Glycemic control after coronary artery bypass grafting: Closure of the audit loop

R. Menaka, T. K. Sabeer, A. Naveen, R. R. Joshi, A. Bhattacharyya

Department of Diabetes and Endocrinology, Manipal Hospital, Bangalore, India

BACKGROUND: Coronary artery disease is more common in people with type 2 diabetes mellitus (type 2 DM) and type 2 DM is an important determinant of outcome in patients undergoing coronary artery bypass grafting (CABG). The first 100 patients in the year 2005 undergoing CABG in our hospital with type 2 DM were found to have unacceptable glycemic control. **AIM:** To see the impact of a structured intervention on the glycemic control in similar situations. **METHODOLOGY:** We introduced the concept of a 'glycemic pathway' for our patients. According to this pathway, we start intravenous insulin before shifting the patient for operation and continue till adequate oral intake commences. We have three insulin scales, which are moved higher or lower to achieve good control. We use a basal bolus regimen when the patient starts eating and review the glycemic control closely, adjusting the dose when necessary to get glucose values in the target range. We have analyzed the first 100 patients who have undergone CABG with the application of our 'glycemic pathway.' **RESULTS:** Glycemic control on intravenous insulin was found to be significantly better after introduction of the pathway (good 33, suboptimal 54, and poor 13 as compared to 23, 18 and 55, respectively, $P < 0.001$). A similar significant improvement was noted with subcutaneous insulin (good 53, suboptimal 45, and poor 2 as compared to 23, 14, and 65, respectively, $P < 0.001$). Hypoglycemic episodes were more but were mostly mild and managed easily. Duration of hospital stay reduced significantly after introduction of the pathway ($P < 0.05$). **CONCLUSIONS:** Our study showed that a structured intervention in the glycemic management of patients undergoing CABG is helpful. The length of hospital stay reduced. The frequency of hypoglycemia was higher but all episodes were minor and managed easily.

KEY WORDS: Coronary artery bypass grafting, diabetes mellitus, glycemic control, structured intervention

Background

Type 2 diabetes mellitus (type 2 DM), and stress hyperglycemia in nondiabetic individuals, is an independent predictor of morbidity and/or mortality in patients admitted to the hospital with myocardial infarction or unstable ischemic syndromes, as well as in those undergoing a variety of surgical procedures.[1] Long-term as well as short-term morbidity and mortality rates were also higher in patients with diabetes after coronary artery bypass grafting (CABG).[1] A direct relationship between postoperative hyperglycemia and mortality has been established in patients with type 2 DM undergoing CABG.[2] Hyperglycemia in the immediate postoperative period is associated with an excess risk of postoperative infection.[3,4] Furnary *et al.* reported that intravenous insulin begun preoperatively resulted in a 60% reduction in sternal wound infections.[5] A blood glucose of more than 200 mg/dl on the first postoperative day increases the risk of serious infection six fold.[6] An increase of hospital stay by one day was documented for every 50 mg increase above 150 mg during the first three postoperative days.[7] Patients with type 2 DM who undergo CABG, with strict blood glucose control monitored by an endocrinologist, do not incur increased healthcare costs and have decreased risk of infection, length of hospital stay, and mortality.[8]

We are at Manipal Hospital, Bangalore, the first 100 patients in the year 2005 undergoing CABG, and with type 2 DM, was compared to those without diabetes.[9]

Correspondence to **Dr. A Bhattacharyya**, Manipal Hospital, 98, Rustom Bagh, Airport Road, Bangalore - 560 017, India.
E-mail: arpan@diabetesendocrinology.in

The Hospital Ethics Committee approval was taken. Exactly what should be the target of glycemic control in hospital is a question that has not been answered clearly. In our hospital we follow a system based on a previous work done by one of the authors (AB)[10] [Figure 1]. By using these criteria the glycemic control was clearly inadequate and as a rule no specialist was involved in managing diabetes [Figure 2].[9] Three of the patients with diabetes died in hospital (as compared to zero deaths among those without diabetes); LV dysfunction, septicemia and septic shock were the causes of death. Glycemic control was poor in all of them.

Aim

On documenting unacceptable glycemic control after CABG in our hospital, we aimed to improve the diabetes control by introducing the 'glycemic pathway' under our direct supervision.

Methodology

Manipal Hospital, Bangalore is situated in South India with a bed strength of 650. This is a tertiary referral hospital with all clinical specialties. We have a fully equipped cardiothoracic department with an average CABG operation rate of 30-40 every month. We have designated specialists in the Department of Diabetes and Endocrinology in our hospital but, as far as the inpatient management of diabetes is concerned, there is no given policy for referral, i.e, the referral to a specialist or physician for management of diabetes depends on the consultant in charge of a particular patient. Glycemic management of most of our patients undergoing CABG is done by cardiothoracic surgeons or anesthetists and specialists are not routinely consulted.

On SC Insulin
- Premeal 80–140 mg/dl
- Bed time 120–180 mg/dl

IV Insulin
- 80–140 mg/dl

Classification of glycemic control
- Good: 80% or more in target range
- Suboptimal: 40–80% in target range
- Poor: <40% in target range

Figure 1: Target Blood Glucose

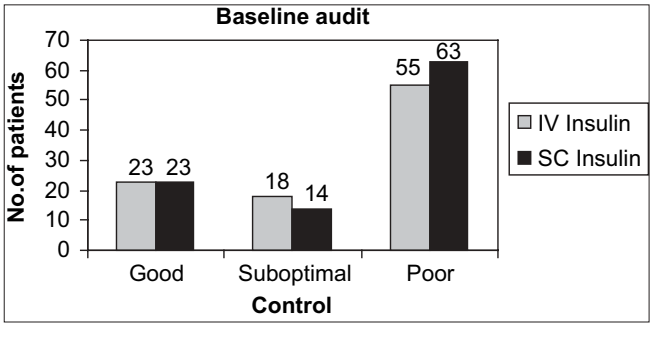

Figure 2: Glycemic control in baseline audit

After presenting the data on glycemic control after CABG in our hospital meeting [Table 1, Figure 2], we decided to introduce the 'glycemic pathway' in conjunction with the cardiothoracic surgeons, cardiac anaesthetists, and staff nurses of the cardiothoracic unit. The Hospital Ethics Committee's approval was taken again. In essence, for patients on IV insulin, we prepared three scales with an increasing rate of flow (in syringe drive). Patients who had been on diet control or on a small dose of an OHA entered in scale A; patients on insulin (>40 units/day) with or without OHA, or whose diabetic control at admission in hospital was unacceptable entered in scale C; and the rest entered in scale B. When three consecutive (one hourly) values were above 140 mg/dl, the scale was moved to the higher one (i.e., from A to B), and when three consecutive (one hourly) values were less than 80 mg/dl scale was moved down (i.e., from C to B). Blood glucose was initially monitored every hour. Monitoring frequency decreased to every 2-4 h when readings were consistently in the target range. A basal bolus regimen was used with premeal and bedtime glucose monitoring when patients started eating after surgery. The whole exercise was monitored by us daily or more than once a day when needed. The insulin dose was adjusted to get as many values as possible in the target range.

Results

We have completed the first 100 patients undergoing CABG with our 'glycemic pathway' [Table 2, Figure 3]. For those on IV insulin, the frequency of blood glucose meter checking has increased from seven to a mean of

Table 1: Baseline audit

	With diabetes	Without diabetes
Number	100	100
Age	59.8	58
Sex	81/19	88/12
BMI	24.2	23.9
Hospital stay	12.4 (7-37)	8.2 (5-32)
Mortality	3	0

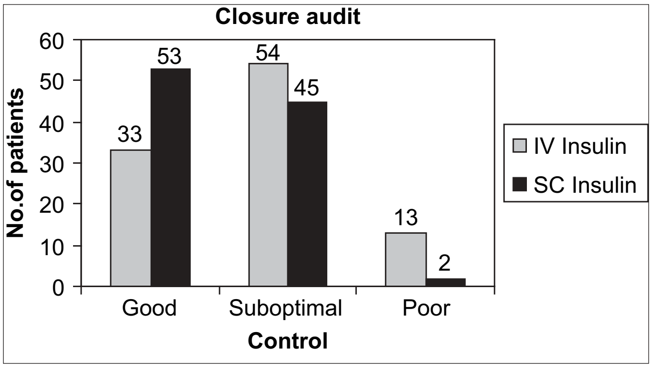

Figure 3: Glycemic control in closure audit

Table 2: Comparison of baseline and closure audit

	Baseline audit	Closure audit	*P* value
Number	100	100	-
Age in years	58	60.4	NS
Sex (M/F)	88/12	83/17	NS
BMI	23.9	23.2	NS
Hospital stay	12.4 (5-32)	8.4 (5-35)	<0.05
Mortality	3	2	NS

16 / day ($P < 0.01$). Glycemic control was found to be significantly better after introduction of the pathway with IV insulin (good 33, suboptimal 54, and poor 13, as compared to 24, 19, and 57, respectively, $P < 0.001$) [Figure 4]. A similar significant improvement was noted with SC insulin (good 53, suboptimal 45, and poor 2, as compared to 23, 14, and 63, respectively, $P < 0.001$) [Figure 5]. Two patients died; the causes of death were congestive cardiac failure and arrhythmia. Both had poor glycemic control.

Hospital stay was significantly reduced after introduction of the pathway (12.4 *vs* 8.4 days, $P < 0.005$). Episodes of hypoglycemia increased from 6 to 35% ($P < 0.01$). This is in concordance with the literature-hypoglycemia is more common when tight glycemic control is attempted.[11] Fortunately, the dangers are less as the patients are monitored in the hospital. All episodes were managed easily and no patient had severe hypoglycemia (i.e., glucose <40 mg / dl).

Conclusion

Control of diabetes mellitus is an important determinant of outcome in patients undergoing CABG.[12] Hyperglycemia has numerous adverse effects on the heart, including impairment of ischemic preconditioning, induction of cardiac myocyte death through apoptosis, and exaggeration of reperfusion cellular injury.

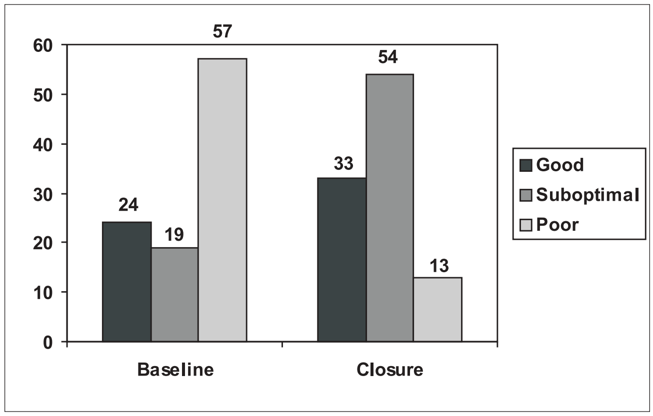

Figure 4: Glycemic control with IV insulin in baseline and closure audit

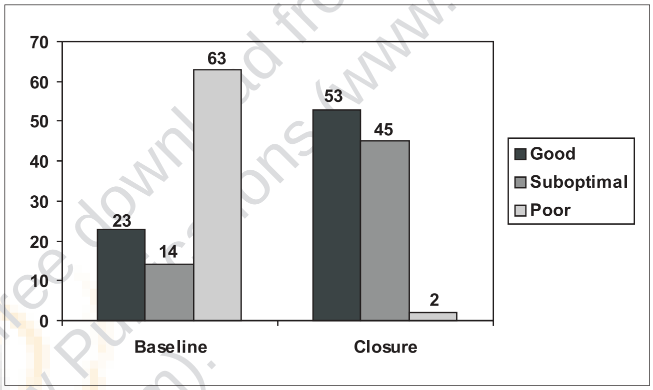

Figure 5: Glycemic control with SC insulin in baseline and closure audit

Hyperglycemia also is a prothrombotic state, with its related abnormalities like reduced plasma fibrinolytic and tissue plasminogen activity due to increase in plasminogen activator inhibitor pathway. These changes are more pronounced with higher glucose levels.[13] One proposed link between hyperglycemia and poor cardiovascular outcome is the effect of acute hyperglycemia on the vascular endothelium. Hyperglycemia may directly alter endothelial function by promoting chemical inactivation of nitric oxide and triggering production of reactive oxygen species (ROS).[14] The ROS are responsible for activation of transcriptional and growth factors that cause cell and tissue injury.

Suboptimal glycemic control is one of the avoidable causes of death and this may be a particularly important issue to address because the degree of hyperglycemia on the first postoperative day is significantly associated with adverse outcomes.[6] After adjusting for potential confounders, McAllister et al. found the risk is increased by 17% for every 18 mg increase in average blood glucose level above 100 mg / dl.[3] Furthermore, hyperglycemia can lead to dehydration, electrolyte disorders, and arrhythmias.[15]

Finally, hyperglycemia leads to various abnormalities that predispose to nosocomial infections, including delayed chemotaxis, diminished granulocyte adherence, impaired phagocytosis and reduced microbiocidal capacity.[16]

Thus, good glycemic control is undoubtedly beneficial after CABG. There are three barriers to achieving good control: the patient, the system and the care providers. In the current context, patients have a passive role and the health care system in institutions where CABG is done is, fortunately, well equipped for achieving good glycemic control. The stress response and the different medications used after CABG can increase insulin resistance and upset glycemic control, but the health-care providers will have to take major share of the responsibility for not achieving a good glycemic control. It is clear from our audit loop closure survey that the diabetes team's intervention in the management of patients undergoing CABG is helpful in improving glycemic control.

We conclude that a systematic plan for glycemic management is warranted for patients undergoing CABG or similar major surgery. Our data was presented at the hospital meeting and it has been decided to continue with the policy of involving the Diabetes and Endocrinology Department in patients' glycemic control after CABG or similar major cardiothoracic surgery. We have agreed to review the protocol at regular intervals to further improve glycemic control and reduce the frequency of hypoglycemia. Hopefully, this approach, in addition to improving the general quality of health care, will reduce the overall cost and mortality.

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