Diabetes Management in the Hospitalized Patient

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Diabetes mellitus is a condition frequently found among hospitalized patients. In addition to established diabetic patients, hyperglycemia is often found in stressed, ill hospitalized patients. Over 6 million hospitalizations per year in the United States are accompanied by hyperglycemia.[1] Many of these cases may reflect unrecognized diabetes mellitus.[2] Patients with diabetes mellitus tend to have longer hospital stays, and the hospitalizations are frequently secondary to complications of diabetes mellitus, mainly those related to the cardiovascular system.[3]

In an acutely ill hospitalized patient, counter-regulatory hormones, such as glucagon, cortisol, epinephrine, and growth hormone, are stimulated. This stress response accelerates hepatic gluconeogenesis, lipolysis, and catabolism, which result in elevated levels of serum glucose, free fatty acids, and ketone bodies. Furthermore, acidosis can occur in acutely ill or surgical patients, which leads to peripheral insulin insensitivity and contributes to the overall hyperglycemic state. Additionally, disruption in the usual daily activities and dietary intake play an important role in achieving glycemic control in the hospital environment.[1]

There are data to suggest that glycemic control in the hospital is important in reducing morbidity and mortality as well as the length of hospitalization. The Diabetes and Insulin-Glucose Infusion in Acute Myocardial Infarction (DIGAMI) trial, a randomized prospective study, enrolled 620 patients with acute myocardial infarction who had admission glucose higher than 198 mg/dl. These hyperglycemic patients were randomized to conventional diabetes care or intravenous insulin followed by multidose subcutaneous daily insulin for $\geq$ 3 months. At time of hospital discharge, the control group had blood glucose level of 162 $\pm$ 54 mg/dl vs. 147$\pm$ 54 mg/dl for the interventional group ($p < 0.01$). At one-year follow up, there was a 29% mortality reduction in the latter group. At 3.4 years, the interventional patients had 25% lower death rates.[4, 5]

Risk of postoperative wound infection is 2-5 times higher in diabetic than in nondiabetic patients.[6] Zerr et al. reported that risk of wound infection increased when the average blood glucose level was > 200mg/dl on postoperative day 1. With the use of intravenous insulin infusion to maintain blood glucose <200 mg/dl immediately postoperatively, they reported a 60% reduction in deep sternal wound infections.[7] In a prospective study of 2467 consecutive diabetic patients undergoing open heart surgical procedures, Furnary et al. compared the outcomes of patients receiving subcutaneous insulin injection with those patients receiving intravenous insulin perioperatively to maintain blood glucose level 150-200 mg/dl. The continuous intravenous insulin infusion patients had 2.5 fold decrease in rate of deep sternal wound infection compared with that for the subcutaneous insulin group maintaining blood glucose level at ~ 200 mg/dl (0.8% vs. 1.9%). Furthermore, there was a fivefold increase risk of death in patients developing deep sternal wounds when compared with patients who did not develop this postoperative complication.[6]

Despite data suggesting the importance of glycemic control in hospitalized patients, only a few studies exist on treatment strategies. There are no universal rules that can be applied to hospitalized diabetic patients to achieve good glucose control. There are various factors that complicate glycemic control in the hospital setting: variability in meal schedules (delayed arrival of food, NPO status for procedures), activity levels, fluid shifts and hemodynamic changes affecting insulin absorption, and medications (narcotics affecting gut motility). Furthermore, the type of diabetes mellitus is important since Type I diabetics require basal amounts of insulin even in the absence of caloric intake.

Treatment goals should include avoidance of deleterious effects of hypoglycemia and hyperglycemia, which can lead to diabetic ketoacidosis and hyperosmolar state. A reasonable upper limit for preprandial blood sugar seems to be 200 mg/dl given that impairment of wound healing, leukocyte function, and renal threshold of glycosuria may appear around this glucose level.[3] Lower limit glucose level may be in the 120-140 mg/dl range.

In general, the patient's pre-hospitalization regimen can serve as a guide in managing his or her diabetes in the hospital. If a patient is NPO or eating erratically, sulfonylureas should be held due to the risk of hypoglycemia. If there is a risk of renal impairment, metformin should be avoided due to the risk of lactic acidosis. Metformin also needs to be held 48 hours prior to certain procedures requiring the use of contrast material. Bedside blood glucose monitoring in an NPO patient should be checked every 4-6 hours. For prolonged NPO status, regular subcutaneous insulin every 4-6 hours usually allows best flexibility in achieving glucose control. However, in a patient who is eating regularly, maintenance doses of oral agents or insulin should

be used rather than resorting to sliding scale coverage alone. Despite the wide use of sliding scale regimen in management of diabetes mellitus in the inpatient setting, when it is used without a standing dose of intermediate insulin, increased rate of hyperglycemic episodes are seen.[8]

Perioperatively, intravenous insulin infusion with frequent glucose monitoring allows the greatest flexibility in achieving glycemic control, especially during NPO status or with erratic oral intake. Once the patient tolerates food well, transition to subcutaneous insulin is made. It is easiest to make this transition in the morning with discontinuation of the insulin drip about 30 minutes after an intermediate acting and regular insulin is administered. For patients starting subcutaneous insulin for the first time, an approximate daily insulin requirement can be calculated by multiplying the patient's weight in kilogram by 0.6. Typically, two thirds of this total dose is given in the morning and the remaining one third in the evening. More NPH than regular insulin is given in the morning and about equal amounts of NPH and regular insulin are given before dinner. With vigilant bedside blood glucose monitoring, the insulin doses can be actively adjusted to achieve the desired glucose range as the patient's activity level and the acuity of illness change. Lastly, to maintain glycemic control after discharge, patient education should begin in the hospital and continued as an outpatient.

Diabetes mellitus is a major comorbid condition in hospitalized patients. However, glycemic control is often neglected in the hospital while attention is given primarily to the acute diagnoses, which warranted the admission. Data now are accumulating which suggest that acute glycemic control affect overall morbidity and mortality of diabetic patients during and after hospitalization. To date, randomized, double-blinded, placebo-controlled, prospective studies are lacking. Further research needs to be done in this area to better determine the optimal glycemic range and the means of achieving this important goal.

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