Blood Glucose Control

Diabetes makes many demands on the individual, not least of which is the need for frequent testing of blood glucose levels. In the early days, blood glucose testing was usually advised only for people with Type 1 diabetes. Nowadays, since the importance of blood glucose control has been fully realised, all people with diabetes are recommended to monitor their blood glucose levels at home.

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Why is Control Important?

Following the advent of insulin, and with the progression of modern medicine, the lives of people with diabetes have been significantly lengthened. The upshot of this has been the recognition of previously unknown complications: amputations, loss of sight, kidney disease, heart disease, and a multitude of other health problems. Although diabetes can now be successfully treated, it is still far from being cured...

The DCCT and UKPDS

Two landmark studies have now proven, without a doubt, that keeping blood glucose levels as close to normal as possible is incredibly important in preventing, or slowing, the progression of long term complications:

- The DCCT (Diabetes Control and Complications Trial) was conducted over nine years in people with Type 1 diabetes; the results were published in 1993 (1).
- The UKPDS (United Kingdom Prospective Diabetes Study) was conducted over twenty years in people with Type 2 diabetes; the results were published in 1998 (2).

That high blood glucose levels were connected to the development of complications came as no great surprise to most people. The link had previously been known as the ‘glucose hypothesis’ and really just needed to be confirmed in properly controlled large-scale studies.

The DCCT (1) conclusively demonstrated that lowering blood glucose to near-normal levels decreases the risk of both the development and the progression of complications, in people with Type 1 diabetes, by a massive 40 - 75%. Five years later, the results of the UKPDS (2) confirmed the relationship between blood glucose control and complications in Type 2 diabetes.

The results of these trials have been reproduced in numerous other studies; the evidence is real.

Blood glucose control can help you to avoid complications or, if you already have complications, it can limit their progression. So the message is clear – CONTROL MATTERS!

It is true that nothing is 100% certain with diabetes. A few unlucky people may develop complications, in spite of meticulously controlling their blood glucose levels. A few very lucky people may not develop any complications, in spite of having neglected their diabetes for many years. But we now have a great deal of evidence supporting the fact that good control of blood glucose levels will improve your chances in the long run.
Need more motivation?

It is sometimes easy 'not to worry about the future'. The short-term benefits of good control are also of importance and should not be overlooked.

Here are some more encouraging reasons for keeping your diabetes well controlled.

- Your general sense of well-being is greatly improved
- Your self esteem is higher
- You have more energy
- Your ability to concentrate is improved
- You are sure to feel less irritable, moody and depressed
- You will have better defence against infections

All of the above will aid your physical, emotional and spiritual wellbeing - enabling you to concentrate on living your life. Ignoring your diabetes may not affect your existence in this world in the short term, but ignoring your diabetes is not likely to enrich either your life, or that of those around you. So don't let it get the better of you and those who love and live with you.

Achieving Control

Getting your diabetes under control may, or may not, be easy. It will depend on the type of diabetes that you have, and the stage that the disease process is at. It will also depend on your motivation, on your knowledge of diabetes, and on your support network.

"Achieving control is not an 'absolute' thing - it is an on-going process, and in itself it becomes a journey through life."

KMR 1999

So how do I achieve control?

You should be "prescribed" some form of treatment for your diabetes, which is appropriate to you and your circumstances. It may simply be a recommendation that you make some changes to your lifestyle, or it may be that you need to have multiple daily injections of insulin. Your treatment should help you to control your blood glucose levels, but it will only work if you work with it.
To work with it, you will need to do certain things each and every day – perform finger-prick blood glucose tests, make decisions concerning your medication, the food that you eat... and so on. This forms the basis of diabetes self-management. And it is these self-care skills that will make the difference.

So, the appropriate treatment, along with good self-care should enable you to take control of your diabetes. In addition, you should learn as much as you can about diabetes and how it is managed – this will help you to control your diabetes to the best of your ability, AND enjoy life to the full.

Factors affecting blood glucose levels

Many health conditions can be easily controlled with a fixed daily dose of the appropriate medication; this is determined by your doctor, and all you have to do is take your medication... Diabetes is different. At first, it may seem that the objective is simply to bring a high blood glucose level down to the normal range. You may be given dietary advice and perhaps some medication, or you may start on insulin straight away, depending on the type of diabetes that you have. You trust you doctor, you go home, you expect (or hope) that all will be well...

But unfortunately your doctor is unable to account for the precise effects of your everyday movements, the exact timing and quantity of everything that goes in your mouth, the time you go to sleep, the time you wake up, whether you choose to walk or take the car, your emotions, any other illnesses or infections you may get... All of these factors can significantly affect blood glucose levels and in an ideal world would need to be balanced on a day-by-day, hour-by-hour basis.

So, perfect blood glucose levels all of the time is well nigh impossible with current treatment approaches - we aim to do the best we can.

Type 2 diabetes

Type 2 diabetes, in particular, is a naturally progressive disease. It is also a very 'heterogeneous' disease, meaning it comes in many different forms. At diagnosis, patients will have high blood glucose values, but insulin levels in the blood may be high, normal or low and this reflects the deterioration of beta cell function with time.

In the early stages of Type 2 diabetes, diet and exercise may be sufficient to keep blood glucose levels in check. Obesity increases insulin resistance, which means that more insulin needs to be produced to keep blood glucose levels in line. Exercise helps combat insulin
resistance and aids weight loss. A change in diet can reduce the challenge on the beta cells and a reduced calorie intake again aids weight loss.

Oral medication (tablets) can help people with Type 2 diabetes, but only whilst they have the ability to produce insulin. Early intervention with tablets may help prolong beta cell function.

High blood glucose levels and increased demand on the beta cells can lead to their deterioration. Eventually, insulin may need to be injected to keep blood glucose levels adequately controlled.

**Type 1 diabetes**

Type 1 diabetes results from the destruction of the insulin producing beta cells in the pancreas. At the time of diagnosis most, but not all, of the beta cells have been destroyed. Often, after insulin therapy has been started, the diabetes appears to 'get better'; for a short while the body recovers its ability to control blood glucose levels. During this period (which may last anything up to ten or twelve months) insulin requirements may fall to little or nothing and blood glucose levels remain within the normal range. Unfortunately though, this 'honeymoon period' does not last and eventually all ability to produce insulin is lost.

Once all of the beta cells have been destroyed, people with Type 1 diabetes become entirely dependent upon their insulin injections. So as the honeymoon period starts to wane, insulin requirements increase.

Control in young people is particularly difficult owing to the rapidly changing needs of the adolescent body.

**On Insulin and On the Rollercoaster**

A common problem for people relying on insulin injections is continual bouncing back and forth of blood glucose levels. Unfortunately the nature of the therapy dictates that insulin levels will rise and fall. A given dose of a particular type of insulin will have a certain duration of action, and at some time, the insulin activity will peak. These activity profiles vary, according to the insulin, the injection site and the individual. In order to minimise big swings in blood glucose levels, it is recommended that you:

- eat small amounts of carbohydrate food often,
- aim to follow a similar pattern of food and activity each day,
- test your blood glucose levels frequently,
- and you record and use your blood glucose results to help determine what works - and what doesn't work - for YOU.
In addition, overcorrecting high, or low blood glucose levels adds to the rollercoaster effect, so talk to your diabetes health professional about this.

The section 'Using Insulin' takes a closer look at how to gain control of your diabetes using insulin.

From a personal perspective the author found the book "Stop the Rollercoaster" (3) an informative and useful guide to the principles involved in insulin treatment. Although this volume is now 10 years old, and some aspects of insulin therapy have further evolved since its publication (notably the introduction of insulin analogues), it still provides a valuable tool for those people on insulin who wish to take on an active role in the management of their diabetes. Many of the principles described in the book are similar to those of insulin pump therapy, and this may be a viable (although costly) option for some people.

Where to Start?

Firstly, stop for a moment, and take stock of your situation. Consider your diabetes and your lifestyle, your work and leisure habits, your diet and so on. Then set yourself some small and achievable targets.

If you haven't done so already, arm yourself with a blood glucose meter - monitoring your blood glucose is the only way in which you will be able to take control of your diabetes.

Measures of Health Status and Control

There are a number of ways in which your general level of health and specifically your diabetes control can be assessed. Remember that relying on how you feel is NOT reliable - many serious health problems can creep up on you unawares; if these are detected and treated early on your life will be longer and more enjoyable in the long run.

For more detailed information on aspects of health care provision - what sort of health care you should expect to receive, and so on - go to the section entitled, 'Your Diabetes Care'.

Blood Glucose Tests

Self monitoring of blood glucose (SMBG) has become the cornerstone of diabetes management. It is the only accurate and reliable tool for immediate feedback of your treatment. Thanks to modern technology, SMBG is quick and relatively painless.

When and how often should you test? This will depend on your diabetes and your lifestyle. What should you do with your test results? These issues are addressed in the section 'Blood Glucose Monitoring'.
Urine Glucose Tests

Up until the 1970s testing urine for glucose was the only way patients could assess their diabetes control at home. I remember putting drops of water and drops of urine into testtubes, adding a fizzy tablet, then comparing the colour of the resulting solution with the colour chart provided. Indeed, it was fiddling about with test kits that set me on the road to becoming a biochemist.

Nowadays the chemical reaction is confined to a tiny pad on the end of a dip-stick that can be passed through a stream of urine. But whilst the technology of urine glucose testing has improved, the usefulness of the test itself has not.

Glucose is filtered out of the blood by the kidneys only when the level in the blood has reached a certain limit, which is called the renal threshold. There are three important points to note with this:

- Everybody’s renal threshold for glucose is different
- An individual’s renal threshold may change
- The kidneys may not start filtering glucose into the urine until your blood glucose is way too high - some people have a renal threshold as high as 10 mmol/l.

Another issue is that of timing. The bladder fills up with urine over a period of hours - a positive spot urine glucose test will not tell you when your blood glucose was high.

Another obvious caveat is that urine glucose testing cannot tell you whether your blood glucose is low, or falling rapidly and you are headed for a hypo.

In short then, whilst urine tests for glucose may be convenient in some circumstances, they are inaccurate and unreliable as a primary indicator of your diabetes control.

Laboratory Tests

Your home blood glucose tests will provide you with a picture of day-to-day control. There are a number of laboratory tests available which can provide a wider impression of how you are doing. The most important of these is the Glycated Haemoglobin (GHb) or HbA1c test. This gives an indication of your blood glucose control over the preceding two months or so. Take a look at the section 'The HbA1c Test' to learn more about this.

A less commonly used test is the Fructosamine test, which gives an indication of blood glucose control over the preceding one to two weeks. This is useful when monitoring changing therapeutic regimens and in pregnancy.
Other laboratory tests that provide information on your diabetes and health status include a blood lipid profile. This is a panel of fat and fat-like substances in the blood. People with diabetes - especially Type 2 or poorly controlled diabetes - tend to have abnormal blood lipid levels and this can add to the risk of developing heart and circulation problems.

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<tr>
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<th>Desirable range*</th>
<th>Comments</th>
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<tbody>
<tr>
<td><strong>Total Cholesterol</strong></td>
<td>&lt; 4.8 mmol/l</td>
<td>Cholesterol is made in the liver; most of our circulating cholesterol is derived from saturated fats in the diet.</td>
</tr>
<tr>
<td><strong>LDL Cholesterol</strong></td>
<td>&lt; 3.0 mmol/l b</td>
<td>'Bad' cholesterol. Low Density Lipoprotein carrier takes cholesterol from the liver to cells and tissues. Surplus cholesterol is deposited on the walls of blood vessels leading to atherosclerosis or 'hardening of the arteries'.</td>
</tr>
<tr>
<td><strong>HDL Cholesterol</strong></td>
<td>&gt; 1.2 mmol/l b</td>
<td>'Good' cholesterol. High Density Lipoprotein carrier takes cholesterol back to the liver.</td>
</tr>
<tr>
<td><strong>Triglycerides</strong></td>
<td>&lt; 1.7 mmol/l</td>
<td>These are natural fats - they consist of three fatty acid molecules and one molecule of glycerol.</td>
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</tbody>
</table>

* These values are **suggested target ranges** based on current recommendations in the literature.

a LDL cholesterol is usually calculated as: LDL chol = Total chol - HDL chol

b It is the ratio of LDL/HDL which determines cardiovascular risk, i.e. risk of heart disease

c Triglycerides, in particular, are usually determined on fasting samples
Blood Pressure

'Blood pressure' is a measure of the force that the blood exerts on the walls of our arteries (vessels taking blood away from the heart). The heart pumps blood round the body in a pulsatile fashion; the pressure exerted when the heart 'beats' is called the systolic pressure and in-between beats the diastolic pressure.

We hear blood pressure referred to as, for example, "a hundred and thirty over seventy". This would be written as 130/70 mm Hg. (The units are millimetres of mercury, a standard unit of pressure measurement). The figures correspond to the systolic and diastolic pressures respectively.

Blood pressure targets are being lowered for people with diabetes; treating high blood pressure early on and with as many therapeutic agents as it takes is becoming an important part of diabetes therapy. High blood pressure can contribute to heart disease, kidney and eye damage and is frequently a problem in people with Type 2 diabetes.

Ideally, you should be aiming for a blood pressure of 135/80 or lower, especially if you have any signs of developing long term complications of diabetes.

There is more on blood pressure and the relationships between hypertension (high blood pressure) and diabetes on the page, 'Hypertension' within the section on long term complications.

Levels of Control

There are various degrees of 'control'. At the end of the day, only you can decide which is best for you and your lifestyle. Your GP, Diabetes Consultant or Diabetes Specialist Nurse may have differing views on what you should be aiming for, so make sure you discuss your intentions with them; there are some instances in which tight or 'intensive' control is not appropriate.

[See table on next page]

Intensive Therapy and Tight Control

The DCCT and UKPDS both employed ‘intensive’ treatment approaches in a group of people and compared the results with ‘conventional’ treatment in another group of people. Those people receiving intensive treatment achieved better control and fared better against the long-term complications of diabetes. Intensive therapy is therefore associated with ‘tight’ control of blood glucose levels.
<table>
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<tr>
<th>HbA1c</th>
<th>Blood Glucose*</th>
<th>Comments</th>
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| Poor control | > 8% | Frequent and/or prolonged episodes of hyperglycaemia where blood glucose levels > 10 mmol/l | • Consider increasing SMBG  
• Does treatment plan need revising? |
| Reasonable control | 7 - 8% | Before meals: 4.4 - 7.0 mmol/l  
1 - 2 hr after meals: < 10 mmol/l | • Individual treatment goals should always take into account the patient's ability to understand and perform SMBG |
| Intensive control | < 7% | Before meals: 4.4 - 6.0 mmol/l  
1 - 2 hr after meals: < 8.0 mmol/l | • Consider increased risk of hypoglycaemia  
• Particularly important in pregnancy  
• This degree of control is inappropriate for some people, especially the very young or old, those at risk of severe hypoglycaemia and those with advanced kidney or heart disease |

* These blood glucose values are suggested target ranges based on current recommendations in the literature. They are, by necessity, generalised for the diabetic population as a whole.
YOUR Level of Control

The level of control that you need to aim for will depend on a number of factors, including the following:

- Your age and your lifestyle
- The type of diabetes that you have and the treatment approach
- Whether you are prone to severe low blood glucose (hypoglycaemia)
- Whether you already have any long-term complications of diabetes or any other significant health problems
- Whether you are pregnant

Aiming for tight control of blood glucose levels may be dangerous in some cases, so make sure that your treatment goals are agreed upon by both yourself and your doctor.