ABSTRACT

- **Objective:** To describe an improvement project to transition postoperative cardiovascular surgery patients from intravenous to subcutaneous insulin.

- **Methods:** A multidisciplinary team of hospitalist physicians, nurses, and a clinical pharmacist in collaboration with the cardiothoracic surgeon developed an evidence-based intervention using a time-point protocol. We evaluated glycemic control by analyzing the percentage of blood glucose levels < 180 mg/dL during postoperative day 1 and 2 before and after the intervention.

- **Results:** The average percentage of blood glucose measurements < 180 mg/dL increased from 38% to 59% (P = 0.08). The average blood glucose level achieved in the pre-intervention group was 203 mg/dL (± 73; median, 196 mg/dL); this decreased to 181 mg/dL (± 72; median, 158 mg/dL) (P = 0.10) after the intervention.

- **Conclusion:** Although there was no statistically significant improvement observed in postoperative blood glucose levels, our results reveal a trend towards improved glycemic control. Subjectively, our project enhanced provider awareness of the importance of maintaining glycemic control in post–cardiac surgery patients through successful collaboration with hospitalist consultation and a multidisciplinary team approach.

Hyperglycemia is associated with increased morbidity and mortality in hospitalized patients [1,2]. In patients undergoing cardiac surgery, hyperglycemia on the first and second postoperative day is the single most important predictor of serious infection and complications [1]. Effective management of in-patient hyperglycemia has been shown to improve clinical outcomes [3–5]. Significant effort has been made to determine the optimal glucose management practices in critically ill patients including patients in the cardiac critical care unit specifically in the setting of post-cardiothoracic surgery [6,7].

Due to the increasing complexity in the comprehensive care of hospitalized patients, there is greater reliance on hospitalists for perioperative co-management. Research assessing the impact of hospitalist co-management reveals benefits including increased implementation of evidence-based medicine, reduced time to surgery, decreased length of stay, and fewer postoperative complications [8]. The Society of Hospital Medicine recognizes perioperative medical management as a key skill for hospitalists, and ability to optimize outcomes in the perioperative period is identified as a core competency [9]. At our institution, medical co-management of diabetic patients undergoing open-heart surgery is common practice.

Medical co-management begins immediately following open-heart surgery. Patients are initiated on continuous insulin infusion per a standardized protocol with a blood glucose level goal of between 80 and 120 mg/dL. Transition to subcutaneous insulin, if clinically indicated, most often occurs the morning of the first postoperative day. We noticed at our institution that the transition from intravenous to subcutaneous insulin was frequently associated with a sharp rise in blood glucose levels. There was no standardized protocol or practice for the transition. Dosing of insulin and monitoring practices were left to the discretion of the hospitalist on duty. In an effort to improve glycemic control in postoperative cardiac sur-

From Mercy Hospital, Iowa City, IA.
surgery patients, we developed an evidence-based protocol for transitioning patients to subcutaneous insulin. We describe our experience in this paper.

SETTING

There are approximately 120 cardiac surgery cases per year at Mercy Hospital in Iowa City, IA, a 234-bed private, nonprofit hospital. One cardiac surgeon performs the majority of surgeries and consults hospitalist physicians regularly to assist in the perioperative management of diabetic patients. The hospitalist program consists of 6 core hospitalist physicians, 6 “PRN” nocturnists physicians, and 1 advance registered nurse practitioner. Post-surgery, patients are admitted to the intensive care unit (ICU) and are initiated on continuous insulin infusion protocol. Transition to subcutaneous insulin, if clinically indicated, most often occurs the morning of the first postoperative day (POD1) prior to transfer to the cardiac telemetry monitored floor.

DEVELOPMENT OF PROTOCOL

A multidisciplinary team of hospitalist physicians, nurses, and a clinical pharmacist evaluated the primary literature. In collaboration with the cardiothoracic surgeon, the team developed a standardized protocol for transitioning from intravenous to subcutaneous insulin. Our protocol is shown in the Figure. Based on the American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control, we set our target postoperative blood glucose level at < 180 mg/dL [10].

The protocol calls for starting subcutaneous transition before IV insulin discontinuation. Specifically, all patients receive a subcutaneous dose of basal insulin 2 hours prior to IV insulin discontinuation. Failure to overlap and allow for appropriate absorption of subcutaneous insulin may lead to severe fluctuations in glycemic control. Glucose is checked with discontinuation of insulin infusion, then every 2 hours x 2. Hospitalists are directed to review blood glucose control twice daily.

A formula was developed to determine subcutaneous insulin dosing. The formula was derived from example protocols provided by the Glycemic Control

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**STANDARDIZED RECOMMENDATIONS**

Reminder: SCIP Measure: POD 1 and 2 BG < 200 mg/dL (@ 0600)

- Give initial glargine (Lantus) dose 2 hours prior to discontinuing IV insulin drip
- Check glucose with discontinuation of insulin infusion and then every 2 hours x 2
- Consider twice daily review of blood glucose to assess need for modification of insulin regimen

In all patients with known diabetes or A1c > 6.5%, consider the following standardized calculation:

Obtain the estimated total daily dose of insulin (TDD) using the last 7 hours’ drip rates, omitting the 2 highest drip rates:

Sum of the 5 lowest drip rates from the last 7 hours \( \times 4 = \) (this is the TDD)

1. Basal insulin dose
   - TDD divided by 2 = \( ____ \) units of glargine (Lantus) SC q 24 hr
   - Give initial glargine (Lantus) dose 2 hours prior to discontinuing IV insulin drip, then every 24 hr at the same time each day

2. Scheduled meal rapid-acting insulin
   - Hold meal dose if patient is NPO, on clear or full liquids, or eating < 50% of meals
   - TDD divided by 6 = \( ____ \) units rapid-acting insulin SC prior to each meal

3. Supplemental rapid-acting insulin per sliding scale orders

**Figure.** Standardized protocol for transitioning patients postoperatively to subcutaneous (SC) insulin.
Mentored Implementation program offered by the Society Hospital of Medicine that had been previously utilized at Good Samaritan Regional Medical Center in Phoenix, AZ [11]. As participants in the Glycemic Control Mentored Implementation program, we were provided with project implementation tools as well as mentoring through teleconferences and emails from experts with quality improvement and glycemic control expertise [11].

As shown in the protocol, at the time-point of transition, the hospitalist evaluates the last 7 insulin infused per hour rates and disregards the highest 2 rates. The remaining 5 rates are added together, and this sum is multiplied by 4 to estimate the total daily dose (TDD) of insulin. The TDD is divided in half, with one half of the TDD administered as basal insulin and the other half divided further to cover 3 meals (as a bolus of rapid-acting insulin). A conservative approach to calculate insulin requirements was desirable in order to err on the side of underestimation and avoid hypoglycemia.

An example:

While Patient A was on the insulin infusion, his last 7 hourly IV insulin rates were: 5, 7, 5, 3, 5, 5, and 4 units/hour respectively. The two highest infusion rates (5 and 7) were eliminated and remaining values tallied (5+5+3+5+4=22). This variable was multiplied by 4 (22 x 4) to provide an estimated TTD of insulin of 88 units. One half of the TDD is 44 units, which is given subcutaneously as basal insulin. The remaining 44 units are divided into 3 doses to be given prior to each meal, that is, 14 units each prior to breakfast, lunch, and dinner.

The protocol was implemented in July 2010.

**EDUCATION**

Education regarding the protocol was provided to the staff by the team pharmacist. Education included reviewing the evidence that supported the protocol elements. Educational sessions with hospitalist physicians took place prior to implementation and continued with monthly review and discussion. Pocket cards were distributed as quick reference guides. During implementation, the clinical pharmacist was available for consulting and real-time review of patient cases.

A continuing education seminar for physicians and nurses involved in this quality improvement project was also held.

**MEASUREMENTS**

The main outcome measure was the percentage of blood glucose values < 180 mg/dL during the defined time-period following discontinuation of IV insulin through the end of postoperative day 2. Secondary endpoints included average blood glucose levels as well as the percentage of patients with hypoglycemia (< 60 mg/dL).

We collected data for all diabetic patients admitted to undergo open-heart surgery and consulted to the hospitalist team for glycemic control during the 6-month period prior to implementation of the protocol (January to June 2010) (n = 15) and the 6-month period October 2010 to March 2011 (n = 8).

**OUTCOMES**

The number of measurements obtained per patient varied from 2 to 9 (average = 6.5). For the 15 pre-intervention patients, glycemic control (blood glucose < 180 mg/dL) was achieved on average 38% of the time. Of the 8 post-intervention patients, the average was 59% (P = 0.08). The average blood glucose achieved from the time of discontinuation of the IV insulin through the end of POD2 was 203 mg/dL (±73 mg/dL; median 196 mg/dL) in the pre-intervention group and 181 mg/dL (±72 mg/dL; median 158 mg/dL) in the post-intervention group (P = 0.10). There were no recorded hypoglycemic events (blood glucose < 60 mg/dL) in either group.

The Surgical Care Improvement Project (SCIP) is a national quality improvement partnership committed to improving surgical care by decreasing surgical complications. The SCIP-INF-4 measures cardiac surgery patients postoperative 6 A.M. serum blood glucose level on POD1 and POD2; measure compliance requires this value to be < 200 mg/dL. Our compliance with the SCIP-INF-4 measure for the first half of 2011 was 96% (total cases evaluated = 50). Our rate of compliance with the SCIP-INF-4 measure within the subgroups of patients evaluated in this project increased from 66% in the pre-intervention group to 87.5% in the post-intervention group. One might surmise that patients...
consulted to the hospitalist team, being diagnosed with diabetes, are predisposed to poor glycemic control, which explains the lower compliance rates; nonetheless, compliance rates increased post-implementation of this quality improvement initiative.

CHALLENGES

There is no standardized approach to achieving or analyzing glycemic control, and it can be challenging. One challenge is maintaining glycemic control when caloric intake, particularly protein intake, is being encouraged. We provide protein, a well-established promoter of wound healing in the postoperative setting, in the form of supplemented milkshakes. Patients are encouraged to drink the milkshakes beginning the morning of POD1. If consumed, they deliver 66 g of protein and approximately 135 to 150 g of carbohydrate and may affect glycemic control throughout the day. Attention to dietary intake and resultant patterns in blood glucose measurement must be closely monitored in order to avoid overestimating requirements and having subsequent hypoglycemic events overnight or after discontinuation of the protein shakes.

Another challenge is the medical predicament presented in the setting of post–cardiovascular surgery. Metabolic derangements due to multiple factors at the time of surgery induce a temporary state of hyperglycemia. Clinicians may find themselves in a therapeutic conundrum in titrating insulin each day because as time passes, the body naturally regains its innate ability to control blood glucose, and insulin requirements may be titrated down. As mentioned previously, patient cases consulted to the hospitalist team are presumably the most challenging with regard to glycemic management. The average hemoglobin A1C of the patients referred within this study was 8.1%. Being known diabetics, the patients are likely to have labile changes to insulin requirements, making the clinical conundrum even more complex.

CONCLUSION

We developed and introduced a standardized set of evidence-based treatment recommendations to address glycemic control in cardiac surgery patients. Although there was an increase in the rate of on-target blood glucose levels after the protocol was implemented, the difference was not statistically significant. The lack of difference is likely related to the small sample size. Subjectively, our project enhanced provider awareness of the importance of maintaining glycemic control in post–cardiac surgery patients. There were no cases of deep sternal wound infection and no cases of hypoglycemia in the study population.

Frequency of blood glucose measurement varied, and the time period assessed varied depending on the time that IV insulin was discontinued. This variability may be unavoidable as the protocol allows decreased monitoring in patients in whom the requirements and titrations are stable; we attempted to stress the need for blood glucose checks and have noticed a subjective trend in response to more frequent monitoring.

The project was made possible through the collaboration between hospitalists, the surgeon, and the multidisciplinary team. Additional opportunities for improvement may be identified with continued review of the intervention. Our promising results compel us to continue application of the protocol as well as assess its impact in a larger number of patients. Currently, hospitalist physicians continue to utilize the standardized recommendations with apparent sustained results.

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REFERENCES


