Evaluation of Glycemic Control with a Pharmacist-Managed Post-Cardiothoracic Surgery Insulin Protocol

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Abstract: Purpose: The purpose of this study is to validate whether a standardized pharmacist-managed protocol improves glycemic control in post-operative patients following cardiothoracic surgery. Methods: The study was conducted via retrospective chart review comparing outcomes from patients treated before and after implementation of a pharmacist-managed insulin protocol. The primary efficacy outcome is defined as the percentage of patients below the target blood glucose level of 200 mg/dL from POD (post-operative day) 1 through POD 2, with secondary outcomes comparing the rates of hypoglycemia, hospital LOS (length of stay), and the incidences of SSI (surgical-site infections) diagnosed through 30 days post-surgery. Eligible participants included all adult patients who had undergone cardiothoracic surgery during the time frame of the study, but excluded any patients requiring intubation or continuous insulin infusion through 12:00 on POD 1. Results: The incidence of post-operative hyperglycemia was similar in the pre-protocol and post-protocol groups with a non-statistically significant trend toward a lower incidence in the post-protocol (19.5% pre-protocol v 12.3% post-protocol, $P = 0.05$). There were no statistically significant differences between both groups with regard to SSI (2.1% vs 4.7%, $P = 0.16$), hospital LOS (9.9 days vs 9.6 days, $P = 0.46$), or hypoglycemia (0.5% vs 2.1%, $P = 0.05$). Conclusion: The pharmacist-managed insulin protocol resulted in similar rates of post-operative hyperglycemia compared to the pre-protocol group.

Key words: Insulin, protocol, pharmacist, cardiothoracic surgery, hyperglycemia, infection.

1. Introduction

SSI (surgical site infections) are one of the primary complications of concern following cardiothoracic surgery, with the incidence at about 3% in the general population [1]. However, this risk is doubled in patients with post-operative hyperglycemia, defined as BG (blood glucose) > 200 mg/dL following surgery through POD (post-operative day) 2 [2]. In 2003, the CMS (Centers for Medicare and Medicaid Services) and the CDC (Centers for Disease Control and Prevention) established the SCIP (Surgical Care Improvement Project) to help reduce post-surgical complications. Based on studies suggesting tight glycemic control can reduce the incidence of SSI [1-5], these guidelines recommend to maintain BG < 200 mg/dL through 6:00 on POD 2 [6].

At KP (Kaiser Permanente) San Francisco Medical Center, post-operative glycemic control has become a growing priority in part due to the large number of cardiothoracic surgeries that are completed at the medical center. In fact in 2011, there were 773 cardiothoracic surgeries completed at the medical center, serving as a tertiary care facility and cardiac referral center for all of Northern California KP region. Despite the large number of surgeries, the management of post-operative glucose is inconsistent and highly dependent on individual prescriber practice. Thus in 2012, a post-cardiothoracic surgery insulin protocol was proposed to help standardize insulin management. Pharmacists offer the ideal candidates to help manage the protocol because as standard practice, they monitor insulin doses and blood glucose measurements upon order verification. In addition, the floor-based pharmacists are easily accessible and can communicate

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with physicians and nurses to clarify issues on the patient floor. Finally, pharmacists are well trained in insulin management and understand the pharmacokinetic and pharmacodynamic properties that may influence clinical outcomes.

1.1 Post Cardiothoracic Insulin Monitoring per Pharmacy Protocol

At KP San Francisco Medical Center, patients who require intraoperative insulin for glycemic control are managed via an IV (intravenous) continuous insulin infusion. Following surgery, the patients are then transferred to the CVICU (Cardiovascular Intensive Care Unit) and remain on the insulin infusion through the morning of POD 1. At this time, the insulin infusion is converted to scheduled doses of SC (subcutaneous) NPH insulin in addition to sliding-scale regular insulin. This conversion helps facilitate the patient's recovery and eventual transition toward discharge. However, prior to protocol implementation, physicians managed this conversion and there was greater variability in how conversions were calculated. Thus, the new protocol allows pharmacists to manage this conversion using a facility-approved dosing algorithm. In addition, pharmacists are responsible for monitoring to ensure nurses administer glucose checks at pre-determined scheduled times and to ensure the correct dose of

insulin is administered. Lastly, pharmacists determine if a patient will require any supplemental doses of insulin at bedtime on POD 1 to ensure appropriate glycemic control through the morning of POD 2. Figs. 1 and 2 diagram the protocol.

To summarize, the protocol specifies three essential responsibilities of the pharmacist:

Conversion of insulin infusion to scheduled SC doses of NPH insulin on POD 1 (previously managed by physicians);

Monitor administration of blood glucose checks and insulin to ensure adherence to the protocol (previously absent);

Order supplemental NPH insulin if necessary on POD 1 at bedtime (previously not standardized).

2. Methods

The purpose of this study is to validate whether a standardized pharmacist-managed protocol improves glycemic control in post-operative patients following cardiothoracic surgery.

This was a single center, retrospective study conducted at KP San Francisco Medical Center from October 2012 to May 2013. The post-protocol group consists of patients treated after protocol implementation on February 20, 2013. All data was retrieved by electronic chart review.

Fig. 1 Insulin protocol timeline.

Fig. 2 Insulin conversion algorithm.

The study includes all patients greater than 18 years of age who underwent cardiothoracic surgery. The study excludes patients that required intubation or continuous insulin infusion through 12:00 on POD 1 as outlined in the originally approved protocol.

The primary outcome is the incidence of post-operative hyperglycemia, defined as having a measured BG of greater than 200 mg/dL from the completion of surgery through the morning of POD 2.

Secondary outcomes include the incidence of SSI diagnosed through POD 30, hospital LOS (length of stay), and incidence of hypoglycemia from the

completion of surgery through the morning of POD 2.

A target sample size of 195 patients for each group was estimated to detect a difference in the primary outcome with 80% power at a two-sided alpha level of 0.05. This estimate was based off of results from a previous study evaluating glycemic control with a post-cardiothoracic insulin protocol [7].

Data was analyzed via 2×2 Chi-square test for all categorical data, and Paired t-test for all continuous data.

Table 1 summarizes the baseline demographics of the patients in each group. Data from 195 patients in

each group was obtained and analyzed. Patients in the post-protocol were slightly older than patients in the pre-protocol group ($P = 0.02$). Both groups were similar with regards to sex and proportion of patients with baseline DM (diabetes mellitus). The most common types of surgeries were CABG (coronary artery bypass grafts) and heart valve replacements. The types of surgery did not differ between the two groups.

3. Results

A total of 38 patients (19.5%) in the pre-protocol

experienced post-operative hyperglycemia, compared to 24 patients (12.3%) in the post-protocol group as shown in Fig. 3. This difference was not statistically significant ($P = 0.05$).

Table 2 summarizes the results from the primary and secondary outcomes of the study. With regards to secondary outcomes, five patients in the pre-protocol and three patients in the post-protocol died (not related to SSI) prior to 30 days post-surgery and thus were not included in the analysis for the development of SSI.

There were four cases of SSI in the pre-protocol group

Table 1 Baseline demographics.

		Pre-protocol <i>N</i> = 195	Post-protocol <i>N</i> = 195	<i>P</i> -value
Patient Characteristics	Years of age $\pm$ SD*	64.2 $\pm$ 13.6	67.2 $\pm$ 12.2	0.02
	Male (%)	140 (71.8)	143 (73.3)	0.73
	DM** (%)	75 (38.5)	72 (36.9)	0.75
Type of Surgery	CABG^ (%)	81 (41.5)	89 (45.6)	0.41
	Heart valve replacement (%)	77 (39.5)	68 (34.9)	0.35
	Aortic repair (%)	14 (7.2)	18 (9.2)	0.46
	Other (%)	23 (11.8)	20 (10.3)	0.63

*Standard deviation; **diabetes mellitus; ^coronary artery bypass graft.

Fig. 3 Incidence (%) of post-operative hyperglycemia (BG > 200 mg/dL).

Table 2 Summary of results.

		Pre-protocol <i>N</i> = 195	Post-protocol <i>N</i> = 195	<i>P</i> -value
Primary outcome	Hyperglycemia (%)	38 (19.5)	24 (12.3)	0.05
	SSI (%)	4 (2.1)*	9 (4.7)**	0.16
Secondary outcomes	Hospital days LOS $\pm$ SD	9.9 $\pm$ 4.9^	9.6 $\pm$ 5.4^^	0.46
	Hypoglycemia (%)	1 (0.5)	4 (2.1)	0.05

N* = 190, *N* = 192, ^*N* = 192, ^^*N* = 193.

(2.1%), and nine cases in the post-protocol group (4.7%). This difference was not statistically significant ($P = 0.46$).

Three patients in the pre-protocol and two patients in the post-protocol were not analyzed for hospital LOS due to death during hospital stay. Hospital LOS did not differ significantly between the two groups (9.9 days in pre-protocol v 9.6 days in post-protocol, $P = 0.46$).

Incidence of hypoglycemia was similar between the two groups and occurred in one patient in the pre-protocol and four patients in the post-protocol group.

The average blood glucose for all measured readings from the time of insulin drip conversion through the morning of POD 2 was lower in the post-protocol group compared to the pre-protocol group (133.6 mg/dL vs 138.3 mg/dL, $P \leq 0.01$). Of the patients who developed SSI, three of the four patients in the pre-protocol group had baseline DM (75.0%), compared to seven of the nine the post-protocol group (77.8%). One of the four patients had post-operative hyperglycemia in the pre-protocol group (25.0%), compared to four of the nine in the post-protocol group (44.4%).

4. Discussion

The current study did not show any differences in post-operative hyperglycemia when comparing patients who were treated before and after implementation of the insulin protocol. However, it should be noted that the rates of post-operative hyperglycemia in this current study were much lower than that in Olansky's study [7]. One possible explanation for this discrepancy may be related to the advancement of perioperative care and development of less invasive surgical techniques since Olansky's study was conducted in 2007 [7]. As surgeries have evolved to become less invasive, it would be expected that less stress would be induced on the body which in turn could result in less post-operative hyperglycemia. Thus, with lower rates of hyperglycemia, we would need a

much larger sample size to detect any differences between the two groups in this study.

Nonetheless, the rates of hyperglycemia in the post-protocol group came close to being significantly lower than that in pre-protocol group. This slight improvement could be attributed to the standardization of insulin management following discontinuation of the insulin infusion, as pharmacists monitored patients systematically to ensure there were no gaps in care. Scheduled insulin doses were calculated the same way based on the estimated 24-hour requirement via an electronic order set. In addition, pharmacists monitored the bedtime BG check on POD 1 much more routinely, and ordered supplemental NPH insulin according to an algorithm as part of the approved protocol. This practice was largely absent prior to protocol implementation.

However, the marginal improvements in hyperglycemia may have been off-set somewhat by the increased incidence of hypoglycemia post-protocol. While these findings were not statistically significant, the results suggest that more stringent insulin guidelines may also result in more hypoglycemia. The risks and benefits of any therapy must be weighed. Thus, caution must be taken when adhering to guidelines, as clinical judgment may be necessary when BG trends suggest less aggressive therapy is warranted.

Despite demonstrating a non-significant trend toward lower rates of hyperglycemia, there was a trend toward higher rates of SSI in the post-protocol. This could have been attributed to the older age of patients in the post-protocol group, as wound-healing may become more impaired as patients age. However, the results may also be a product of random variation as the data was not statistically significant. Due to the low rates of SSI in the general population, a study would require thousands of patients to be powered to detect any potential differences.

There were some limitations in this current study. As mentioned before, the sample size used was

underestimated to detect any difference in post-operative hyperglycemia because the results from both groups showed a much lower incidence compared to previous studies. If the assumption was made that there is a real difference, the study sample size would require 401 patients in each group to reach statistical significance based on the results reported in this study. In addition, the study was not adequately powered to detect differences in clinical outcomes (i.e., SSI) due to the relative low incidence.

Another limitation was the potential under-reporting of SSI, as only diagnoses with ICD-9 coding were reported in the results of this study. Under-reporting may have been due to lack of uniform diagnosis criteria for physicians, as often times it is made on a subjective clinical judgment rather than based on systematic criteria. There were also instances where antibiotics were prescribed as a precautionary for patients who may have had a SSI, but were not officially diagnosed. These patients were not included in the data despite the possibility that they may have contracted a real infection.

5. Conclusion

In conclusion, the pharmacist-managed insulin protocol resulted in similar rates of hyperglycemia as pre-protocol. Future efforts to improve the protocol should focus on further fine-tuning the insulin dosing algorithm with the hope of further reducing the incidence of post-operative hyperglycemia while maintain low rates of hypoglycemia. In addition, implementing a documentation system in the electronic medical record could be useful in tracking interventions and improving the continuity of care. With further improvements, consideration should be given to conduct a study with a larger sample size in order to capture the true impact of the protocol. Ultimately, the goal remains to reduce surgical site infections by improving glycemic control, and optimizing patient outcomes while conserving valuable

health care resources.

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