Thoracic and Cardiovascular Surgery

The Transition from Insulin Infusions to Long-Term Diabetes Therapy: The Argument for Insulin Analogs

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After cardiac surgery, it is medical mismanagement to place an order for sliding scale insulin at the time of transitioning from intravenous insulin. Use of basal-prandial-correction therapy with insulin analogs constitutes a suitable transitioning regimen for inpatient management of hyperglycemia after heart surgery, to be ordered before interruption of intravenous insulin infusion, in conjunction with a program of blood glucose monitoring before meals, at bedtime, and midsleep. In the ambulatory setting, in comparison to neutral protamine Hagedorn, long-acting insulin analogs reduce hypoglycemia. In comparison to regular insulin, rapid-acting insulin analogs reduce hypoglycemia and improve postprandial control. A standardized approach to order entry for basal-prandial-correction therapy enhances safety and staff familiarity while preserving individualization of patient care. Proposed predictors of successful transition are described. Dose requirements during intravenous insulin infusion can be used to guide initial dose assignments of basal insulin therapy. As the patient approaches discharge, the total daily doses of subcutaneous insulin and basal insulin dose are decreased, and the proportion of prandial insulin approaches or exceeds 50% of the total daily dose as the absolute amount of prandial insulin increases. Before discharge, hyperglycemic patients not known to have diabetes should be advised of the need for outpatient reassessment, and those known to have diabetes but requiring intensification of therapy should participate in decision-making concerning their options for intensified treatment.

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Among cardiac patients and critically ill populations, hyperglycemia is associated with increased mortality. Following cardiac surgery specifically, wound infections and other morbidities are increased among patients having diabetes or uncontrolled hyperglycemia. Strict glycemic control during the perioperative time period can reduce morbidities and mortality. Some of the most striking outcome results have been achieved with the use of perioperative intravenous insulin infusions. Outside of the intensive care unit, and after the third postoperative day in the hospital, or during subsequent outpatient follow-up after heart surgery, concerning the importance of glycemic control or the methods used to achieve control, there are less population-specific data than during the earlier timeframe immediately following surgery in relation to outcomes. Nevertheless, it is reasonable to apply hospital and outpatient glycemic standards for glycemic control that have been advocated for hospitalized and general populations.[1-4]

This review will present opinion on optimal use of insulin at the time of transitioning from intravenous insulin to subcutaneous insulin after heart surgery and on management options at the time of discharge. It is necessary to begin, however, with an admonition against use of sliding scale insulin.

Medical Mismanagement by the Use of Sliding Scale

The default order for a busy prescriber at the time of transition from intravenous insulin infusion, if an institutional standardized sliding scale exists, is likely to be sliding scale. For this discussion, "sliding scale" refers to an algorithm that assigns blood glucose test times and short- or rapid-acting insulin, in preassigned doses that often are arbitrarily deter-

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mined without consideration for the insulin sensitivity of the patient to be administered at predetermined times according to severity of hyperglycemia, without consideration for carbohydrate exposure, and to be used without concomitant orders for intermediate- or long-acting insulin or scheduled mealtime insulin.

Use of sliding scale insulin as monotherapy results in poor control, inferior to that obtained with scheduled or programmed insulin.[5-12] Hyperglycemia and sometimes ketoacidosis result from omission of scheduled insulin.[6] Sliding scale insulin doses, given reactively after development of hyperglycemia, are implicated in the causation of hospital hypoglycemia, especially in the presence of renal failure.[5] The hospital study by Golightly and colleagues uncovered 10 episodes of hypoglycemia occurring among 6 of 90 patients treated with sliding scale insulin and additionally showed that a target range glucose resulted after only 12% of the administered sliding scale doses, whereas subtherapeutic glycemic results were seen after 84% of the doses. Despite the deficiencies of control during sliding scale treatment, in 81% of cases or 73 patients, no adjustment of insulin was made.[11] At some hospitals, it is possible to order a standard sliding scale by checking a box, clicking once on-line, or giving a three-syllable verbal order.

In contrast to sliding scale, transitioning to scheduled insulin is designed to maintain glycemic control. The barrier to transitioning to scheduled insulin is the necessity to enter several well-considered insulin orders, assigning doses for each component of therapy (basal, prandial, and correction as described below); to create associated orders about frequency of monitoring, alert parameters, and treatment of hypoglycemia; and to revise orders for scheduled insulin at least daily. To optimize the likelihood of receiving orders other than sliding scale, institutions have used several approaches, discussed below under "Overcoming Barriers to Implementation."

Postoperative Transitioning to Basal-Prandial-Correction Therapy

Once patients begin to eat after heart surgery, the model for inpatient subcutaneous insulin delivery is a style of outpatient management described as basal-prandial-correction therapy.[13,14] Basal therapy is given once or twice daily as intermediate- or long-acting insulin. Prandial insulin is given before each meal as regular insulin or rapid-acting analog. In outpatient treatment regimens, correction therapy using regular insulin or rapid-acting analog is given before meals along with prandial insulin, if necessary, to correct premeal hyperglycemia, and sometimes is given at bedtime. Treatment with basal long-acting analog and prandial rapid-acting analog when used for ambulatory patients having type 1 diabetes can improve A1C and the 24-hour glucose profile and reduce the likelihood of nocturnal hypoglycemia.[15,16] In ambulatory management, insulin treatment for patients having type 2 diabetes sometimes is initiated with basal insulin used in combination with oral agents, or with premixed insulin given twice daily (intermediate insulin mixed with rapid-acting analog or regular insulin) with or without oral agents. An alternative is the prandial use of rapid-acting analog insulin added to oral agents. Standards by which a regimen might be assessed include A1C, mean blood glucose, postprandial control, freedom from hypoglycemia, and patient satisfaction. For at least some patients having type 2 diabetes who require insulin, by these standards premixed regimens, basal-only insulin regimens, or prandial-only regimens prove to be inferior to basal-prandial-correction insulin therapy.

Basal-prandial-correction therapy can be adapted to provide an effect regimen for inpatient transitioning from intravenous insulin infusion to subcutaneous insulin management after heart surgery.[17-26] Initiation of subcutaneous insulin following heart surgery usually begins at least 2 hours before interruption of intravenous insulin infusion. However, initiation of subcutaneous therapy need not be deferred until interruption of intravenous insulin is imminent. Rather, after patients are hemodynamically stable and independent of pressor support, subcutaneous insulin may be given concomitantly with intravenous infusion of insulin. Although correction doses of subcutaneous insulin are superfluous during intravenous insulin infusion, subcutaneous prandial insulin may reduce the lability of the infusion rate of insulin required under the intravenous insulin protocol and, more importantly, may prevent glycemic excursions rather than treat them reactively. Subcutaneous basal insulin may reduce insulin requirements delivered by intravenous infusion and prepare the patient for smooth transition later. The mainstays of basal-prandial-correction therapy are the basal use of neutral protamine hagedorn (NPH), glargine, or determir insulin and the prandial and correction dose use of regular insulin or rapid-acting insulin analogs.[14]

In ambulatory management, the value of analogs has been disputed from a cost–benefit analysis point of view, with the arguments that A1C differences have been difficult to demonstrate, that outcomes have not been linked to the use of analogs, and that safety in pregnancy is unproven.[27,28] However, with respect to the risk for hypoglycemia and postprandial control, superiority of analogs has been suggested in treatment of both type 1 and type 2 diabetes. In comparison to ambulatory patients a principal difference for postoperative heart patients is the risk of inadequate prandial intake. Although emesis is infrequent, characteristically appetite is suppressed. Used alone, NPH or premixed insulins deliver both prandial and basal coverage. It is not possible to interrupt the prandial component of coverage delivered by these insulins without loss of basal coverage. Since there is need for a prescribing style that allows interruption of the prandial component without compromise to the basal component of therapy in the hospital, a strong rationale exists for the preferential use of insulin analogs.

Monitoring with Meals, HS, and 0300

To enhance safety through detection of hypoglycemia and to provide around-the-clock opportunity for treatment of hy-