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Annotation

Home monitoring of diabetic control

Diabetic children have decades of diabetes ahead of them. This statement of the obvious indicates the responsibility carried by those who care for diabetic children, particularly if they accept the relationship between persistent hyperglycaemia and the development of diabetic microvascular complications in later life.[1]

Urine testing

Ideal control of diabetes can be taken to mean the maintenance of the blood glucose concentration within the normal range throughout the 24 hours. This ideal is rarely achieved with current methods of management. Nevertheless the diabetic child generally feels better, is more likely to grow normally, and is less likely to suffer from recurrent ketoacidosis if persistent hyperglycaemia is avoided.[2] This has long been recognised and is the rationale behind the measurement of urine glucose concentrations, for many years the only method available for home monitoring of diabetic control.

Urine analysis for glucose is non-invasive and indirectly estimates the blood glucose concentration. While it can provide valuable information on the prevailing pattern of blood glucose on a day-to-day basis,[3] a negative urine test does not mean that the blood glucose concentration is normal at the time of testing. The interpretation of the results may be made difficult by the uncertainty about, and possible variability of, the renal threshold for glucose in an individual diabetic child.[4] Despite this, if the blood glucose concentration exceeds the renal threshold there is a clinically useful relationship between the urine glucose concentration and the mean blood glucose concentration from the time of the last bladder voiding.[5] Since the average renal threshold is about 10 mmol/l, in practice most urine tests should be free of glucose if they are to approach the criteria of 'good control'.

Urine testing is unique in that it gives an indication of blood ketone concentration. The presence of strong urinary ketones, in association with high urinary glucose concentration, can be used as a warning sign for children and their parents that extra insulin or medical advice is urgently required. However the indirect and retrospective nature of urine tests is a difficult concept for the average diabetic child and family.

Blood glucose measurement

The development of techniques for measuring blood glucose at home is an important advance in the understanding of the control of diabetes both for patients and their physicians.[6 7] The obvious advantage compared with urine testing is that the measurement provides information on the blood glucose concentration at the time of testing; this is available to the patient immediately and to the physician subsequently for interpretation within the framework of the management regimen. The target should be to keep the blood glucose levels between 5 and 10 mmol/l. Alternatively one might aim to keep the postprandial levels below, say, 13 mmol/l while keeping mid-afternoon or fasting levels above 4 mmol/l.

The ability to measure blood glucose at home has a number of advantages for the family in the management of their diabetic child. If blood glucose tests are performed regularly they show the daily profile of postprandial peaks and mid-afternoon troughs of blood glucose. In this way the family collects data which the doctor can use to teach the logic of the diabetic management regimen or to suggest alterations to it. The ability to collect these data at home, especially if associated with a telephone link or a visiting community nurse, makes admission to hospital for 'stabilisation of diabetes' a largely obsolete practice.

Many diabetic children, especially those less than 10 years old, find finger pricking many times a day an unwelcome and additional assault. Nevertheless such children and their parents may still find occasional blood glucose measurements extremely valuable as guidelines for immediate action. For example: has he had enough extra carbohydrate after a bout of strenuous exercise? Does he need more or less insulin during a vomiting illness? A further specific example is the worry that most parents share about nocturnal hypoglycaemia. It is possible, especially with younger diabetic children, for parents to perform a capillary blood glucose measurement at their own

bedtime without waking the child and in this way assuage their fears of undetected hypoglycaemia or cause them to rouse the child for extra food.

There are many older children who find the testing of urine repugnant. The need for privacy to collect the samples and to perform the tests orientates their life towards lavatories which, at time of developing sexuality, must carry worrysome connotations. Many teenagers prefer instead to prick their fingers to measure their blood glucose concentration. This can be done perfectly reasonably, given a little discretion, even in public places such as cafés and discotheques. Furthermore there is a degree of fascination associated with blood letting, particularly if coupled with the use of an instrument of the pocket computer variety.

Other patients for whom blood glucose monitoring is particularly appropriate are those who are too young to provide urine samples on demand. In our experience with infants developing diabetes before age 1 year, blood glucose monitoring using capillary samples obtained from heel pricks has been acceptable to the parents and seems to have been tolerated by the children without obvious distress. One such patient is now 5 years old and the parents continue to use blood glucose monitoring as the only method of assessing diabetic control.

Home monitoring equipment

The development of spring-loaded devices to facilitate the drawing of a capillary blood sample is a useful advance in diabetic management. It would be wrong to say that finger pricking is entirely painless with such devices since the finger pad may feel bruised for some hours afterwards. Nevertheless many children take to these devices and most parents find them more acceptable than using the lancets alone.

There are many different methods for measuring blood glucose from capillary samples. In one system capillary blood is collected on to filter paper and posted to the hospital laboratory for processing.[8] This allows profiles of blood glucose results to be available so that the physician can advise his patient at the outpatient visit. This system requires finger-pricking, filter papers, envelopes, and postage stamps. Its main disadvantage is that it does not give an instantaneous measurement of blood glucose which is after all the greatest attraction of measuring blood glucose at home.

Precise measurement of blood glucose on capillary samples requires a reagent strip and some form of reflectance meter. Many combinations have been used which include the Boehringer* strips together with the mains operated Reflomat* and battery-operated Hypo-Count II†; and the Dextrostix‡ used with a variety of mains and battery-operated meters such as the Hypo-Count I and II†, the Eyetone‡, the Glucocheck,§ and most recently, the Glucometer‡. There have been several comparative studies of the various systems, including consumer reports in which such factors as reliability and cost of the machine have been taken into account.[9 10] I think it would be fair to say that while individual enthusiasts prefer one system to another, many of the current meter systems are satisfactory. It is possible to measure blood glucose with less precision but with considerably greater convenience using reagent strips without meters. This has been possible for many years using Dextrostix‡. More recently the BM Test-Glycemie strips* have been produced specifically for use without a meter.[11] These are designed to allow a reasonable colour match by eye, using two colour strips against a reference colour chart.

Educational investment

Whichever system of blood glucose measurement is used, it requires a significant investment of time and energy in family education. This additional effort, especially in long-established diabetic patients, is offset by the fact that instruction on blood glucose monitoring (particularly if carried out in the home) provides very good overall instruction on the management of diabetes. Furthermore for most patients there is a direct logic in measuring blood glucose concentration which does not apply to the measurement of urinary glucose concentration. However it should not be assumed that blood glucose monitoring *per se* will achieve better diabetic control. It may do. It may be that the teaching associated with the introduction of blood glucose monitoring will by itself result in an improvement in diabetic control.[12] Without the necessary understanding the measurement of blood glucose concentration at home will have little effect on diabetic control.

The future

Recent observations using the 'open-loop' insulin infusion systems show that it is possible for carefully selected patients to achieve quite remarkable degrees of continuous normoglycaemia.[13] It seems likely that during the next few years systems of this type will

*Boehringer Corporation, Lewes, E. Sussex
†Hypoguard, Woodbridge, Suffolk
‡Miles Laboratories Ltd, Stoke Poges, Slough
§Medistron Ltd, Crawley, Sussex

be generally introduced into clinical practice. They can only work on the basis of an intelligent understanding of diabetes by the patient coupled with frequent measurement of blood glucose concentrations. Until such time as reliable implantable blood glucose transducers are developed, it will be essential for patients using insulin infusion devices to use one or other system of blood glucose self-monitoring.

For the present the monitoring of diabetic control by children in their normal day-to-day lives should be based on a combination of urine and blood glucose testing. The results need to be recorded in a codified manner for interpretation and discussion in the clinic. Such systems of testing must make sense to the child and his family. Those who care for diabetic children must take on this responsibility for adequate instruction on diabetes and its management.

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