Glycemic Assessment and Monitoring an Essential Tool in Modern Diabetes Management

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Diabetes mellitus (DM) is a major chronic disease which has relatively high prevalence and accounts for an increasing portion of total health care costs. It is, therefore, crucial to investigate how to improve cost-effectiveness of treating this disease. Traditional management involved diet, activity, insulin and oral agents but now education, empowerment and monitoring of glycemic status are an integral part in modern diabetes management. We do not act on what we do not know. In the case of self-monitoring blood glucose (SMBG), it is of interest to understand if this procedure is the best way to monitor the metabolic conditions of patients with diabetes mellitus, both in terms of cost and efficacy. Knowing which components of the diabetes regimen most closely correlate with glycemic control permits refinement of diabetes management to attain better long-term outcomes. Many factors, including age, gender, duration of disease, number and frequency of insulin injections and frequency of self-monitoring of blood glucose (SMBG), have been determined to be predictors of glycosylated hemoglobin (HbA1c) concentration, the standard index of control over the period of the past 3 months. However, it is important to stress the fact that data, such as blood glucose values, are never sufficient by themselves to assess improvements in clinical outcomes. Data must first be transformed into information by exploiting the available knowledge on the clinical problem, and then the derived information should be used for decision-making. For these reasons, the patient’s education plays a crucial role in obtaining good metabolic control. Blood glucose monitoring is important in optimizing long-term outcomes in diabetic patients. Reliance on near-patient testing and the use of longer term measures of glycation are the current cornerstones.

The American Diabetes Association (ADA) recommends that patients with type 1 diabetes monitor blood glucose at least three times daily, and patients with type 2 diabetes who are treated with insulin or oral hypoglycemic drugs monitor blood glucose daily. In practice, the actual frequency of monitoring is individualized. Self blood glucose monitoring is especially important for glycemic control in patients with type 1 diabetes, because their blood glucose concentrations are less stable from day to day than are those in patients with type 2 diabetes. In either group, the fasting blood glucose concentration is often used to monitor progress since it correlates well with HbA1c values, although some authors have argued that post prandial blood glucose measurements are a better marker of glycemic control than fasting values.

Blood glucose monitoring works in Type 1 DM which is amply evidenced by DCCT trial findings. The findings of the Diabetes Control and Complications Trial (DCCT) in patients older than 13 years with type 1 diabetes, together with the availability of improved methods of monitoring glycemia (self blood glucose monitoring and HbA1c measurement), resulted in greatly increased efforts to improve glycemic control to reduce the risk of long-term complications. Thus, improved metabolic control seen in the intensively treated group in the DCCT was associated with more hypoglycemia than in the conventionally treated patients. This was particularly true in the adolescent cohort. As health care teams gained more experience with intensified regimens during the DCCT, frequency of severe hypoglycemia decreased despite maintenance of significantly lower HbA1c concentrations. The effectiveness of self blood glucose monitoring in terms of improving glycemic control in patients with type 2 diabetes is not clear. Data from the third National Health and Nutrition Examination Survey (NHANES III) revealed no correlation between the frequency of monitoring in patients with type 2 diabetes and their HbA1c values. In contrast, a cohort study of 24,312 patients with diabetes who were members of a group model health maintenance organization found that more frequent self monitoring of blood glucose was associated with improved glycemic control regardless of diabetes type. For patients with type 2 diabetes, adherence to ADA monitoring guidelines resulted in an improvement in HbA1c of approximately 0.6 percent compared with nonadherent patients. A meta-analysis (done before these two studies) found no improvement in glycemic control with self monitoring in patients with type 2 diabetes. There is evidence based work in that direction currently in progress. The final recommendations should, therefore, include a statement that requires associating SMBG with a set of procedures to effectively use the monitoring results. If this recommendation is followed in future studies, there is a very good chance that the guidelines on self-monitoring for diabetes care will be clearly justified by clinical evidence. Monitoring blood glucose is a tool, not a therapeutic intervention. It provides important information with which motivated patients can modify their behavior and improve their HbA1c values safely. Fasting blood glucose concentrations are fairly stable in patients with type 2 diabetes, but can vary by about 15 percent from day to day, and therefore changes in therapy should be based on an average over several days.

However there are two situations like uremia and perioperative diabetic management where role of monitoring needs to be overemphasized to physicians at large. The two most common tests for glycemic control, glycated hemoglobin HbA1c and fructosamine, are significantly flawed in the context of uremia. Fructosamine is the less satisfactorily reliable of the two indices. Therefore, in practice, reliance on these measures alone may be optimistic, and we advocate the use of patient glucose diaries, catering for individualized dialysis regimens, to supplement the information that can be derived from metabolic parameters. We do not advocate the abandonment of measurements of HbA1c and fructosamine in uremia, but rather a more complete realization of their limitations until such time that a clearly superior method is apparent.
There are approximately 32 million patients with diabetes mellitus in India today. It is estimated that 50% of diabetic patients will require surgery of some kind during their lifetime. Therefore, perioperative management of these patients is not by any means a rare event. As a group, diabetic patients represent a larger portion of the surgical population annually than nondiabetic individuals. Many of the surgical procedures done in patients with diabetes are necessitated by the classic complications of diabetes—retinopathy, neuropathy, nephropathy, and vasculopathy. Procedures specific to diabetic complications include ophthalmologic procedures (cataract extraction and vitrectomy), limb amputation, renal transplantation, and coronary artery bypass grafting (CABG). Whether the surgery is being performed for a diabetic complication or is unrelated to diabetes, the presence of one or more of the complications of diabetes increases the perioperative risk and prolongs hospitalization. The average diabetic patient will spend 30% to 50% more time in the hospital postoperatively than a nondiabetic patient undergoing the same procedure, regardless of the surgical outcome. Therefore, patients with diabetes mellitus need careful preoperative assessment to identify previously unknown complications or stabilize those that are known before undergoing the stress of surgery. This assessment includes detecting occult coronary artery disease, peripheral vascular disease, renal insufficiency or autonomic insufficiency. Naturally, diabetic patients must then undergo appropriately aggressive glycemic management perioperatively. Bedside blood glucose monitoring up to hourly pre- and intraoperatively is essential to using these insulin algorithms safely and effectively. Blood glucose should be monitored at least every 2 to 4 hours overnight and then every 1 to 2 hours preoperatively. The continuous insulin infusion should be started at least 2 hours before surgery, if not earlier, to allow titration and stabilization before entering the operating room. As soon as the insulin infusion is begun, blood glucose values should be measured hourly. Intraoperatively, the blood glucose should be checked hourly (or every 30 minutes in patients undergoing cardiovascular procedures) regardless of the mode of delivery of the insulin, because the IV dextrose can be titrated as needed to prevent hypoglycemia in either situation. Postoperatively, initial monitoring should continue every 1 to 2 hours, but once stabilized both modalities can be monitored every 1 to 4 hours until transition back to an outpatient regimen is appropriate. Spot urine glucose monitoring, which formed the basis of the insulin sliding scales of the past, is not a reliable indicator of true blood levels and is not recommended. Urine ketone measurement is indicated in a patient with type 1 diabetes if hyperglycemia persists at greater than 250 mg/dL—usually an issue in more critically ill patients. Routine screening of ketones is not necessary otherwise.

There is increasing evidence that aggressive glycemic control for patients admitted into the hospital improves clinical outcomes, especially for patients with cardiovascular disease. There appear to be a variety of mechanisms for this. Although hyperglycemia has been shown to result in poor wound healing and more infectious complications, especially after cardiac surgical procedures, what has become clear is that the treatment of hyperglycemia with i.v. glucose, insulin, and potassium (GIK) results in better clinical outcomes even in patients without diabetes. The mechanisms for this are not yet clear, but could be related to the insulin administration, perhaps due to suppression of various cytokines or free fatty acids. There is sufficient data now available after DIGAMI Study showing that Insulin and tight glycemic control in the coronary care unit reduces mortality, morbidity and salvages the myocardium. In fact the famous Belgian study from van den Berghe et al only re-emphasizes maintenance of ‘euglycemia’ (blood glucose 80-110 mg% by 4 hourly blood glucose monitoring in ICU) in both diabetic and non-diabetic critically ill patients not only saves lives but reduces time on mechanical ventilator as well as reduces mortality. The current status of blood glucose monitoring in India is vastly underused and the frequency of testing is poor. Even in tertiary care medical centers regular blood glucose monitoring is still restricted to hospital or nursing-home based point of care testing. Physician or patient driven blood glucose monitoring is existing in multiple dose insulin using Diabetes Cohorts namely Type 1 or Gestational Diabetes Mellitus (GDM). Even today a vast majority still relies on unreliable urine glucose which has virtually no place in contemporary metabolic management. It is only reserved for rural setups where no blood glucose monitoring is not available and never should be used. Also the frequency of testing can vary from daily 3 to 7 point testing in brittle diabetics, GDM, Type 1 diabetics to weekly 3 to 15 points in a stable Type 2 diabetics. These will only be possible if decisions are taken only when patients are empowered to take them.

In this issue the Hopkin’s Diabetes group of Saudek et al review the current relevance of assessment of glycemic status. They also discuss the barriers of monitoring. Later they talk of the novel technologies of interstitial fluid measurement like CGMS etc, which are useful research tools but may have no or little role in clinical diabetes or on outcomes.

Mohan et al give their finding on a new blood glucose monitoring device made by a US based company, Johnson & Johnson for Asian population. This was possible due to team work of scientists and diabetologists in Asia. The first barrier to monitoring is cost of blood glucose monitor in developing nations like India and China. It was imperative to provide a top quality cost effective but field tested device specifically tailored to Asian and Indian needs. Mohan et al give the first results of this excellent study and accurate device in Indian population. Mohan et al study shows how a device like blood glucose monitor is tested in an Indian set up by GCP guidelines just like a new drug is tested in a clinical trial setting. To gain regulatory approval to launch blood glucose monitor in the United States, manufacturers must compare their meter performance to a laboratory standard and plot the data on an error grid analysis. The relevance of this study is that the sleek new ‘One Touch Horizon’ which had a global launch in India stand the quality control criteria of the global norms. The US Food and Drug Administration (FDA) performed a series of studies to evaluate the accuracy of many of the available meters. Their conclusion was that most glucose meters are reasonably accurate. In an older study, however, the American Diabetes Association estimated that only 50 to 70 percent of meters are capable of obtaining a result within 20 percent of a reference laboratory. Even if a particular brand of meter is considered reliable, individual units may perform more or less well. Thus, caution and common sense need to be used when using the data obtained. Newer glucose meters are quite accurate. Earlier meters required the operator to apply blood to a strip of paper, wait an appropriate length of time, wipe the blood off, and then insert the strip in the meter to obtain a reading. Errors at any stage of this process may alter the blood glucose measurement. Many of the newer meters reduce operator error by requiring that the strip be inserted before blood is applied. The patient then puts a drop of blood on the external portion of the strip and the machine automatically gives a reading. Several blood glucose meters are now available that use sites other than the finger to obtain blood samples in an effort to reduce the pain involved with fingersticks. A study of one of these devices that obtains samples from the arm found that it provided accurate results and was less painful than fingerstick testing. Monitoring from alternate sites, such as the skin of the
forearm, may give results which are somewhat lower than those taken at the fingertips, since they may sample venous blood rather than capillary blood. While this should not be a problem if the patient uses one or other site exclusively, the between-test variability will increase if multiple sites are used. Some glucose strips have considerable batch to batch variation, and require recalibration to a meter every time a new batch is used. Many strips are packaged in groups of 25 inside a can containing a preservative. Common errors include leaving the lid off for long periods of time and putting several lots of strips into one can for convenience. Smaller pack of ten make the strips more affordable to less wastage and better compliance. There are two other potential problems with glucose strips. First, patients with decreased visual acuity may have difficulty reading them. Second, the results are usually shown in 40 mg/dL increments, which may not be sufficiently accurate in patients attempting to attain strict glycemic control. The next hurdle is to ensure that both testing frequency improves and the action taken after testing leads to meaningful treatment targets. The future needs are to have strips at an affordable cost without compromising accuracy and eventually painless testing devices.

The real world diabetic medicine monitoring is getting center stage only if both physicians and patients will act on results delivered to them by such user-friendly technology. Blood glucose measurement and treatment may soon be the first tele managed disease effectively. For the same reasons, the use of current technological solutions, such as telemedicine, may provide suitable instruments for a better use of the data; higher quality information can be obtained by associating the data with proper knowledge, provided by expert or by clinical guidelines. There is now a need to develop Indian carbohydrate counters with our diets and treatment provided by expert or by clinical guidelines. There is now a need to care hospital clinic.

REFERENCES