



Diabetes and Measurements of Glucose Levels and Glycaemic Control

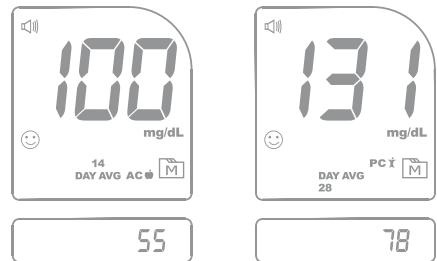


BLOOD OR PLASMA GLUCOSE

We all have to eat food to survive and to contribute to the maintenance and repair of the body and its organs. Food is broken down in the gastro-intestinal tract and reabsorbed, one product being glucose that can be stored as glycogen. Glucose molecules are one of the most important factors in the regulation of energy and metabolism of the body. The glucose level in the blood is tightly controlled in healthy subjects, but can also be changed during certain stress conditions or in states of disease. One reason for this tight control is that the brain needs glucose to stay alert. If glucose levels decrease too much some counter-regulatory hormones will try to restore the levels by influencing the liver and muscle storage depots of glycogen to catalyze and increase glucose in the general circulation. This is a short-acting mechanism when the body waits for food intake to restore the glucose and glycogen levels. If no food is available for a longer period the fuel resource will switch to catalyzing fat deposits and the production of so called ketone bodies, that can be used by the brain instead of glucose to avoid fainting and by the muscles for prolonged exercise capacity.

Blood glucose can be measured directly but currently more often as plasma glucose, one of the components of the blood volume itself. **Modern devices can be used for measurement of blood or plasma glucose and modern laboratory method to analyse the long-term glycaemic regulation via the glycated haemoglobin level (HbA1c).** All these variables can be used

for routine screening of disturbances of glucose metabolism with elevated level, hyperglycaemia, in some cases for diagnosing diabetes mellitus (based mainly on repeated plasma glucose levels 7.0 mmol/L or above; 126 mg/dL) or a state between normal glucose metabolism and overt diabetes that is often called impaired fasting glucose, IFG (with repeated plasma glucose levels in the interval 5.5-7.0 mmol/L; 120-125 mg/dL). In some cases also a standardised oral glucose tolerance test, OGTT (75 g glucose in 33 ml water solution) can be used when 2-hour levels of glucose provide additional diagnostic information. This is often used for special categories of patients or healthy subjects, for example to detect diabetes in pregnancy.



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- ▶ Pre & Post- Meal Recording

DIABETES

Several forms of diabetes mellitus exist with the common feature of increased glucose levels in the blood and its components (plasma), a condition named hyperglycaemia. The onset can be sudden or it can take some longer time to develop a state of hyperglycaemia and symptoms associated with this condition such as tiredness, increased thirst or volumes of urinary voiding.

The most common form is **type 2 diabetes (80-85%)** of all and then comes **type 1 diabetes (10-15%)** as well as some special forms called MODY, LADA and forms caused by exogenous factors such as infection, chemical influences (alcohol) or other harmful factors such as tumours of the pancreas, the abdominal organ producing insulin. There are two major pathophysiological mechanisms influencing the increased glucose levels (hyperglycaemia). Firstly, the beta-cells of the islets of Langerhans in the pancreas are responsible for insulin production, the hormone regulating glucose levels and facilitating glucose uptake in peripheral tissues. Secondly the insulin sensitivity of the liver and peripheral tissues (fat and muscle) plays an important role as regulator of the effect of insulin.

If the primary production of insulin is too low, or the effect of insulin in the periphery is compromised (insulin resistance) these could both contribute to hyperglycaemia and the development of type 2 diabetes.

In **type 1 diabetes** the beta-cell fail to produce insulin, as is also the case in some forms of diabetes in the adult (LADA). However, in **type 2 diabetes**, both mechanisms are of great importance as insulin resistance is often substantially increased due to obesity. Other contributing factors could be related to the influence of chronic inflammation or ageing itself.



RISKS AND CONSEQUENCES

The complications related to hyperglycaemia in diabetes are manifold, but could be controlled and prevented if hyperglycaemia is controlled by treatment and frequent evaluation of glucose levels or the long-term marker of hyperglycaemia called glycated haemoglobin (HbA1c). There are complications related to the vasculature, and a common subdivision would be to define microvascular complication (in the retina of the eye, in the renal function leading to increased albuminuria, or in the peripheral blood circulation leading to difficulties in wound of the extremities) and macrovascular complications (cardiovascular complications such as stroke or coronary heart disease).

Other complications include neuropathy with loss of sensitivity or problems with burning sensations in the feet, and nephropathy leading to renal failure and risk of dialysis. If retina changes develop too far, called retinopathy, different degrees of blindness could be the consequence. Other complications of diabetes in poor control involve the gastro-intestinal tract, mental function or reproduction. Therefore diabetes is a medical condition influencing most organs of the body and can lead to serious consequences if not correctly diagnosed, monitored and treated.

On the other hand, by use of modern technologies or drug treatment most patients with **type 1 diabetes** can live almost a normal life except for the influence of repeated glucose measurements and insulin injections. The same is true for many patients with **type 2 diabetes**, even if many elderly patients will find it increasingly difficult to manage the disease on their own and will therefore need different support systems, e.g. by relatives or via home visits of community nurses.



G71

- ▶ Innovative Slim Design
- ▶ Simple Use
- ▶ Portable

SYMPTOMS

In many cases diabetes will go undetected for some time, occasionally for years, if there are no symptoms or no increased urinary excretion of glucose. It takes a blood glucose level of around 11 mmol/L (200 mg/dL) to give a spill-over effect in the urine, and the diagnostic level as indicated above is repeated fasting plasma levels of 7.0 mmol/L (126 mg/dL) or above. Otherwise the symptoms of hyperglycaemia are well-known to be tiredness, increased thirst and urinary volumes or frequent voiding.

Other symptoms include a proneness to dermal infections, for example *candida albicans* infections in the groins or under the breasts, or repeated urinary tract infections. In retrospect, after the diagnosis has been made also other symptoms could be explained by sub-clinical diabetes, for example impotence and disturbances of vision.



G31

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- ▶ Pre & Post- Meal Recording
- ▶ LCD Backlight

TREATMENT OF DIABETES

All patients with a diagnosis of **type 1 diabetes** will need insulin injections to a varying degree. Insulin can be given at every meal or otherwise once or twice daily. Modern insulin treatment should be guided by a near normal glycaemic control (less than 7.0% HbA1c = 52 mmol/mol of HbA1c). For patients with **type 2 diabetes** the most common treatment starts with lifestyle interventions including a balanced diet and increased physical activity, as well as smoking cessation in all smokers. After a varying period treatment with various tablets is most often needed as the beta cell function, and thereby the insulin secretion, tends to diminish with time since diabetes diagnosis. Some of these tablets aim to increase insulin secretion (sulphonylurea, glinides, DPP-4 inhibitors) or to improve insulin sensitivity (metformin, glitazones). Some newer drugs given as injections acts as enhancers of insulin secretion (incretin analogues). Finally there is also one drug acting only in the gastro-intestinal tract to decrease glucose production in the intestinal mucosa after food intake (acarbose).

After longer follow-up most patients with **type 2 diabetes** will need insulin therapy as there continuous beta-cell impairment secondary to hyperglycaemia. The goal for glycaemic control in patients with **type 2 diabetes** is normally less than HbA1c 7% in the middle-aged or newly detected patients, but higher (8-9%) in the elderly or frail patients with many comorbidities and increased risk of low glucose levels (hypoglycaemia) that might even trigger cardiovascular events according to recent guidelines.

In addition most patients with diabetes will also need some medication to control cardiovascular risk factors, for example drugs that lower blood pressure, hyperlipidaemia or drugs that lower the risk of thrombo-embolism (aspirin or anti-coagulants).



HOW TO PERFORM MEASUREMENT OF GLUCOSE AT HOME

As all patients with diabetes have a varying degree of hyperglycaemia, both during day-time and night-time, it is of importance to monitor glycaemic control, both in regular health care and at the home of patients. Some patients will need more frequent monitoring, for example in patients with labile diabetes or with complication, as well as in pregnant women with diabetes. Other patients with a more stable form of diabetes, or with less ambitious antiglycaemic treatment, for example in the frail elderly, will need less frequent monitoring.

Today several devices exist for home measurement of glucose. These were once introduced for the measurement of blood glucose but have now shifted to the measurement of plasma glucose due to the change in international recommendations.

For some patients a daily monitoring of glucose levels is obligatory, for example in pregnant women with diabetes, while in other patients less frequent monitoring is needed. This should be decided after a clinical examination and a review of the medical history and treatment by the responsible physician.



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