A Comparison of Outcomes Among Diabetic Patients Undergoing Cardiac Surgery Using Insulin Infusion versus Insulin Bolus in Glucose Management

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Background --- Perioperative hyperglycemia during on-pump cardiac surgery is associated with increased incidence of postoperative complications such as deep sternal wound infection, cardiac, renal, neurologic complications, prolonged intubation and longer stay in the intensive care unit, particularly among diabetic patients. Intraoperative glycemic control can be difficult to control because the stress response of cardiac surgery and cardiopulmonary bypass can induce profound hyperglycemia. Intraoperative blood glucose control significantly reduces postoperative morbidity and mortality in cardiac patients under cardiopulmonary bypass. This study was done to determine and compare outcomes of diabetic patients undergoing open heart surgery receiving insulin bolus versus insulin infusion for glucose control.

Methods --- This is a prospective randomized controlled study involving 86 adult diabetic patients who underwent on-pump cardiac surgery. Patients were randomly assigned to receive insulin bolus or insulin infusion to maintain glucose levels between 80-120mg/dl. Insulin therapy was initiated according to modified Portland protocol. Intraoperative blood glucose levels were measured hourly and titrated accordingly. Postoperative blood glucose levels were also determined and titrated with insulin until 12 hours. Outcomes of glucose management were followed up for in-hospital events thru chart review and interview from patients and relatives. The primary outcome was a composite of death, stroke, coma, sternal wound infection, cardiac arrhythmias (new onset atrial fibrillation, heart block, and cardiac arrest), and prolonged ventilation. The secondary outcomes were episodes hyperglycemia and hypoglycemia.

Results --- Twenty of 43 patients in the bolus group and 20 of 43 patients had an in-hospital event. More deaths (0 vs. 2, [P=0.49]) occurred in the infusion group. Mean glucose concentrations were lower in the bolus group than in the infusion group during induction of anesthesia (171.2±87.5 vs. 158.4 ± 89.81, [P=0.504]), on bypass 396.3±80.33 vs. 398.9 ± 103.5, [P=0.89]), rewarming (399.1±81.14 vs. 402.1 ± 85.21, [P=0.84]), and post-bypass (360 ± 10 vs. 386.7 ± 31, [P= 0.59] were not statistically significant. Mean glucose concentrations postoperatively taken upon arrival at ICU (290 ± 93.87 vs. 291.28 ± 116.53, P=0.97]) were similar in both groups. The average 12 hours glucose concentrations were lower in the infusion group but not significantly (214.57 ± 43.15 vs. 206.47 ± 62.58, {P=0.48]). The frequency of intraoperative hypoglycemia was low. Increased episodes of hyperglycemia was noted in both groups (41 vs. 38, [P=0.43]). Postoperative hypoglycemia was low in both groups. Postoperative hyperglycemia was seen in 27 patients in bolus group and 25 patients in the infusion group.

Conclusions* ---** Intraoperative hyperglycemia under cardiopulmonary bypass is an independent risk factor for mortality and complications in diabetic patients. Although this pilot study showed no difference in clinical outcomes among the two study groups, the sample size was not large enough to allow for any definite conclusions or recommendations on the effect of glucose control on the outcomes of surgery. Insulin bolus can be used intraoperatively and postoperatively with similar outcome in the infusion group. ***Phil Heart Center J 2013; 17(1):34-42.

Key Words: Insulin ▪ Hyperglycemia ▪ Cardiac Surgery

Perioperative hyperglycemia during on-pump cardiac surgery is associated with increased incidence of postoperative complications such as deep sternal wound infection, cardiac, renal, neurologic complications, prolonged intubation and longer stay in the intensive care unit,

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particularly among diabetic patients. Intraoperative glycemic control can be difficult to control because the stress response of cardiac surgery and cardiopulmonary bypass can induce profound hyperglycemia. Intraoperative blood glucose control significantly reduces postoperative morbidity and mortality in cardiac patients under cardiopulmonary bypass.[1] Hyperglycemia is a normal response to stress. Surgery results in increase levels of stress hormones and inflammatory cytokines which results in hepatic glucose production, impaired peripheral glucose utilization, relative insulin deficiency and hyperglycemia.[2]

Intraoperative glucose management in cardiac surgery under cardiopulmonary bypass (CPB) is difficult to control. Diabetic patients undergoing coronary artery bypass graft (CABG) surgery have a higher 30-day mortality and in-hospital morbidity than non-diabetic. Studies reported that tight intraoperative blood glucose control significantly reduces postoperative morbidity and mortality in cardiac surgery patients. Hyperglycemia is common for both diabetic and non diabetic patients during and after cardiac surgery. As such, adjustments of insulin dose, often to higher levels, are often done to attain euglycemia. However, some of these methods fail to succeed in controlling sugar levels.[3-4] Management of perioperative hyperglycemia has been controversial, with some judges this event as harmless and beneficial, thus, they do not treat this aggressively.[3,5] On the other hand, some suggest that postoperative hyperglycemia is directly related to mortality in patients with diabetes mellitus (DM), and thus should be aggressively managed. [6-7]

The hyperglycemia that occurs in cardiac surgery and its effect on the outcomes may be explained by the following phenomena. Firstly, those patients who have complicated postoperative course usually receive glucogenic agents, like epinephrine. As such, they have both elevated sugar levels and a more morbid outcome. Second, the diabetic patients with increased co-morbidities and greater insulin resistance have higher degree of postoperative hyperglycemia.[8] Lastly, several studies have cited that insulin has a direct effect on postoperative outcomes independent of the levels of serum glucose, particularly in nondabetic patients.[3,9] These explanations should be taken with caution, since it is still unclear whether perioperative hyperglycemia has a direct effect on adverse events and mortality in cardiac surgery, particularly in non-diabetic patients.

Shine et. al reviewed the importance of perioperative blood glucose management in cardiac surgical patients concluded that hyperglycemia is a common problem during cardiac surgical procedures because of insulin resistance due to cytokines released during the surgical procedure.[10] While insulin administration decreases blood glucose levels, it is also associated with improved results. Its intraoperative use in cardiac surgery is increasing. He recommended an algorithm for insulin administration that is easy to follow and with minimal distractions, easy to implement, and which allows monitoring of patients to avoid the complications of hypoglycemia.[10] Hovorka and coworkers, examined 60 patients, demonstrated that computer algorithm with variable sampling was more effective and comparably safe in euglycemia in post-cardiac surgery patients than the standard protocol.[11]

Gandhi and colleagues[14] in 2005 conducted a prospective cohort study involving 409 patients undergoing cardiac surgery. They found out that the higher the intraoperative blood glucose levels have a higher risk for postoperative complications and death. When the blood glucose concentration was more than 100 mg•dL, a further 20 mg•dL increase in glucose concentration was associated with a 34% increase experiencing adverse events. Later, in 2007, the same investigators did a randomized trial in 307 subjects on intensive intraoperative insulin therapy versus conventional glucose management during cardiac surgery. They found out an increased incidence of death and stroke in the intensive group raises concern about routine implementation of this intervention.[15]

Several authors have studied the effect of the hypothermic cardiopulmonary bypass (CPB) and subsequent rewarming on the levels of glucose and insulin. Lehot and colleagues[12] noted that during hypothermic CPB, the levels of insulin drops, while the glucose levels increases.

However, during rewarming, both blood glucose and insulin levels increases, but there is a higher degree of increase of insulin, along with the concomitant rise in the levels of cytokines, stress and growth hormones. The same observation was noted by Wasmuth and colleagues.[13] In addition to the above observations, they stated that the increased levels of blood glucose, which is due to relative state of insulin resistance as well as the increased circulating levels of catecholamines and growth hormones, can also be aggravated by the absorption of the insulin by the plastic material used in the extracorporeal circuit, use of steroids and ongoing glucose administration in the cardioplegia solution.

Doenst et. al concluded that peak hyperglycemia during CPB is associated with adverse post operative outcomes in both diabetic and non-diabetic patients. This state of insulin resistance, which is manifested as hyperglycemia, is related to poor outcome. They considered that treatment of insulin resistance might improve outcomes in patients undergoing cardiac surgery.[1]

Furnary and co-workers examined the effects of glycemic control during CABG surgery in 3554 patients from 1987-2001. The patients were divided into three groups based on the year of surgery, method of glycemic control, and targeted glucose levels. They were able to find out that patients treated with a continuous insulin infusion had a reduced rate of postoperative deep surgical site infection, compared to controls who received intermittent subcutaneous insulin. Patients undergoing CABG who received continuous insulin had 2.5% mortality rate (652615) patients), compared to a 5.3% mortality rate (50/942 patients) in those who received subcutaneous insulin. They concluded that continuous insulin infusion normalized hospital mortality for patients with diabetes undergoing CABG. They recommended that continuous insulin infusion become the standard of care for glycometabolic control in all patients undergoing cardiac surgical procedures.[6]

Furnary and colleagues[16] included 1980 patients from 2001 to 2005 in addition to the original cohort of the Portland Diabetic Project. This study showed that perioperative hyperglycemia during cardiac surgery and first 2 postoperative days has a significant effects on wound infection, length of hospital stay and in-hospital mortality. An effective and safe reduction of blood sugar levels to near normal can be achieved with the use of Portland CII Protocol on the day of cardiac surgery and continued through first 2 postoperative days. An increase in 3-BG was an independent predictor of perioperative mortality (P <0.001). Mean 3-BG was also significantly related to the incidence of deep sternal wound infections, hospital length of stay, blood transfusions, new onset atrial fibrillation, and low output cardiac syndrome.[16]

Van den Berghe and co-workers in a prospective randomized study demonstrated the importance of tight glycemic control in patients undergoing CABG surgery in 1548 mechanically ventilated patients in the surgical intensive care unit of which 63% of patients had cardiac surgery, and only 13% had a history of diabetes. Patient were randomly assigned to conventional treatment group (insulin administered only if serum glucose >215mg/dl to maintain serum glucose of 180-200mg/dl) and intensive group (received continuous insulin infusion to maintain glucose levels between 80-110mg/dl). Insulin therapy resulted in a one-third reduction in serum glucose levels and lowered mortality from 8.0% to 4.6% (P <.04). The mortality was most notable in those patients who required an extended ICU stay of > 5 days.[17]

At the Philippine Heart Center, the outcomes for controlling the intraoperative and postoperative blood sugar have not been fully elucidated. Both insulin bolus and insulin infusion have been employed by the anesthesiologists in order to achieve blood sugar control. This paper will serve as a pilot study to determine the outcomes of administering insulin bolus versus insulin infusion among adult diabetic patients undergoing cardiac surgery under cardiopulmonary bypass.

METHODOLOGY

This study was approved by the Institutional Review Board. Between February 2010 to November 2010, an informed consent was obtained on qualified subjects more than 21 years old, with known diabetes or newly diagnosed and admitted for elective on-pump cardiac surgery were prospectively randomized thru computer block randomization. Excluded were pregnant, preoperative use of inotropes and/or vasopressor and surgery needing deep hypothermic circulatory arrest.

On the basis of the results of the study of Intensive Insulin Therapy versus conventional Glucose Management during Cardiac Surgery by Gandhi et. al in February 2007 which arrived at a composite mortality of 46% among continuous insulin treatment group, $n \geq 43$ patients per treatment group at confidence level of 95% ($\alpha = 0.05$), power of 80% ($\beta = 0.2$), to detect signifi-cant difference with insulin bolus group of 30%. The occurrence of any composite event will indicate that the composite did occur.

Upon arrival at operating room, all patients were given with intravenous fluid. Initial blood glucose level was taken after the induction of anesthesia. Insulin therapy was initiated when BGL exceeds 180mg/dl for insulin bolus group and BGL greater than 80 mg/dl for insulin infusion group. Subsequently, dosing was titrated according to Modified Portland protocol[16] (Appendix). Adjustment of insulin dose was based on hourly measurements of blood glucose intraoperatively using a glucose analyzer. Blood samples were taken by needle prick in the earlobe intraoperatively and finger prick postoperatively. Blood glucose determinations were done every hour intraoperatively and up to 12 hours postoperatively until the desired blood glucose level were achieved. Hourly blood glucose control is performed after each dose adjustment.

The insulin was administered during prebypass period through central venous catheter using an infusion device or intravenous bolus dosing. The standard insulin concentration was 50 units/50ml normal saline of regular-acting insulin in syringe delivered through a standard infusion device. The insulin bolus dosing was administered via central line using insulin concentration of 100 U/ml of regular-acting insulin. During bypass period, insulin administration was delivered through the reservoir of CPB machine. Once CPB was terminated, insulin administration was given via central line.

For all patients, inhalational or intravenous anesthesia was used during induction and maintenance and titrated to its hemodynamic effect. Surgical and anesthesia management proceeded with the usual routine care. Dexamethasone 15mg was given after induction of anesthesia to modify the inflammatory effect of CPB. The use of inotropic support depends on the patients' needs. During the postoperative period, all patients were treated either insulin bolus or infusion therapy throughout the stay in the intensive care unit according to study protocol. Blood glucose levels were measured every hour for 12 hours. Blood glucose determinations and insulin therapy were terminated after 12 hours in the postoperative recovery unit. Thereafter, the attending cardiologist or endocrinologist will continue to manage blood glucose and provide individualize approach for ongoing insulin therapy.

The composite outcomes of all-cause-in-hospital events that occurred after surgery were identified and followed up thru chart review and interview from patients or relatives. The primary endpoint were in-hospital composite outcomes including as all-cause mortality and events such as stroke, coma, deep sternal wound infection, acute or worsening renal failure, cardiac (new onset atrial fibrillation, heart block, cardiac arrest), prolonged ventilation. The secondary endpoints were the episodes of hyperglycemia and hypoglycemia.

Statistical analysis. Continuous data were described as mean ± SD and categorical data were presented as frequency and percent distribution. To compare the two interventions in terms of baseline characteristics and outcome variables, T-test, Mann-Whitney test, logistic regression and Chi-square test were used. A P-value <0.05 was considered statistically significant.

RESULTS

The results of this study are presented in tables with mean values and standard deviation. Eighty six (86) patients were enrolled in this study, including 43 subjects in bolus group and 43 subjects in infusion group.

Table 1. Baseline Characteristics of Diabetic Cardiac Surgery Patients Managed with Insulin Bolus and Infusion (PHC, 2010)

Variable		Insulin Bolus (N = 43) n (%)	Insulin Infusion (N = 43) n (%)	P-Value
Age, yr (Mean, SD)		57.5 ± 9.18	58.9 ± 8.35	0.45
Gender				
	Male	31 (36)	34 (39.5)	0.61
	Female	12 (13.5)	9 (10.4)	
Weight, kg (Mean ± SD)		66.0 ± 9.62	68.6 ± 13.5	0.31
Height, cm (Mean ± SD)		162.8 ± 8.15	163.7 ± 7.71	0.31
BMI, kg/m² (Mean ± SD)		24.2 ± 5.21	25.3 ± 4.01	0.28
BSA (Mean ± SD)		1.71 ± 0.16	1.75 ± 0.20	0.40
Diabetes Treatment				
	Insulin	0 (0)	5 (5.8)	0.14
	Insulin & OHA	4 (4.6)	3 (3.4)	
	OHA only	27 (31.3)	24 (27.9)	
	none	12 (13.9)	11 (12.7)	
History of hypertension		37 (43)	37 (43)	1.00
Smoking history,				
	Current	7 (8.1)	5 (5.81)	0.14
	Previous	23 (26.7)	16 (18.6)	
	Never	13 (15.1)	22 (25.5)	
COPD		10 (11.6)	10 (11.6)	1.00
EUROscore (Mean ± SD)		4.0 ± 2.16	4.6 ± 2.7	0.36
LVEF, % (Mean ± SD)		56.4 ± 11.96	56.1 ± 13.3	0.93
NYHA FC				
	2	23 (26.7)	18 (20.9)	0.30
	3	19 (22)	24 (27.9)	
	4	1 (1.1)	1 (1.1)	
ASA Classification				
	2	4 (4.6)	4 (4.6)	1.00
	3	39 (45.3)	39 (45.3)	
Surgical Procedure				
CABG		38 (44.2)	36 (41.8)	
Valve		3 (3.5)	4(4.6)	
Vascular		1 (1.2)	1(1.2)	
Combined		0	1(1.2)	
Left Atrial Mass Excision		1(1.2)	1(1.2)	

*BSA - body surface area BMI - body mass index OHA - oral hypoglycemic agents COPD - Chronic Obstructive Lung Disease LVEF - Left Ventricular Ejection Fraction NYHA FC - New York Heart Association Functional Classification Status ASA Classification - American Society of Anesthesiologists Physical Status Classification

Table 1 shows the baseline characteristics of the patients in both groups. Both groups were similar in age, sex, weight, height, BSA and BMI. There were no differences in bolus or infusion group in relation to ASA physical status. In the bolus group, 4.65% were physical status (PS) 2 and 45.3% were PS 3 and in the infusion arm, 4.65% were PS 2 and 39% were PS 3. Applying the risk evaluation for cardiac surgical patients from EuroSCORE, no differences were found between two groups. The diabetes treatment in bolus group were 4% using insulin and oral hypoglycemic (OHA) agents, 31.3% using OHA, 13.9% without medication. In the infusion group, 5.8% used insulin, 3.48% using insulin and OHA, 27.9% using OHA, 11% with no treatment. These patients with no diabetic treatment were recently diagnosed diabetic or noted only upon admission. Smoking history showed no significant difference in both groups.

CABG surgery comprised the majority of surgical procedure among the subjects (Table 1), 44.1% from bolus group and 41.86% from the infusion group. At the Philippine Heart Center, about 50-65% of adult cardiac surgery is CABG. The duration of ischemic time (Table 2) showed no statistical differences between the two groups. Preoperative and postoperative creatinine showed similar results in both groups.

The baseline BGL was higher in bolus group after induction of anesthesia than infusion group (171.2±87.5 mg/dl vs.158.4±89.91 mg/dl,[P =0.504]) (Table 4). During CPB, glucose concentrations were similar in both groups (396.3 ± 80.33 vs. 389.9 ± 103.5 [P=0.896]). Glucose concentrations were similar during rewarming in both groups (399.1±81.14 vs. 402.1±85.21, [P=0.844]). Post-bypass glucose concentrations were lower in bolus group than the infusion group (360±101 vs. 386.7±316, [P=0.979]). Glucose concentrations were similar on arrival in ICU in both groups (290±93.87 vs. 291.28±116.53, [P=0.979]). The average 12 hours glucose concentrations were lower in the infusion group than in the bolus group (214.5±43.15 vs. 206.47±116.53, [P=0.486]). The infusion group stayed more on insulin therapy compared to the bolus group. However, this is inherent on the type insulin treatment to which patients were grouped. (Table 3)

Glycemic control was not different between the two groups (Table 1). The frequency of intraoperative hypoglycemia was low in both groups. Three patients in the bolus group and two patients in infusion group had experienced hypoglycemia during surgery. Hypoglycemic episodes were clinically corrected. Although 47.6% of patients in bolus group had intraoperative hyperglycemia than 44.1% in infusion group, this difference did not reach statistical significance (P=0.433). As per protocol, administered insulin was adjusted according to glucose concentrations. The frequency of postoperative hypoglycemia and hyperglycemia were similar in both groups.

The composite outcomes of insulin therapy are shown in Table 5. Clinical outcomes were not statistically different between the two groups: 20 composite outcomes of 43 patients in the bolus group and 20 composite outcomes of 43 patients in the infusion group had an in-hospital event. No perioperative stroke was observed in both groups. The incidence of coma was observed but not significant. Prolonged ventilation and atrial fibrillation were the predominant outcomes. Coma, heart block and and mortality increased in the infusion group. Deep sternal wound infection and acute or worsening renal failure was observed more in the bolus group.

DISCUSSION

The main results of this study demonstrated that there are no significant differences between insulin bolus and insulin infusion groups. Specifically, we examined the duration of cardiopulmonary bypass, duration of ischemic time, intraoperative hypoglycemia and hyperglycemia, postoperative hypoglycemia and hyperglycemia. BGL were evaluated as baseline, during CPB, during rewarming, post CPB and average 12 hours postoperative BGL. The incidence of stroke, coma, DSWI, acute or worsening renal failure, prolonged mechanical ventilation, heart block, new onset AF, and mortality were evaluated as the outcomes. Higher incidence of death was observed in the infusion group. The mortality observed in infusion group did not show significant difference.

Patients in both groups were comparable as to age, gender and weight, height, BMI and BSA. In addition, there were no differences between the two groups for physical status (ASA), NYHC as well as EuroSCORE indices of risk. Considering co-morbidities such as history of hypertension, smoking and presence of COPD were similar in both groups.

The patients included in our series were scheduled for elective surgeries; therefore, emergency surgeries, pregnant, patients using inotropic support, reoperations or redo-surgeries and surgeries with deep hypothermic circulatory arrest were excluded from this study. The lack of statistical significance in both groups can be attributed to the limited duration of glucose control since in this study blood glucose levels were monitored and controlled only during surgery and during the first 12 hours of postoperative recovery.

Table 2. Comparison of Operative Data and Creatinine Values of Diabetic Cardiac Surgery Patients Managed with Insulin Bolus and Infusion (PHC, 2010)

	Insulin Bolus N = 43 mean ± SD	Insulin Infusion (N = 43) mean ± SD	P-Value
Lenght of CPB (min)	149.7 ± 47.54	178.9 ± 61.41	**0.01**
Lenght of ischemic time (min)	111.6 ± 42.4	122.0 ± 51.91	0.31
Preoperative creatinine (mg/dl)	0.11 ± 0.04	0.10 ± 0.08	0.91
Post operative creatinine (mg/dl)	0.11 ± 0.06	0.11 ± 0.06	0.80

Table 3. Comparison of the Intraoperative and Postoperative Glucose Levels and Duration of Insulin Therapy of Diabetic Cardiac Surgery Patients Managed with Insulin Bolus and Infusion (PHC, 2010)

	Insulin Bolus N = 43 mean ± SD	Insulin Infusion (N = 43) mean ± SD	P-Value
Intraoperative BGL (mg/dl)			
Baseline	171.2 ± 87.5	398.9 ± 103.5	0.50
During CPB	396.3 ± 80.33	398.9 ± 103.5	0.89
Rewarming	399.1 ± 81.14	402.1 ± 85.21	0.84
Post CPB	360.0 ± 101.0	386.7 ± 316.0	0.59
PACU BGL (mg/dl)			
Baseline	290.0 ± 93.87	291.28± 116.53	0.97
Ave 12hrs PACU BGL (mg/dl)	214.5 ± 43.15	206.47 ± 62.58	0.48
Total no. of hours of insulin therapy (hrs)	12.58 ± 3.60	17.7 ± 2.46	0.00

Table 4. Comparison of Intraoperative and Postoperative Glycemic Control in Diabetic Patients Undergoing Cardiac Surgery Managed with Insulin Bolus and Insulin Infusion (PHC, 2010)

Outcome	Insulin Bolus N = 43 mean ± SD	Insulin Infusion (N = 43) mean ± SD	P-Value
Intraoperative hypoglycemia*	3 (3.5)	2 (2.3)	1.00
Intraoperative hyperglycemia†	41 (47.6)	38 (44.1)	0.43
PACU hypoglycemia*	1 (1.1)	1 (1.1)	1.00
PACU hyperglycemia†	27 (31.3)	25 (29)	0.82

*Hypoglycemia is BGL < 60 mg/dL. †Hyperglycemia is BGL > 200 mg/dL

Table 5. Comparison of the Incidence of In-hospital Outcomes of Diabetic Cardiac Surgery Patients Managed with Insulin Bolus and Insulin Infusion (PHC, 2010)

	Insulin Bolus N = 43 mean ± SD	Infusion (N = 43) mean ± SD	P-Value
Stroke	0	0	-
Coma	1 (1.6)	2 (2.3)	1.00
Deep Sternal Wound Infection	2 (2.3)	1 (1.6)	1.00
Acute or worsening renal failure	4 (4.6)	2 (2.3)	0.67
Prolonged mechanical ventilation	7 (8.1)	7 (8.1)	1.00
Heart Block	0	0	0
Atrial Fibrillation	6 (6.9)	6 (6.9)	1.00
All-cause mortality	0	2 (2.3)	0.49

In our study, intraoperative hypoglycemia occurred in 3.48% of the bolus group and in 2.32% of patients from the infusion group, and postoperative hypoglycemia occurred in 1.16% of bolus group and 1.16% of infusion group with no statistical difference between groups. There were no cases of neurological sequelae of hypoglycemia, which suggests that either protocol was safe in this population. This study did not emphasize strict glycemic control. Strict glucose control is difficult to achieve during cardiac surgery requiring CPB because of the stress of surgery, anesthesia, cardioplegia and inotropic support.[19-20] The administration of large amounts of insulin during surgery has been associated with an increased risk for postoperative hypoglycemia.[19]

Glucose concentrations did not completely normalize intraoperatively in both groups despite insulin therapy being given during surgery. The beneficial effect of improved glycemic control would have been more evident if intraoperative glucose concentrations were normalized. However, a more aggressive insulin protocol may lower intraoperative glucose concentrations but it may result to increased frequency of hypoglycemia. Although glucose concentrations postoperatively were lower than intraoperative values, hyperglycemia was still observed. The incidence of postoperative hypoglycemia episodes was slightly lower in this study.

CONCLUSION

Intraoperative hyperglycemia under cardiopulmonary bypass is an independent risk factor for mortality and complications in diabetic patients. Although this pilot study showed no difference in clinical outcomes among the two study groups, the sample size was not large enough to allow for any definite conclusions or recommendations on the effect of glucose control on the outcomes of surgery. Insulin bolus can be used intraoperatively and postoperatively with similar outcome in the infusion group.

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