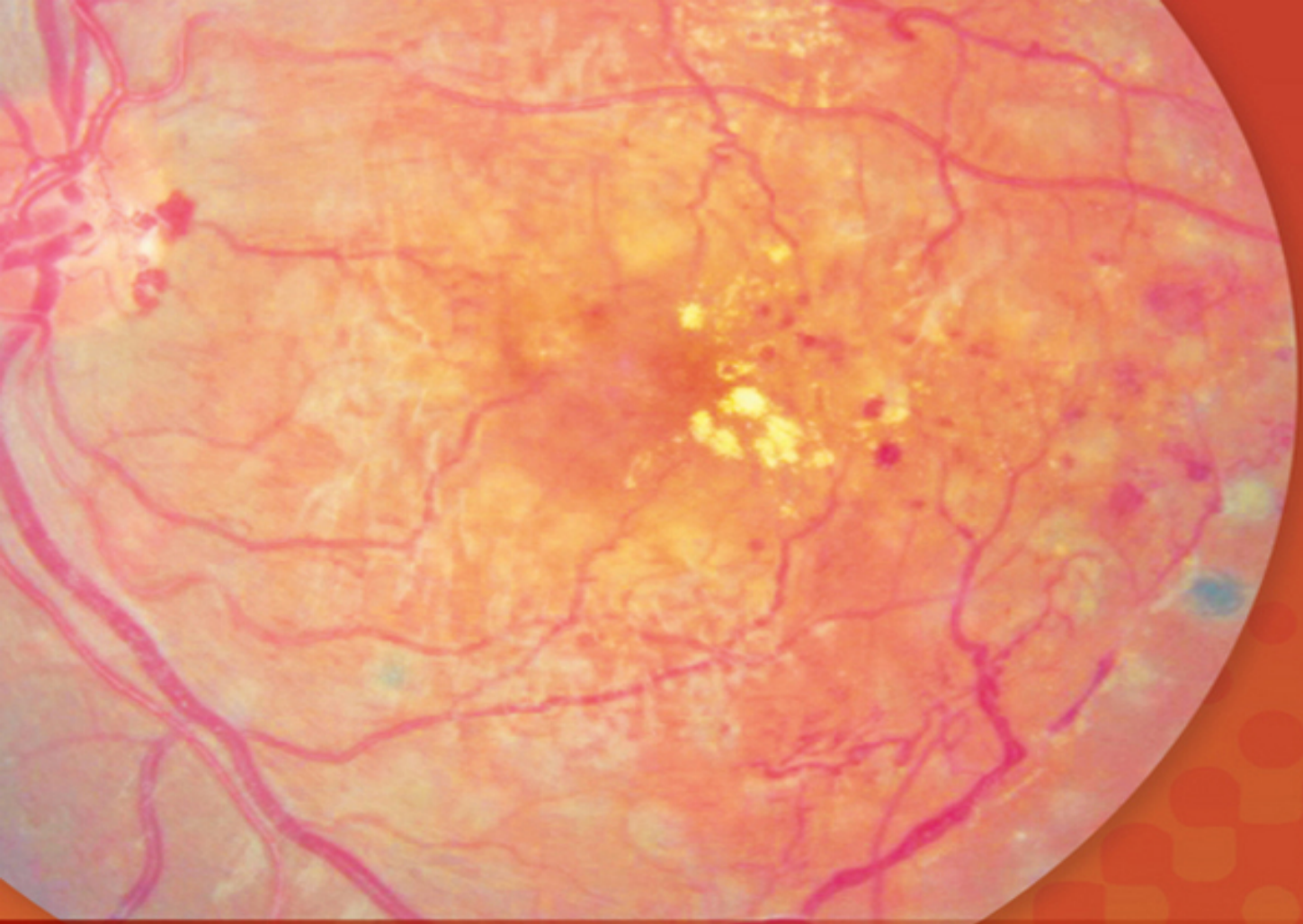

SECOND EDITION

Handbook of Retinal Screening in Diabetes

Diagnosis & Management

ROY TAYLOR & DEBORAH BATEY

WILEY-BLACKWELL

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Companion website

This book is accompanied by a companion website:
www.wiley.com/go/taylor/retinalscreening
The website features:
• PowerPoints of all figures from the book for downloading

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Preface to Second Edition

The second edition of this book benefits from the extensive feedback on the first edition received from retinal screeners and specialists in diabetes and ophthalmology. It retains the successful overall format of its predecessor and includes a range of new images. This edition has been co-authored by a retinal screener of many years experience. This extends the down-to-earth, practical slant of the first edition.

A simple and effective grading system is used to classify the images shown. Up-to-date information is provided on diagnosis and treatment of diabetic retinopathy. Additionally, new sections provide the information required to prepare for – and pass – the Diploma in Retinal Screening. This qualification is now necessary for all retinal screeners in the UK.

Using the approach demonstrated, the retinal screening team in Newcastle upon Tyne has recently been able to publish data showing that diabetes is no longer the commonest cause of preventable blindness in the working age population. The book reflects the expertise of the whole team, and we would particularly thank Mr Rajen Gupta, Consultant Ophthalmologist for his continuing expert input.

We hope that you will enjoy using this Handbook and the associated website. Most of all, we hope that it will contribute to best possible care for people with diabetes.

Roy Taylor and Deborah Batey

January 2012

How to Use This Book

The first five chapters of this book are intended to be self-contained – so that each can be read or not depending upon the needs of the reader. A summary of important information is provided as a fact file at the end of each of these chapters. Self-assessment questions for each chapter are given in Chapter 14.

When examining the images in Chapters 6–12 it is essential to use a bright light such as a desk lamp or be close to a bright reading lamp. Diffuse fluorescent lighting is particularly poor for seeing fine retinal details. However, to allow the viewing of images as they would be seen during screening – full size upon a screen – a website has been created for the use of readers of this book. It can be found at www.wiley.com/go/taylor/retinalscreening. The images may be viewed either in colour or as red-free, and the images can be magnified as required. The descriptive text may be read to allow consideration of all the features.

The chapter on background information (Chapter 13) will introduce to people new to clinical diabetes or retinal screening the general knowledge that will benefit their patients.

1

Type 1 Diabetes

What Causes Type 1 Diabetes?

Diabetes is a disorder in which blood glucose levels are high. In normal health, blood glucose levels are precisely controlled by the hormone insulin. This is made by the beta cells in the pancreas gland, an organ behind the stomach. Minute-to-minute control of insulin production by the beta cells normally keeps blood glucose levels constant. After a meal, the rate of insulin production rises sharply.

Type 1 diabetes is the result of destruction of the beta cells in the pancreas. This is most often caused by the body's defence mechanisms attacking the cells as though they were invaders (an 'autoimmune' process). The process of beta-cell destruction happens over a period of many months, but symptoms can start very suddenly once the number of functioning beta cells falls to a critical level.

Who Gets Type 1 Diabetes?

Type 1 diabetes used to be called juvenile-onset diabetes (and insulin-dependent diabetes mellitus). It can occur any time from early childhood into late adult life, but starts most commonly in early adolescence. The condition is slightly more likely to occur if family members have type 1 diabetes, but many people have no such family history.

Approximately 0.2% of children of school age have type 1 diabetes in the UK. In the population as a whole it affects around 0.3%.

How Does It Present?

The main symptoms come on over a period of weeks and are:

- thirst
- passing large amounts of urine
- weight loss
- tiredness
- skin infections, especially thrush.

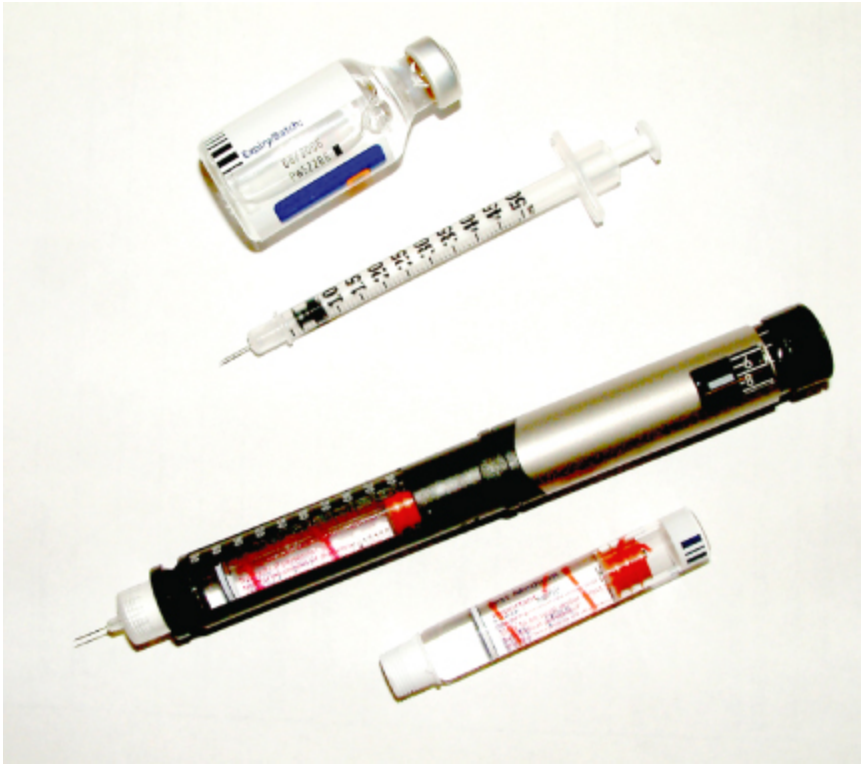
There will be glucose (sugar) present in the urine. In addition, ketones are likely to be present in the urine. Ketones are the by-product of fat breakdown and are normal in trace amounts for anyone during fasting. However, excessive amounts of ketones are present in urine only when lack of insulin allows fat to break down excessively.

Essentials of Management

Insulin

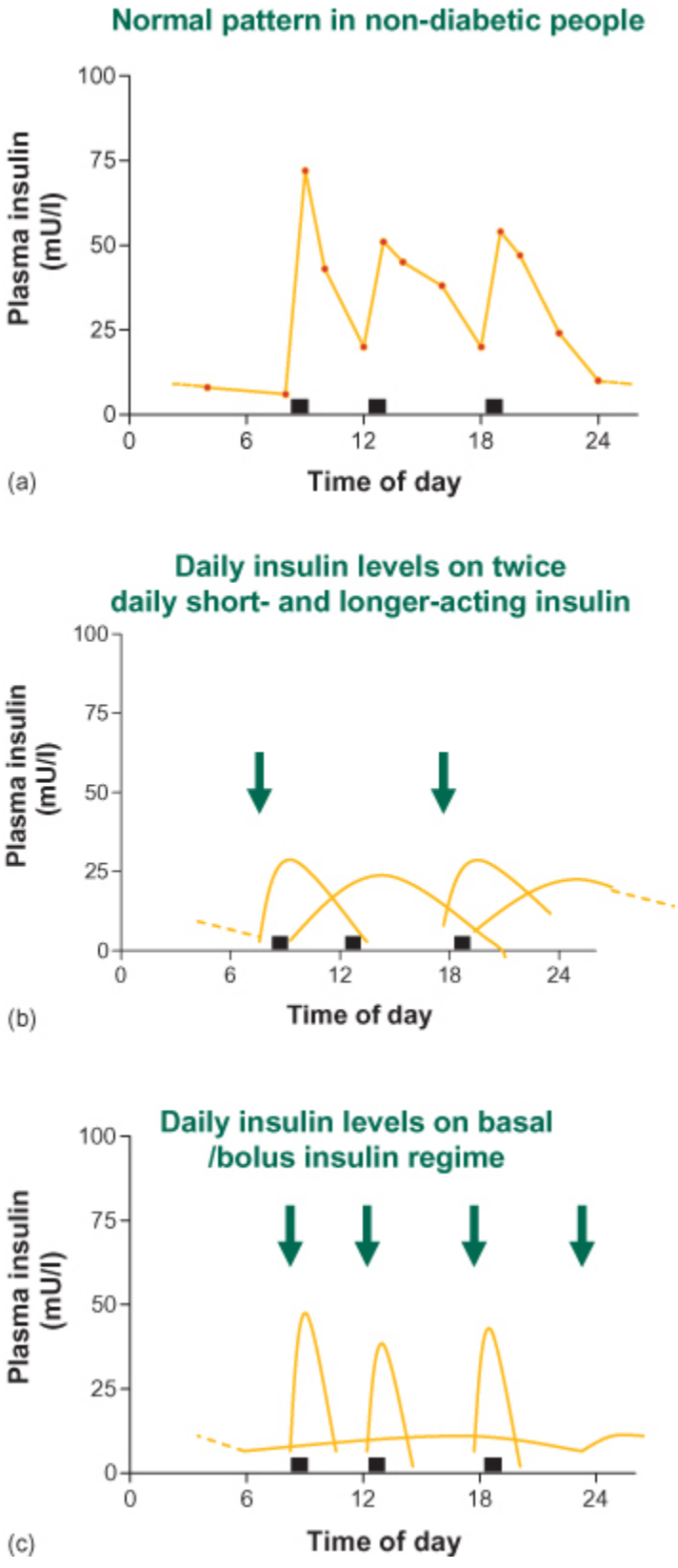
Insulin must be replaced to maintain life. As the insulin molecule is a peptide (a small protein), it would be broken down in the stomach if swallowed – just like any protein food. Insulin has to be injected into the fat layer under the skin. This may be done using a disposable syringe with insulin drawn from a vial, or by using a pen injector (Figure 1.1). It is usually advised that insulin be injected through the skin into the fatty tissue of the abdomen, the upper thighs or hips.

Figure 1.1 Insulin pens contain a 3 ml cartridge of insulin and are convenient to use because the required dose can rapidly be set and then injected. This avoids having to draw up a dose of insulin into a syringe from a vial



There are two basic types of insulin regimen. A combined injection of short-acting insulin and intermediate-acting insulin may be given before both breakfast and the evening meal (Figure 1.2). This has the advantage of simplicity, but the disadvantage that meals have to be eaten at fairly fixed times and in fairly fixed quantities.

Figure 1.2 (a) Insulin levels normally increase sharply after meals, and fall back towards a low baseline afterwards; the black boxes show the meal times. (b) This shows, in a diagrammatic form, what happens when a dose of short-acting insulin and a dose of longer-acting insulin are injected before both breakfast and the evening meal. This insulin regimen is simple, but does mean that meals have to be eaten at predictable times. (c) This shows similar information when a basal (very-long-acting) insulin is injected before bed to provide a low background of insulin to mimic the normal situation. Doses of very short-acting insulin are given before meals, and there is flexibility in both the timing and the size of meals


Normal pattern in non-diabetic people
Plasma insulin (mU/l)
100
75
50
25
0
0
6
12
18
24
Time of day
(a)
Daily insulin levels on twice daily short- and longer-acting insulin
Plasma insulin (mU/l)
100
75
50
25
0
0
6
12
18
24
Time of day
(b)
Daily insulin levels on basal /bolus insulin regime
Plasma insulin (mU/l)
100
75
50
25
0
0
6
12
18
24
Time of day
(c)

The second regimen tries to mimic the normal situation, with a low background of insulin being provided by a single daily injection of longer-acting insulin, together with the use of very short-acting insulin taken at a time when it is convenient to eat a meal, and in an amount corresponding to the size of that meal. Although this may involve three or more injections per day of very short-acting insulin, these can be given using a convenient pen device.

The insulin pump is an alternative approach to the second type of regimen. By having a continuous subcutaneous infusion of insulin with the possibility of giving doses before meals, these devices achieve similar control overall. Their usefulness has been hyped up too much, but they do suit some individuals very well.

The names of some of the commonly used insulins are listed in Table 1.1.

Table 1.1 Commonly used insulins and their time of action

Insulin[a]	**Time of action**	**Use**
Humalog Novorapid	0 min–2 hours *Very short*	As meal boluses (single doses)
Actrapid Humulin S	15 min–6 hours *Short*	1. As part of a twice daily short- and intermediate-acting insulin regimen 2. As meal boluses with evening long insulin
Humulin I Insulatard	1–14 hours *Intermediate*	1. As part of a twice daily short- and intermediate-acting insulin regimen 2. As overnight insulin (used with short-acting insulin to cover meals)
Lantus	1–24 hours *Long*	As basal insulin (used with boluses of very short-acting insulin to cover meals)

[a]The names in each box refer to similar insulins made by different manufacturers.

Food

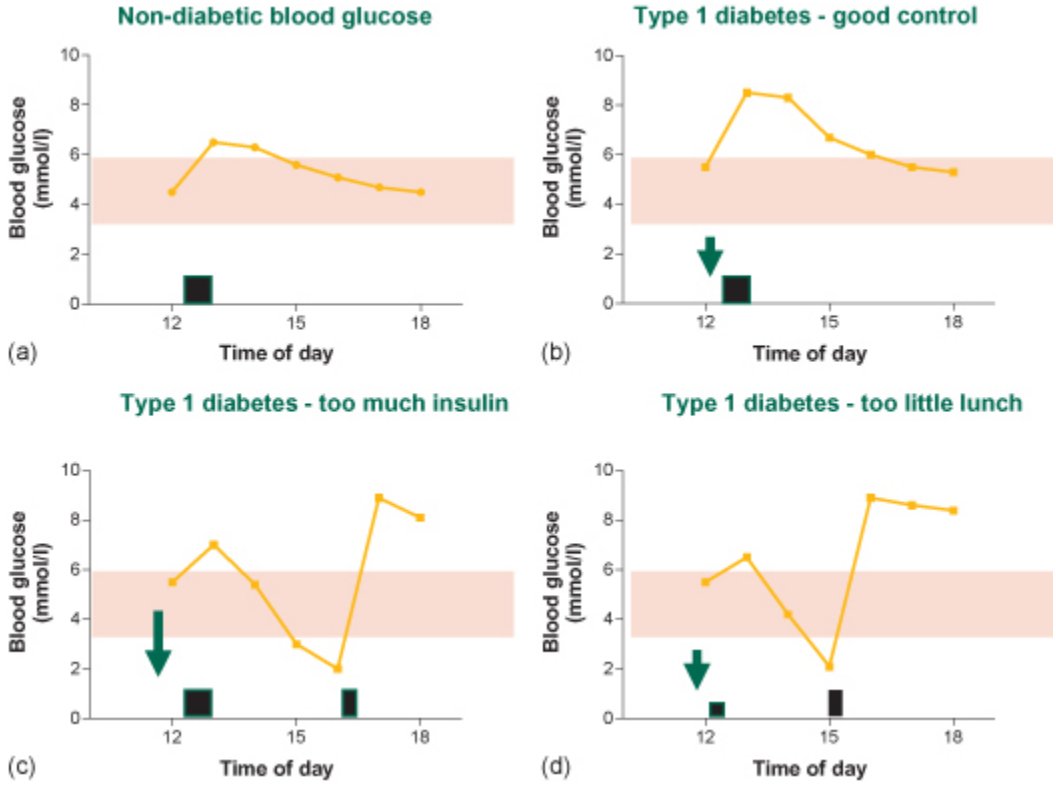
People with diabetes can eat normally, with a few modifications. Overall, the pattern of eating advised is merely that of a healthy lifestyle – not too much sugar, avoid fatty foods, and plenty of fruit and vegetables. Carbohydrate foods such as bread, pasta, potatoes and biscuits need to be considered in determining what dose of insulin is required. Since the 1930s carbohydrate has been 'counted' as 10 g exchanges. For example, an apple, a small potato or a digestive biscuit each can be counted as a 10 g exchange of carbohydrate. A person with diabetes is trained to assess how many carbohydrate exchanges would be in a meal. They will then inject meal-time insulin in a dose to cover this. For example, if an individual needed 1.0 units for each carbohydrate exchange then a meal consisting of 8 exchanges would require 8 units of insulin.

Hypoglycaemia

This word merely means 'low blood glucose' and is usually shortened to 'hypo'. Hypos occur when the balance of injected insulin and food eaten is not correct. If, for example, only a small meal had been taken even though a dose of insulin appropriate for a larger meal had already been injected, then the insulin would have too great an effect upon blood glucose and the level will fall (Figure 1.3).

Figure 1.3 (a) In non-diabetic people, blood glucose levels rise after eating, but the rise is limited by the normal insulin response and smooth control is achieved whatever the size of the meal. In all the graphs the meal size is represented by the black boxes and the normal pre-meal range of glucose is shown by the shaded area. (b) In well-controlled type 1 diabetes the rise in blood glucose after eating is likely to be greater than normal, but, if the insulin dose (represented by the arrow) matches the meal size, control will be achieved. (c) If too great a dose of insulin were given,

the rise after the meal would be smaller and blood glucose levels would fall below the normal range. Symptoms of a hypo would draw attention to the need for extra food, and blood glucose levels would tend to overshoot. (d) If only a small lunch were taken with a dose of insulin of usual size then blood glucose levels would rise little before the insulin caused a fall. Again, symptoms of a hypo would occur, extra food would be taken and blood glucose levels would overshoot



A hypo causes sweating, shakiness, a feeling of great hunger and eventually muddled thinking. If it is not treated by eating some sugary food, the muddled thinking will get worse and eventually the person will lose consciousness. There is a great risk that a person may be assumed to have drunk too much alcohol because of the uncoordinated movements and confusion.

Especially after many years of type 1 diabetes, awareness of the early symptoms of hypos becomes blunted. There is

then a risk of loss of consciousness without warning. The treatment of hypoglycaemia is administration of any sugary drink. A person who is hypoglycaemic may be uncooperative. Treatment from a doctor or paramedic would involve intravenous administration of glucose, or subcutaneous injection of glucagon. Glucagon is a hormone that has an opposite effect to that of insulin and causes the liver to produce glucose.

Ketoacidosis

If a person with type 1 diabetes did not take insulin, glucose could not be used by the body and fat (the main alternative fuel) would be mobilized excessively. High levels of ketones would be present in the blood and urine. As ketones are weak acids, the blood becomes slightly acidic. Nausea and then vomiting occurs. Once vomiting starts the condition is likely to be fatal within 1–2 days unless treated.

Anyone with type 1 diabetes who is ill is advised to test their blood glucose frequently and also to test their urine for ketones. The insulin dose always needs to be increased during illness, even if no food is eaten (because the body becomes resistant to ordinary levels of insulin). It is vital that expert medical help is obtained. Hospital admission is necessary for established ketoacidosis.

Living with Type 1 Diabetes

Few people who do not have type 1 diabetes actually appreciate the difficulty of living with a condition that requires attention every time the person wishes to eat or exercise.

To maintain the fine balance between blood glucose levels that are too high or too low requires detailed understanding of diabetes as well as hour-to-hour effort every single day. Adjusting insulin regimens to fit with work patterns,

including shift work, is not always straightforward. In practice, individuals adopt habits that lead to average blood glucose levels, which reflect a compromise that they themselves can tolerate. These are often higher than might be ideal, but considerable empathy and insight into individual circumstances are required before it can be said that control ‘must’ be better. Most other people in the diabetes team do not need to take diabetes home with them.

During any minor illness the need for insulin rises and major adjustments are needed to keep control.

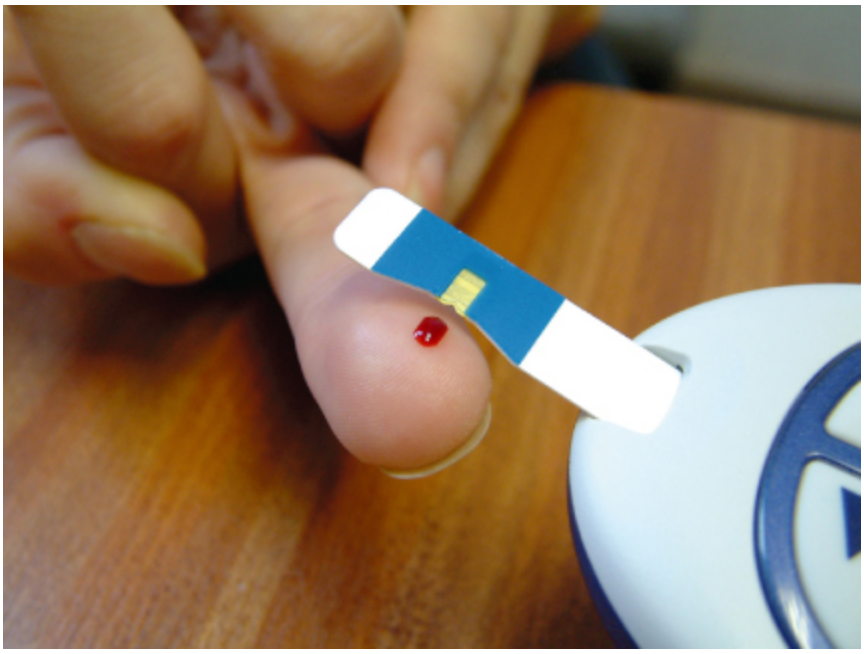
In order to hold a driving licence people with diabetes have to be able to recognize the early symptoms of hypoglycaemia, and have to obey the driving rules:

- Test blood glucose before driving
- Always keep glucose tablets or sweets in the car
- Plan longer journeys to ensure appropriate stops for snacks.

Blood Glucose Testing

It is only possible to ‘know’ one’s own blood glucose level if it is either very high or very low. For this reason it is important for people with diabetes to be able to test their blood glucose level. By using a finger-pricking device, a tiny drop of blood can be obtained. This is placed on a disposable strip connected to a meter (Figure 1.4).

Figure 1.4 To test blood glucose, a short needle is used to prick the finger and the drop of blood is placed on the test strip; the strip is connected to a small meter which gives a read-out of the result within seconds



The level of glucose in blood is measured in millimoles per litre (mmol/l). The non-diabetic fasting range for blood glucose is 3.5–5.5 mmol/l. In type 1 diabetes blood glucose levels would ideally be between 4 and 7 mmol/l before meals, but in practice much higher numbers may be observed. For each individual, a target range will have been agreed. In very long-standing type 1 diabetes, blood glucose levels may vary unpredictably and it may be necessary to aim for higher numbers in order to avoid very frequent hypos.

Complications

High blood glucose levels for many years can damage the smallest blood vessels – capillaries. The particular tissues that are most affected by this process are the retina, nerves and kidneys. These complications are known as ‘microvascular’ complications. The number of people with such complications increases as the duration of type 1 diabetes increases (see Figure 4.2).

Large blood vessels are also affected by high blood glucose levels. These ‘macrovascular’ complications include premature heart attacks, strokes and poor circulation to the feet. Diabetes causes fat to be deposited in the arterial walls, accelerating atherosclerosis (hardening of the arteries).

The risk of developing these long-term complications of diabetes is directly related to how well the diabetes is controlled. It is possible to assess this by a single blood test which indicates the average blood glucose levels over a period of 2 months. This is possible because glucose becomes attached to the pigment in red blood cells (haemoglobin). The amount of glucose attached to haemoglobin is measured in the test as ‘HbA1c’ (known as glycated haemoglobin). In non-diabetic people, the normal amount of glucose in the blood causes the level of HbA1c to be up to 6.0%. A very well-motivated person with type 1 diabetes may be able to achieve an HbA1c of 7.5% or less. Some people can only manage to achieve HbA1c levels of over 12%. A major study carried out in the USA demonstrated very clearly the relationship between HbA1c and the chance of developing complications. In general, the higher the HbA1c, the higher the risk of developing complications.

A further important factor is that of blood pressure. In diabetes, the higher the blood pressure, the faster complications will develop. Very tight control of blood pressure has been shown to have a greater effect than very tight control of blood glucose in slowing the rate of progression of complications. Although this may seem surprising at first, it has to be seen as a series of stages:

1. High blood glucose damages the capillaries and arteries.

2. High blood pressure will cause the damaged capillaries to leak or burst.

3. Reversal of high blood pressure will have an immediate effect upon the wellbeing of blood vessels.

4. Reversal of high blood glucose will just slow further damage.

However, it has to be recognized that some people appear to be less susceptible to complications than others. Other unknown factors determine the risk of complications for any one individual.

History

The word ‘diabetes’ comes from the Greek word for a siphon. This illustrates very clearly the main symptoms of type 1 diabetes – constant excessive drinking and passing of urine. The first written reference to diabetes dates back to 1500 BC. In 1889, Oscar Minkowski discovered that removal of the pancreas caused diabetes in animals. In 1921, Banting, Best, Collip and McLeod discovered a method of purifying insulin extracted from the pancreas of animals. The first patient to be treated with insulin received a dose in January 1922. Previously, type 1 diabetes was more rapidly fatal then most cancers, and insulin was hailed as a cure for diabetes. However, by the 1930s it was clear that long-term complications became very troublesome.

Fact file

- Type 1 diabetes is caused by destruction of the beta cells of the pancreas.
- The problems of type 1 diabetes are primarily due to failure to produce insulin.
- Treatment consists of injecting insulin in a pattern to balance carbohydrate food.
- Too much insulin, too little food or unaccustomed physical activity causes hypoglycaemia (hypo).
- Hypos cause some or all of: sweating, shakiness, incoordination, aggressive behaviour and eventually unconsciousness.

- Hypos are treated by giving anything containing sugar.
- Illness in type 1 diabetes may cause ketoacidosis and the need for hospital admission.
- HbA1c is a measure of average blood glucose over about 2 months.
- Microvascular complications include damage to the retina, nerves and kidneys.
- Macrovascular complications include premature heart attack, strokes and poor circulation.
- The rate of development of complications can be slowed by tight control of blood pressure and blood glucose.

Further reading

Diabetes UK. Available at: www.diabetes.org.uk/home.htm.

Fox C, Kilvert A. *Type 1 Diabetes: Answers at your fingertips*. London: Class Publishing, 2007.

National Institutes of Health, USA. Available at: http://diabetes.niddk.nih.gov/dm/pubs/control.