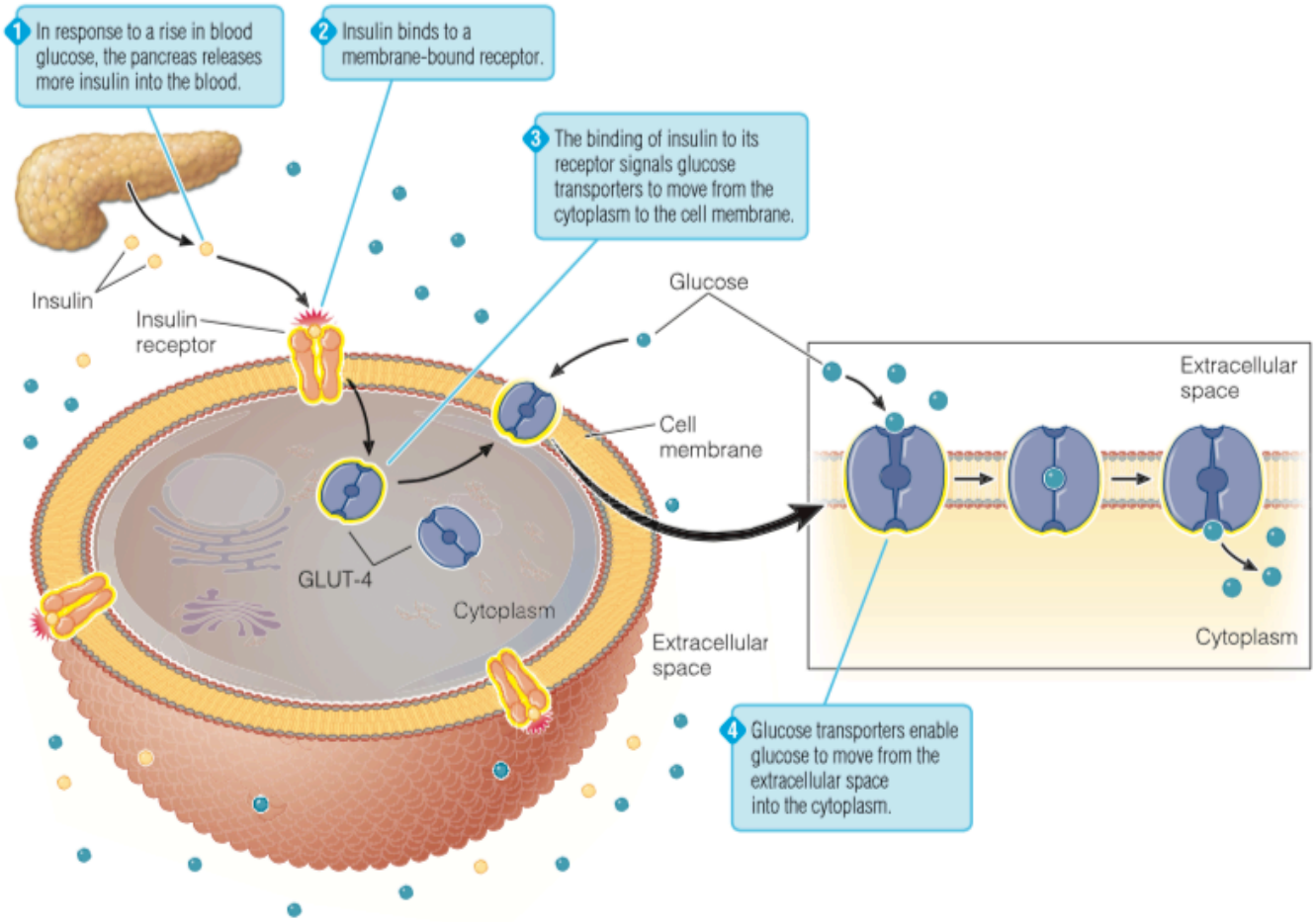


Definition

Diabetes mellitus, commonly known as diabetes, is a disorder of carbohydrate metabolism characterized by high blood sugar level (hyperglycaemia) and high level of sugar in urine (glycosuria). It is accompanied ín many cases by secondary alterations of fat and protein metabolism, resulting in an array of physical disorders.

Diabetes therefore, is a metabolic disease. It can be kept well under control and reasonably managed with proper care though it cannot be cured once it occurs.

Figure 17.9 The Role of Insulin in Cellular Uptake of Glucose



Source: Nutritional Sciences: From Fundamentals to Food 2e by McGuire/Beerman, Figure 4-19, page 147.

Classification

- The general classification of diabetes is based upon two major types:

a) type I, insulin-dependent diabetes mellitus (IDDM)
b) type II, non-insulin-dependent diabetes mellitus (NIDDM).

85-90 percent of the diabetic population is non-insulin dependent; the other 10 to 15 percent is insulin-dependent.

- Another types of diabetes is Gestational diabetes is hyperglycaemia diagnosed during pregnancy that had not been previously diagnosed.

Type1- Insulin Dependent Diabetes Mellitus

- **What is it?-** This is the most severe form of diabetes, occurring most often in childhood or young adulthood. The body attacks the beta cells in your pancreas so no more insulin is produced. Glucose is still produced from carbohydrate metabolism but instead of entering cells, it builds up in the blood. It may, or may not be an inherited trait.
- **Causes-** Recent research indicates that the islet cells of the pancreas may have been damaged, either by a disease (such as rubella) or by certain chemicals that were toxic, which led to the onset of the disease.
- **Symptoms-** The classic symptoms of IDDM are polydipsia, polyphagia, and polyuria, accompanied by rapid weight loss and often ketoacidosis.
- **Importance of dietary management-** IDDM has a rapid onset, is very unstable, and causes metabolic imbalances that are difficult to control. For these reasons the diet is very carefully planned and coordinated with the insulin and exercise regime.
- **Failure of management-** Failure to time and regulate the meals with these factors will result in great fluctuations in blood glucose, ranging from acute hypoglycemia to extreme hyperglycemia.

Type 2- Non Insulin Dependent Diabetes Mellitus

- **What is it?**- Type 2 diabetes, formerly called ‘adult-onset diabetes’ or ‘non-insulin- dependent diabetes’, is the most common type of diabetes. The onset of type 2 diabetes can be at any age – even during childhood – and is mainly caused by obesity.
- **Causes**- Type 2 diabetes usually begins with insulin resistance, a condition in which fat, muscle and liver cells do not use insulin properly. Obesity, physical inactivity, and hypertension are strong risk factors for the onset of NIDDM.
- Symptoms- The symptoms are similar to those of IDDM, except there is no weight loss and very rarely ketoacidosis.

Type 2- Non Insulin Dependent Diabetes Mellitus

- Management strategies- NIDDM is a milder form of diabetes and is most often controlled with weight loss and an exercise program. Occasionally an oral hypoglycemic drug will be necessary.
- Failure of management - diabetic persons have increased risks of developing major complications such as kidney disease, vascular disease, nerve impairment, and diseases of the retina of the eye. In fact, as much as 20% of the diabetic population becomes blind. Fluctuations of blood glucose from uncontrolled diabetes are thought to be one important factor in the onset of these conditions, making it even more imperative to manage and monitor the diet carefully.

Diagnosis of diabetes and prediabetes

- Classic symptoms such as polydipsia, polyuria, and rapid weight loss associated with gross and unequivocal elevation of blood glucose (over 11.1 mmol/L, or 200 mg/dL) make the diagnosis of diabetes mellitus.
- A fasting plasma glucose level above 7.0 mmol/L (126 mg/dL)
- Hyperglycemia that is not sufficient to meet the diagnostic criteria for diabetes is classified as either impaired fasting glucose (IFG) or impaired glucose tolerance (IGT). IFG and IGT have been officially termed “pre-diabetes”
  - IFG = fasting plasma glucose (FPG) 100 mg/dL (5.6 mmol/L) to 125 mg/dL (6.9 mmol/L)
  - IGT = 2-h plasma glucose 140 mg/dL (7.8 mmol/L) to 199 mg/dL (11.0 mmol/L)

Diagnosis of diabetes and prediabetes

- An oral glucose tolerance test (OGTT) can be performed for impaired fasting plasma glucose (6.1–7.0 mmol/L, 110–126 mg/dL), when 2-hour postprandial plasma glucose exceeds 7.8 mmol/L (140 mg/dL) or for individuals at high risk of diabetes
- The OGTT identifies individuals with diabetes, impaired glucose tolerance, and gestational diabetes.
- After an overnight fast of 10 to 16 hours, an oral glucose load of 75 g (or 40 g/m2) is given. The subject remains seated during the test. Water is permitted, but smoking is not. Blood is taken before glucose administration and 0.5, 1, 1.5, and 2 hours later for plasma glucose determination

Acute complications of diabetes

Diabetic Ketoacidosis (DKA)

- DKA is a common and life-threatening complication of type 1 diabetes, particularly at the time of diagnosis.
- In type 2 diabetes patients, DKA occurs during concomitant acute illness or during transition to insulin dependency
- DKA is caused by very low levels of effective circulating insulin and a concomitant increase in glucagon, cortisol, and growth hormone. Impaired glucose utilization and increased glucose production by the liver and kidneys result in hyperglycemia. Lipolysis leads to increased production of ketones, especially beta-hydroxybutyrate (β-OHB), ketonemia, and metabolic acidosis which is exaggerated by ongoing fluid and electrolyte losses.

Acute complications of diabetes

- Insulin omission, inadequate insulin dosing during infection, gastrointestinal illness, trauma and stress, or pump failure can precipitate DKA
- DKA is defined as a triad of:
  - hyperglycemia, i.e., plasma glucose >250 mg/dL (>13.88 mmol/L)
  - venous pH <7.3 and/or bicarbonate <15 mmol/L
  - moderate or large ketone levels in urine or blood
- Treatment: correcting dehydration, correcting electrolyte imbalance, continuous IV insulin administration

Acute complications of diabetes

HYPERGLYCEMIC HYPEROSMOLAR STATE (HHS)

- HHS is defined as extreme elevation in blood glucose >600 mg/dL (>33.30 mmol/L) in the absence of significant ketosis and acidosis.
- Decrease in the effective action of circulating insulin coupled with a concomitant elevation of counter regulatory hormones lead to increased hepatic and renal glucose production and impaired glucose utilization in peripheral tissues, which result in hyperglycemia and parallel changes in osmolality of the extracellular space.
- HHS is associated with glycosuria, leading to osmotic diuresis, with loss of water, sodium, potassium, and other electrolytes.
- The majority of HHS episodes are precipitated by an infectious process; other precipitants include cerebrovascular accident, alcohol abuse, pancreatitis, myocardial infarction, trauma, and drugs.
- Treatment: diabetes education, prevent dehydration by intravenous rehydration, avoid medications such as corticosteroids, intravenous insulin to correct hyperglycemia.

Acute complications of diabetes

HYPOGLYCEMIA

Hypoglycemia is insulin shock. This may take place in patients who are receiving insulin where there is imbalance between diet and insulin dosage, or it may be caused due to delay in eating, omission of food or loss of food by vomiting and diarrhea. In some patients excessive exercise may also cause symptoms of insulin shock.

In such cases the patients becomes pale, nervous, weak and hungry. The person tends to have excessive perspiration and moist skin. S/he may have uncoordinated movements, nausea, vomiting or convulsions. If not treated by giving sugar or fruit juice, the patient may go into coma or even die.

- The goal of treatment of hypoglycemia is to immediately increase the blood glucose approximately 3–4 mmol/L (~55–70 mg/dL). This can be accomplished by giving glucose tablets or sweetened fluids, such as juice, glucagon injection in unconscious patients, or dextrose infusion in a hospital setting.

Chronic Complications of Diabetes

1. Diabetic Eye Disease

(a) Prevalence of diabetic retinopathy, especially in middle-aged and elderly people, causing visual disability.

(b) Risk of blindness especially in older persons which is indicated by deposition of white exudate and haemmorhage or by oedematous swelling of retinal tissues.

(c) Cataract and other eye diseases occur earlier and more often in diabetics than in non-diabetics.

2. Kidney Diseases Progressive impairment of renal function, accompanied by urinary protein loss and culminating in end-stage renal failure may be seen in diabetics.

3. Diabetic Neuropathy Damage to nerve fibres conducting sensation and blood vessels as well as the viscera is the most common complication of diabetes.

4. Cardio-Vascular Diseases CHD (coronary heart disease) occurs more frequently and has notably more serious consequences in diabetics than in non-diabetics.

Atheresclerotic disease of the small arteries in diabetics is responsible for the high incidence of claudication and gangrene in the lower limbs, and for cerebral infarction, stroke and diffused cerebral disease.

Chronic Complications of Diabetes

5. The Diabetic Foot Diabetics are affected by a peculiar disability which severely damages the tissues of the foot. It is seen in the form of chronic ulceration, sepsis, and gangrene. It may necessitate amputation of the foot.

Three major factors have been identified which lead to the diabetic foot. They are:

1. Chronic diabetic neuropathy
2. Atherosclerotic obstruction of the arteries that supply the lower limbs
3. Bacterial infection

It is possible to control the extent of tissue damage with correct care.

6. Gastroparesis Gastroparesis is also called delayed gastric emptying. It results in food remaining in the stomach for a longer period of time than normal. Normally, the stomach contracts to move food down into the small intestine for digestion and the vagus nerve controls these contractions. Gastroparesis may occur when the vagus nerve is damaged and the muscles of the stomach and intestines do not work normally. Food then moves slowly or stops moving through the digestive tract.

Chronic gastroparesis is more often due to autonomic neuropathy. This may occur in people with Type 1 or Type 2 diabetes. Due to a high blood glucose level for a long time, the vagus nerve becomes damaged resulting in gastroparesis. Gastroparesis has

Medical Nutrition therapy

Characteristics and goals

Goals of nutrition therapy

Medical nutritional therapy is pivotal in the management and care of diabetes. Nutritional intervention provides a cost-effective strategy for reducing the complications, hence the morbidity and mortality, of diabetes.

- The first and preeminent goal is achieving and maintaining blood glucose levels as near normal as possible by balancing food intake with insulin (either endogenous or exogenous) or antidiabetes agents. Prevent hyperglycemia and hypoglycemia
- Second in priority is achieving and maintaining optimal serum lipid levels. Cardiovascular disease is the most common complication of diabetes. Lipoprotein abnormalities play a major role in atherosclerosis.
- Regulate safe levels of fatty acids, ketones, and amino acids by optimizing glucose use, normalizing glucose production, and enhancing insulin sensitivity.

Nutritional therapy for type I diabetes

- Usual food intake and pattern preference should be determined and used as the basis for insulin requirement prescriptions
- Eating at consistent times is vital for appropriate use of insulin.
- Intensified therapy may be considered for those willing and able to comply and can provide considerably more flexibility in meal planning.
- Individuals can be taught to adjust premeal insulin to compensate for changes in their meal plans, to delay premeal insulin for meals that are late, and to administer insulin for snacks that are not part of their meal plan.
- Intensified therapy may include carbohydrate counting with adjusted multiple injections or use of an insulin pump. The individual's skill and educational level must be considered.

Nutritional therapy for type II diabetes

- Emphasis should be given on maintenance of desired weight and glucose, lipid, and blood pressure goals. Loss of 10% of current weight was shown to improve diabetes control
- Strategies may be aimed at improving food selection (e.g. reducing dietary fats and saturated fats), spreading meals throughout the day, and incorporating regular exercise habits.
- If dietary and behavioral intervention is not successful, an antidiabetes agent may be needed.
- Stopping or changing oral agents is preferable to dietary manipulation for type 2 diabetic patients who are experiencing hypoglycemia.
- Insulin therapy should be a last resort after all combinations of oral medications have been exhausted, as it may exacerbate concomitant hyperinsulinemia and promote weight gain.

Nutritional plan

Macronutrient Intakes The recommended macronutrient distribution (percent of kcalories from carbohydrate, fat, and protein) depends on food preferences and metabolic factors (for example, insulin sensitivity, blood lipid levels, and kidney function).[22] Intakes suggested for the general population are often used as a guideline

(: . .). Day-to-day consistency in carbohydrate intake is associated with better glycemic control, unless the patient is undergoing intensive insulin therapy that matches insulin doses to mealtime carbohydrate intakes.[23]

Total Carbohydrate Intake The amount of carbohydrate consumed has the greatest influence on blood glucose levels after meals—the more grams of carbohydrate ingested, the greater the glycemic response. The carbohydrate recommendation is based in part on the person's metabolic needs, the type of insulin or other medications used to manage the diabetes, and individual preferences. For optimal health, the carbohydrate sources should be whole grains, legumes, vegetables, fruits, and milk products, whereas foods made with refined grains and added sugars should be limited.[24]

Nutritional plan

Macronutrient DRI for adults:

Macronutrient ranges (% of total kcal):

- Carbohydrate: 45–65%
- Fat: 20–35%
- Protein: 10–35%

Carbohydrate RDA: 130 g/day

Fiber AI: 21–38 g/day

Protein RDA: 0.8 g/kg body weight

Glycemic Index Different carbohydrate-containing foods have different effects on blood glucose levels after they are ingested; for example, consuming a portion of white rice causes blood glucose to increase more than would a similar portion of barley. A food's glycemic effect is influenced by the type of carbohydrate in a food, the food's fiber content, the preparation method, the other foods included in a meal, and individual tolerances. For individuals with diabetes, choosing foods with a low **glycemic index (GI)** over those with a high GI may modestly improve glycemic control.[25]

Sugars A common misperception is that people with diabetes need to avoid sugar and sugar-containing foods. In reality, table sugar (sucrose), made up of glucose and fructose, has a lower glycemic effect than starch. Because moderate consumption of sugar has not been shown to adversely affect glycemic control,[27] sugar recommendations for people with diabetes are similar to those for the general population, which suggest minimizing foods and beverages that contain added sugars. However, sugars and sugary foods must be counted as part of the daily carbohydrate allowance.

Fructose, a naturally occurring monosaccharide in fruit, has minimal effects on blood glucose levels when compared with similar amounts of sucrose or starch. Although some food products marketed to people with diabetes are sweetened with fructose, intakes of fructose should be limited—to no more than 12 percent of total kcalories—to avoid excessive energy intakes or adverse effects on blood lipids (high fructose intakes may increase blood triglyceride levels in some individuals).[28] Sugar alcohols (such as sorbitol and maltitol) have lower glycemic effects than glucose or sucrose and may be used as sugar substitutes. Artificial sweeteners (such as aspartame, saccharin, and sucralose) contain no digestible carbohydrate and can be safely used in place of sugar.

Nutritional plan

Whole Grains and Fiber Recommendations for whole grain and fiber intakes are similar to those for the general population. People with diabetes are encouraged to include fiber-rich foods such as whole-grain cereals, legumes, fruits, and vegetables in their diet. Although some studies have suggested that very high intakes of fiber (more than 50 grams per day) may improve glycemic control, many individuals have difficulty enjoying or tolerating such large amounts of fiber.[29]

Dietary Fat In individuals with diabetes, a Mediterranean-style dietary pattern that emphasizes monounsaturated fats may benefit both glycemic control and cardiovascular disease (CVD) risk.[30] In addition, increased intakes of omega-3 fatty acids from fatty fish or plant sources may improve the lipoprotein profile and various other CVD risk factors (see Chapter 3). Other guidelines related to fat intake are similar to those suggested for the general population: saturated fat should be less than 10 percent of total kcalories, *trans* fats should be minimized, and cholesterol intake should be less than 300 milligrams daily.

- Higher fat, especially saturated fat, intake in numerous studies has been shown to contribute to an increase in insulin resist- ance. High-fat meals have been shown to interfere with insulin signaling, whereas lower fat diets improve insulin sensitivity.
- Limiting intake of saturated fatty acids to less than 7 percent of total energy, consuming minimal recommended.

Exercise

Following are the additional benefits of exercise for persons with diabetes.

1. Increased sensitivity to insulin and improved glucose tolerance. A minimal level of insulin is needed for glucose uptake by the muscle at rest. An even smaller amount of insulin is needed to stimulate glucose uptake in exercising muscles. This reduces insulin requirements and increases the storage and utilization of glucose, thereby causing less extreme fluctuation in blood glucose over a 24-hour period.
2. Exercise adds to the blood glucose-lowering effect of injected insulin, so regular physical activity can permit a *reduction* in insulin dosages.
3. Physical training can help reverse the resistance to insulin that occurs as a result of obesity.
4. Reduction of risk factors for atherosclerosis, which occurs with increased frequency in the diabetic population. Regular exercise affects a lowering in triglycerides and very-low-density lipoprotein (VLDL), a decrease in total cholesterol and low-density lipoprotein (LDL) and an increase in high-density lipoprotein (HDL).
5. Lowers blood pressure. High blood pressure can increase the overall chronic problems that occur with diabetes. The reduction of blood pressure with exercise occurs even without weight loss or decrease in body fat.

Insulin

It is available in several forms. Soluble insulin is always used in an emergency situation of diabetic ketosis, but for the long-term treatment it has the disadvantage of a rather short action so that two or three injections may be required every day. For patients requiring less than 60 units of insulin per day, a single daily injection of one of the modified insulins such as protamine zinc insulin or zinc-suspension suffices. Some insulins are given in Table 9.2

In brief, the following are the types of insulin available in the market.

The following are the types of insulin available in the market:

1. Short-Acting Insulin

- Humalog
- Novolog
- Apidra
- Humulin
- Velosulin

These cover a period of four to six hours. They are given before breakfast and dinner. They are used for short-term periods of control as indicated in surgery, during labour and delivery, or in periods of illness. They may be used in mixtures with other insulins for control of juvenile diabetes when a closer, more even control is necessary. The carbohydrate distribution in the meal is 2/5, 1/5, and 2/5 for breakfast, lunch and dinner respectively.

2. Medium-Acting or Intermediate-Acting Insulin

(i) Natural Protamine Hagedorn (NPH) or Isophane, (ii) Lente, and
(iii) Globin.

NPH is most widely used. It is given in the morning, usually before breakfast. The peak activity of all the above mentioned three types is eight to 10 hours after administration, that is about mid-afternoon and then last in the waning period, a total of 20–24 hours. The meal distribution pattern having a larger lunch and dinner with allocation for a midafternoon and bedtime snack may be used. This gives a 1/7, 2/7, 1/7, 2/7, 1/7, carbohydrate distribution in meal pattern for breakfast, lunch, midafternoon, dinner and bedtime respectively.

3. Long-Acting Insulin

Long-acting insulins don't peak like short-acting insulins — they can control blood sugar for an entire day. This is similar to the action of insulin normally produced by your pancreas to help control blood sugar levels between meals.

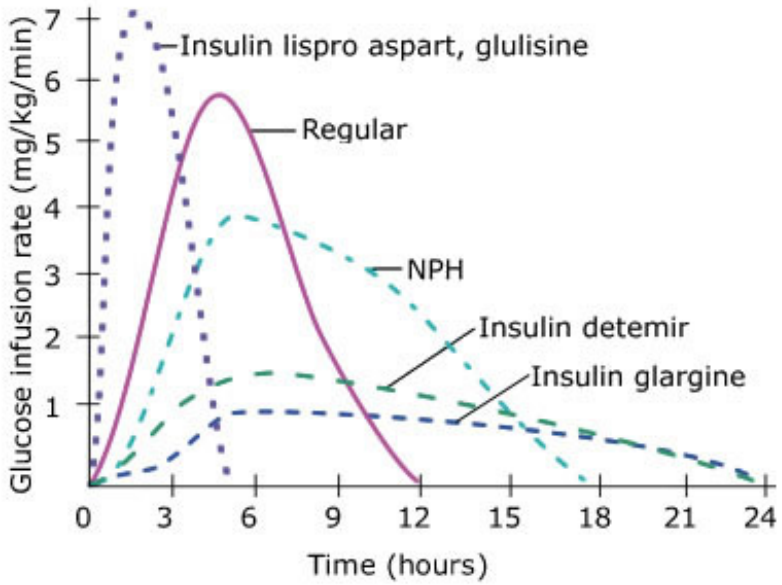
Long-acting insulins are also called basal or background insulins. They keep working in the background to keep your blood sugar under control throughout your daily routine.

There are currently four different long-acting insulin products available:

- insulin glargine (Lantus), lasts up to 24 hours
- insulin detemir (Levemir), lasts 18 to 23 hours
- insulin glargine injection (Toujeo), lasts more than 24 hours

- **Insulin pump therapy** delivers insulin in two ways: in a steady, measured, and continuous dose (the basal insulin), and as a surge (bolus) dose at mealtime. Insulin pumps can also deliver precise insulin doses for different times of day, which may be necessary to correct for situations such as the dawn phenomenon (increase in blood glucose level that occurs in the hours before and after waking). Pump therapy requires a committed and motivated person who is willing to do a minimum of four blood glucose tests per day, keep blood glucose and food records, and learn the technical features of pump usage.

Activity Profiles of Different Types of Insulin



Use of background insulin

- **Why we need it**?- Basal or background insulin, such as determir, glargine, or NPH, is required in the post- absorptive state to restrain endogenous glucose output primarily from the liver and to limit lipolysis and excess flux of free fatty acids to the liver.
- **Which ones to use?**- Glargine and detemir are insulin analogs of 24-hour duration with no peak action time. NPH is also occasionally used as background insulin but usually has to be given twice a day. . There are also premixed insulins that are usually used in persons with type 2 diabetes, often when insulin is initiated
- **When to use?**- They can be injected any time during the day, as long as they are taken around the same time each day, and cannot be mixed with other insulins. The type and timing of insulin regimens should be individualized based on eating and exercise habits and blood glucose concentrations.