# Study of Intraoperative Tight Control of Blood Sugar Level in Patients Undergoing Off Pump Coronary Artery Bypass Grafting in View of Inotropic Requirement and Cardiac Index

**Pallavi D. Meshram[1], Sanjeevani Inamdar[2]**


## ABSTRACT

**Introduction**: Perioperative hyperglycemia can have detrimental effects on myocardial preservation in coronary revascularization procedures**.** Aim of this study was to compare effectiveness of tight control of blood sugar during off pump coronary artery bypass grafting in reducing myocardial damage and improve cardiac performance.
**Material and methods:** A prospective comparative study was done in 60 nondiabetic patients of age group 35-75 years of ASA grade II and III posted for off pump coronary arteries bypass grafting. Patients were randomized into Group I (30 patients) for tight control of blood sugar level (80-120 mg / dl) with the help of continuous insulin infusion protocol intraoperatively; up to 8 hrs. in postoperative period and Group II (30 patients) for conventional control of blood sugar level (200 mg/dl) with the help of insulin infusion, started when blood sugar level was more than 200 mg/dl. Blood sugar concentration measured with handheld glucometer half hourly. Cardiac indices were monitored every hourly till 8 hour postoperatively. Inotropic score was calculated in both the groups.
**Results**: Mean blood sugar level in group I was 115+/- 6.63 mg /dl and in group II was 191+/-45.49 mg/dl without any incidence of hypoglycemia. Mean insulin required for group I was 3.77+/-2.2 U and for group II was 2.27+/-0.87 U. The patients in group I had higher cardiac indices at all-time intervals which is statistically significant. At the end of 8 Hours cardiac index in group I was 3.78+/- 0.54 and in group II was 3.15+/- 0.74.% change in cardiac index from baseline in group I was 55.56% and in group II was 21.96%. The “p” value was 0.001 by “t” test which was highly significant. Comparison of inotropic scores revealed no statistical significance difference.
**Conclusion:** Hyperglycemia can be tightly controlled (80-120mg/dl) with insulin infusion protocols in non-diabetic patients undergoing off pump CABG. Tight glycemic control was having beneficial effects on contractile function of heart as revealed by significantly better cardiac indices and trend towards lesser need of inotropic support.


**Keywords:** Tight Glycemic Control, Coronary Artery Bypass Grafting, Glucose-Insulin- Potassium Infusion

## INTRODUCTION

Technological advances and fewer complications are advantages of myocardial revascularization without cardiopulmonary bypass [off pump coronary artery bypass (OPCAB).But patients remain to have unpredictable ischemic reperfusion damage to myocardium and impaired cardiac performances during OPCAB. This implies an ongoing need to develop strategies for myocardial protection during these procedures.

First time in 1962, Sodi-Pallares et al[1] showed in patients with acute myocardial infarction that infusion of glucose – insulin- potassium (GIK) reduces electromyographic signs of ischemia, reduces ventricular ectopy, limits infarct size & improves survival. Majority of the patients without diabetes have derangement of glucose metabolism due to surgical and anesthesia stresses perioperatively. Tight glycemic control in perioperative period especially with high dose insulin (hyperinsulinemic normoglycemic clamp) significantly decrease incidence of ventricular arrhythmias, less myocardial acidosis, better preservation of wall motion and decrease area of tissue necrosis in myocardium subjected to ischemia and reperfusion (2, 3, 4, 5).

These favorable results prompted us to study tight glycemic control with modified GIK regimen (Adopted from Gandhi et al Feb.2007)[6] in improving cardiovascular performance in OPCAB.

Aim of this study was to compare the effectiveness of intraoperative tight control of blood sugar (80 to 120 mg%) with that of conventional blood sugar (200 mg%) control in OPCAB in reducing myocardial damage and improving cardiac performance. Objectives of this study are to study effectiveness of tight glycemic control in view of,

1. Cardiac performance in the form of any improvement in cardiac index.
2. Inotropic requirement.

## MATERIAL AND METHODS

After institutional ethical committee approval, adults patients scheduled for elective primary myocardial revascularization without cardiopulmonary bypass were included in this prospective comparative, randomized control

[1]Assistant Professor, Department of Anaesthesia Government Dental College Nagpur Maharashtra, [2]Ex-Professor and Head, Department of Cardiovascular Anaesthesia, India

**Corresponding author:** Dr. Pallavi D. Meshram, Assistant Professor, Departmemt of Anaesthesia, Government Dental College Nagpur Maharashtra, India
**Address:** 310, Vishwakarma Nagar Nagpur Maharashtra, India

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study. Patients were randomly divided into two groups of 30 each.

**Group I: -n=30 (study group)**

These patients received continuous infusion of insulin (50 IU of Actrapid HM in 50 ml of 0.9% of normal saline) at rate of 2 IU/ hr with help of infusion pump started just after induction of anesthesia.

A separate infusion of 5% dextrose 500 ml with 80 meq of potassium chloride at rate 100 ml / hr started so as to avoid any hypoglycemia. Half hourly blood sugar estimation was done with hand held glucometer, and insulin infusion rate was then adjusted according to algorithm (TABLE 1) (adopted from Gandhi et al 2007)[6] so as to maintain blood sugar level between 80 to 120 mg/d. If previous 2 hrs trend was increasing blood sugar then infusion rate was increased accordingly from column 1 to column 2and then column 2 to column3.

When glucose level is < 80 mg/dl, insulin infusion is stopped &50ml/h of 10% dextrose infusion initiated. Glucose is checked every 30 minutes until glucose level is ≥80mg/dl then 10% dextrose infusion discontinued. Insulin infusion is restarted, always in COLUMN 1 of protocol.

**Group II: -n = 30 (Control Group)**

Patients in the conventional treatment group did not receiveinsulin during surgery unless their glucose levels exceeded200 mg/dl. If glucose concentration was between200 mg/ dl and 250 mg/dl, patients receivedan intravenous infusion of insulin starting with 2 ml/hr, then titrating infusion rate until theglucose concentration was around 200 mg/dl.If the intraoperative glucose concentration was greater than>250 mg/dl, patients received an intravenousinfusion of insulin at a rate, increased 50% to 100% of previous rate and continued until the glucose levelwas around 200 mg/dl.

A separate infusion of 5% dextrose 500 ml with 80 meq of potassium chloride at rate 100 ml / hr. started so as to avoid any hypoglycemia.

Insulin infusion & control of blood sugar were continued during post-operative period till patients were extubated from elective ventilation, in both study and control group or till 8 hrs. from induction time.

**Inclusion criteria**

a. Surgery under general anesthesia.
b. ASA status II and III
c. Age group 35 to 75 yrs.
d. Sex both male and female
e. weight 45 to 75 kg

**Exclusion criteria**

a. Patients with diabetes mellitus type I and II either on diabetic diet, oral hypoglycemic drugs or insulin
b. Patients with chronic renal failure with creatinine clearance > 2mg /ml
c. Patients with acute renal failure with urine output < 20 ml /kg /24 hr.
d. Patients with hepatic insufficiency with sr. bilirubin > 2.5 mg /ml, AST or ALT > 100 IU.
e. Patients with hyperkalemia serum Poassium >5.5 meq /L.
F. Patients with emergency CABG.
g. Redo CABG.
h. Combined CABG with any other cardiac procedure.

Patient under study underwent thorough preoperative assessment including detailed history, clinical examination & all necessary investigations including blood sugar profile so as to evaluate any unknown diabetes status and written informed consent is taken from each patients.

**Anesthetic technique**

Previously prescribed cardiovascularmedications were continued until thetime of operation. After premedication with midazolam 0.03mg/kg and fentanyl 1mcg/kg, pulmonary artery catheter was inserted through right internal jugular vein (CCOMBO- EDWARD LIFE SCIENCES). Standardized anesthetic and surgical managementprotocols were used in all patients and no interventions werewithheld during the study period. including the use of cardiopulmonarybypass.Major goals of hemodynamic management were tomaintain cardiac index greater than 2.2 $L/min^1/m^2$ and systolic blood pressure >100 mm of Hg; when afterload, preload and heart rate were optimized. Warmed lactated ringer saline and packed cells were used to replace fluid losses and maintainhemoglobin at 10 gm/dl. Following parameters were monitored - continuous cardiac output, ECG, pulse oxymeter, end tidal carbon dioxide, temperature (both surface and core temperature).

**Induction:** Induction of anesthesia was done with Thiopentone Na (3-5 mg/kg.) & fentanyl 25 to 50 µ/kgin titrated doses. Under direct laryngoscopic vision, tracheal intubation done after Vecuronium.

**Maintenance of Anaesthesia:-** Anesthesia was maintained on $O_2$ (50%) + $N_2O$ (50%) + Vecuronium as skeletal muscle relaxant + Sevoflurane as anesthetic agent + continuous infusion of Midazolam 1mg /hr + fentanyl 1to 2 µg/kg/hr + Intermittentpositive pressure ventilation.

Arterial blood samples obtained at ½ hrs interval during CABG to measure blood sugar concentration with hand held glucometer. Subsequent administration of insulin was given as per the protocol.After revascularization, all patients were transferredto the cardiac intensive care unit intubated.

**Parameters measured**

1) Glucose concentration was measured every ½ hourly intra operatively & hourly post operatively for 8 hrs.
2) Cardiac index (CI) was compared in both the groups with the help of continuous cardiac output monitor every hourly.
3) Inotropic agents were used to maintain cardiac index 2.2 $L/min/m^2$ Or higher and systolic blood pressure of 100 mm of Hg or higher in presence of central venous pressure 12 mm of Hg, pulmonary capillary wedge pressure of 14 mm of Hg and heart rate 70 to 100/min. For use of inotropic agents, an inotropic score was used to quantify the number of inotropes used, dosage & length of administration.

The score ranges from 0 to 5 where,

0 - No inotropic support or dopamine < 2 µg/kg/min
1- Inotropic support 2 µg /kg/min. or more for 24 hrs.
2 - Use of two inotropes.
3 - Use of epinephrine
4 – Use of three inotropes.
5 – Inotropic support for 24 hrs or more

## RESULTS

All patients were non diabetic, underwent off pump coronary artery bypass grafting (OPCAB). The two groups were demographically identical. (Table 2). The two groups were also comparable regarding h/o recent myocardial infarction (Recent M I), h/o congestive cardiac failure (CCF), h/o hypertension (HT), ejection fractions, number of coronary vessels involved and involvement of left anterior descending artery (LAD) > 50%. (table 2).

Both groups had similar baseline blood sugar level just after anesthetic induction. After induction glucose concentrations were lower in the intensive treatmentgroup than in theconventional treatment group at all-time intervals.At end of 8 hrs, mean blood sugar concentration in group I was 114 ±9.01 and in group II was 213 ± 10.65.'p' value was highly significant by't' test. (table 3). No patient in eithergroup developed hypoglycemia intraoperatively or postoperatively. Van Den Berghe and colleagues in 2001 reported incidence of hypoglycaemia to be 5% without significant sequalae, in their study of maintaining blood sugar level 80 to 110 mg /dl in critically ill patients[7] whereas that reported by Chaney et al. isin 40% of patients in the "tight control" group required treatment.[8] Several studies using a modified insulin clamp technique, reveal the safe and effective use of this treatment in cardiac surgical patients without hypoglycaemia with effective glycemic control.[9,10] Mean glucose levels were 115.50 ± 6.63 mg / dl in the intensive treatment group (group I) and191.62 ± 45.49 mg/dl in the conventionaltreatment group (group II). (table 3)

Maximum insulin required in group I was 9 U/ hr. and in group II was 3 U/hr. (table 5). Mean insulin required in Group I was 3.77 ± 2.2 IU at the end of eight hour and in Group II was 2.27 ± 0.78 IU at end of eight hour.'p' value was 0.001 which was highly significant.

Both groups started with similar cardiac indices. The patients in group I (tight sugar control) had higher cardiac indices at all-time intervals vs. cardiac indices of patients in group II (conventional sugar control). At end of 8 hrs. cardiac index in group I was 3.78 ± 0.54 and in group II was 3.15 ± 0.74.The 'p' value was 0.001 by't' test which

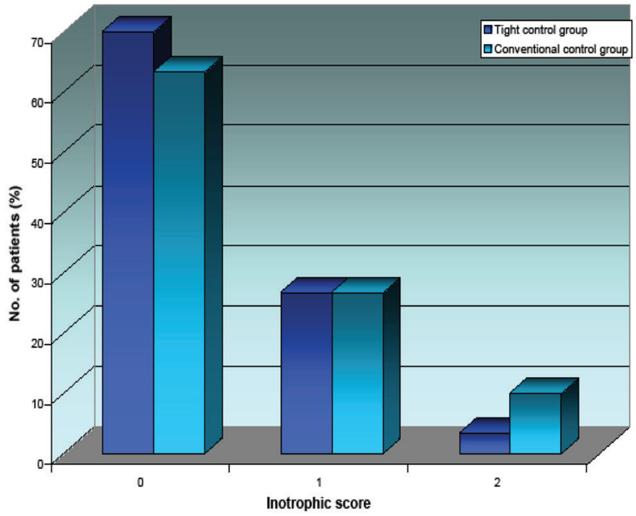


**Figure-1:** Comparison of inotropic score in both groups

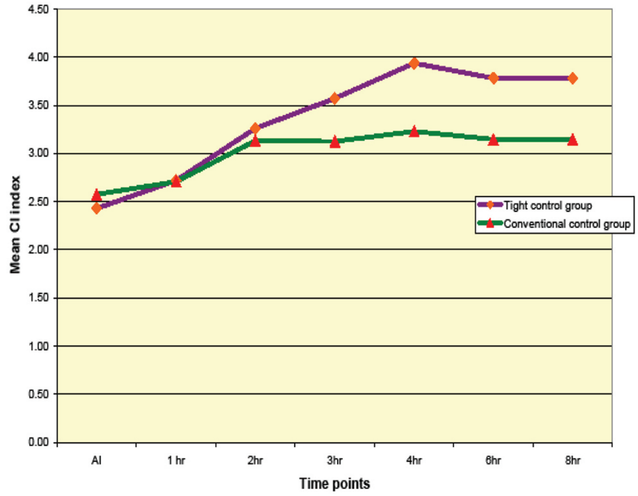


**Figure-2:** Comparison of cardiac index in both groups

| Column1 | | Column 2 | | Column 3 | |
|---|---|---|---|---|---|
| Serum Glucose Level, mg/dl | Insulin Infusion Rate, U/h | Serum Glucose Level, mg/dl | Insulin Infusion Rate, U/h | Serum Glucose Level, mg/dl | Insulin Infusion Rate, U/h |
| > 400 | 18 | > 400 | 25 | > 400 | 30 |
| 351-400 | 16 | 351-400 | 22 | 351-400 | 27 |
| 301-350 | 14 | 301-350 | 20 | 301-350 | 24 |
| 251-300 | 12 | 251-300 | 18 | 251-300 | 21 |
| 201-250 | 10 | 201-250 | 15 | 201-250 | 18 |
| 176-200 | 8 | 176-200 | 12 | 176-200 | 15 |
| 151-175 | 6 | 151-175 | 9 | 151-175 | 12 |
| 121-150 | 4 | 121-150 | 7 | 121-150 | 9 |
| 101-120 | 2 | 101-120 | 4 | 101-120 | 6 |
| 80-100 | 1 | 80-100 | 2 | 80-100 | 3 |
| <80 | Off | <80 | Off | <80 | Off |

**Table-1:** Insulin infusion protocol

| Parameter | | | P value | Significance |
|---|---|---|---|---|
| | Group I | Group II | | |
| Age | 60.60 9.78 | 60.23 ± 9.24 | 0.88 | NS |
| Weight | 61.93 ± 7.41 | 62.93 ± 6.49 | 0.58 | NS |
| Height | 156.13 ± 6.73 | 157.27 ± 6.60 | 0.51 | NS |
| BMI | 25.47 3.26 | 25.50 ± 2.79 | 0.96 | NS |
| Male | 23 (76.66 %) | 24 (80 %) | 0.754 | NS |
| Female | 7 (23.33 %) | 6 (20 %) | | |
| H/O recent MI < 90 days | | | | |
| Yes | 7 (23.33 %) | 6 (20 %) | 0.754 | NS |
| No | 23 (76.66 %) | 24 (80 %) | | |
| H/o CCF | | | | |
| Yes | 3 (10 %) | 3(10 %) | | NS |
| No | 27 (90 %) | 27 (90 %) | | NS |
| EF Gradation | | | | |
| Grade 1 > 60 | 8(26.66 %) | 8(26.66 %) | 0.73 | NS |
| Grade 2: 40-59 | 18 (60 %) | 18 (60 %) | | |
| Grade 3: 20-39 | 4(13.33 %) | 4(13.33 %) | | |
| No. of vessels involved | | | | |
| 1 | 9 (30 %) | 11(36.66 %) | 0.73 | NS |
| 2 | 7 (46.66 %) | 8 (36.66%) | | |
| 3 | 14(23.33 %) | 11(26.66%) | | |
| LAD > 50% lumen involved | | | | |
| Yes | 16(53.33 %) | 17(56.67 %) | 0.795 | NS |
| No | 14 (46.67 %) | 13 (43.33%) | | |

**Table-2:**

| Time points | BSL Mean ± SD | | Significance |
|---|---|---|---|
| | Tight controlgroup I | Conventional control group II | |
| After induction | 104.17±12.86 | 100.33± 12.55 | 0.25 |
| 1Hr | 119.80±13.45 | 164.23± 18.24 | 0.00 |
| 2Hrs | 119.60±14.96 | 202.37± 29.81 | 0.00 |
| 3Hrs | 122.03±20.12 | 207.53± 24.46 | 0.00 |
| 4 Hrs | 109.60±12.90 | 224.20± 18.78 | 0.00 |
| 6 Hrs | 119.13±14.91 | 229.63± 14.35 | 0.00 |
| 8 Hrs | 114.17±9.01 | 213.07± 10.65 | 0.00 |

**Table-3:**

| Time points | CI Mean ± SD | | Significance |
|---|---|---|---|
| | Tight controlgroup | Conventional control groups | |
| After induction | 2.43±0.46 | 2.58±0.61 | 0.30 |
| 1Hr | 2.72±0.53 | 2.71±0.57 | 0.93 |
| 2Hrs | 3.26±0.39 | 3.13±0.67 | 0.36 |
| 3Hrs | 3.57±0.50 | 3.13±0.56 | 0.001 |
| 4 Hrs | 3.94±0.53 | 3.23±0.64 | 0.001 |
| 6 Hrs | 3.78±0.58 | 3.15±0.63 | 0.001 |
| 8 Hrs | 3.78±0.54 | 3.15±0.74 | 0.001 |

**Table-5:**

is highly significant statistically.% change in cardiac index after induction in group I was 55.56% and in group II was 21.96%.The ‘p’ value was 0.001 by‘t’ test which was highly significant.(table 4).

Comparison of inotropic scores revealed no statistical significance as number of patients with inotropic score 0 were 21(70%) in group I and in group II were 19 (63.3%), with inotropic score 1 were 8 (26.7%) in group I and in group II were 8 (26.7%), and with inotropic score 2 was 1(3.3%) in group I and in group II were 3 (10%).(figure 2).The ‘p’ value was 0.351which was insignificant (table 26). The mean inotropic score in Group I was 0.33± 0.55 and in Group II

| Time points | Insulin Mean ± SD | | Significance |
|---|---|---|---|
| | Tight controlgroup | Conventional control groups | |
| After induction | 2.00±0.00 | 0.00±0.00 | - |
| 1Hr | 2.87±1.11 | 0.00±0.00 | - |
| 2Hrs | 2.90±1.27 | 0.97±1.16 | 0.001 |
| 3Hrs | 3.50±2.56 | 1.07±1.05 | 0.001 |
| 4 Hrs | 2.77±1.94 | 2.00±0.64 | 0.04 |
| 6 Hrs | 3.73±2.26 | 2.27±0.45 | 0.001 |
| 8 Hrs | 3.77±2.22 | 2.27±0.78 | 0.001 |

**Table-5:**

was 0.47 ± 0.68.But there is trend towards lesser need of inotropic agents with tight control of blood sugar than conventional control.

## DISSCUSION

Hyperglycemia in perioperative period is caused or exacerbated by surgical stress and anesthesia because of counter regulatory hormones. Acute hyperglycemia occurring intraoperatively abolishes ischemic preconditioning [11] and amplifies reperfusion injury to heart (12). During ischemia, glucose is preferred substrate for myocardium, but marked insulin resistance leads to hyperglycemia & impaired cellular uptake of glucose & increase FFA concentrate. Free fatty acids are detrimental to the ischemic myocardium because increased oxygen consumption required for metabolizing the new substrate (i.e. FFA).Hyperglycemia also leads to increased free radical release &increasing oxidative stress causing endothelial dysfunction which may affect myocardial ischemia.[13,14,15]

There are several mechanisms by which GIK solutions enhancethe performance of the ischemic myocardium.[16,17,18]

1. The increased supplyof adenosine triphosphate derived from glycolytic pathways helps to maintain cell membrane function andintegrity, which is critical to the preservation of myocytes, endothelial and vascular smooth muscle cells.
2. In patientswith coronary artery disease, GIK therapy resulted in a morefavorable oxygen supply/demand ratio by increasing arterialglucose uptake while decreasing free fatty acid levels. 3. Membrane stabilization and anti-arrhythmic effects.[7] Presumably, insulin improves the potassium uptakeof the myocyte reducing the incidence ofventricular arrhythmia.
4. Improved myocardial glycogen content enabling prolonged synthesis ofadenosine triphosphate and creatin triphosphate during anaerobicconditions.
5. Postoperative insulin resistance This can be reduced by using individually administered, high-dose insulin for maintaining euglycemia.
6. Reduction of free fatty acids (FFA) with its negative consequences.

In a retrospective observationalstudy of 409 patients undergoing cardiac surgery, Gandhiet al, found that a 20mg/dL increase in the mean intraoperativeglucose level was associated with increased postoperative mortalityand morbidity[19]. Ouattara et al demonstrated that adverse events afterCABG was 7.2% more likely in those patients with poorly controlledintraoperative blood glucose levels[20]

Benefits of GIK solution and tight glycemic control in cardiac surgical patients, we hypothesized that with tight control of blood sugar with a modified GIKinfusion during OPCAB would protect the heart from ischemic-reperfusiondamage resulting in improved cardiac performance.

In present study, the patients were randomly divided into two groups of 30 each. (TABLE1).

GROUP I- Tight control of blood sugar (80-120 mg /dl)

GROUP II- Conventional control of blood sugar (200 mg/dl)

All patients were non diabetic, underwent off pump coronary artery bypass grafting (OPCAB).

The two groups were demographically identical. The age, weight, height, BMI distribution were also statistically insignificant as shown in (table 2). The two groups were also comparable regarding certain baseline characteristics like h/o recent myocardial infarction (Recent M I) (table 2), h/o congestive cardiac failure (CCF) (table 5), h/o hypertension (HT) (table 2). Preoperative h/o drug intake like ACE inhibitors (angiotensine converting enzyme inhibitors), β blockers, diuretics, nitrates was also comparable in both groups.

Both groups were also comparable regarding ejection fractions, and number of coronary vessels involved and involvement of left anterior descending artery (LAD) > 50%. (table2).

Both groups had similar baseline blood sugar level just after anesthetic induction. Afterwards glucose levels were lower in the intensive treatmentgroup than in theconventional treatment group at all-time intervals.(table 3) At end of 8 hrs mean blood sugar concentration in group I was 114 ±9.01 and in group II was 213 ± 10.65.'p' value was highly significant by't' test. (table 3). No patient in eithergroup developed hypoglycemia intraoperatively or postoperatively. Van Den Berghe and colleagues in 2001 reported incidence of hypoglycaemia to be 5% without significant sequalae in their study of maintaining blood sugar level 80 to 110 mg / dl in critically ill patients[7]. Chaney et al. reported that 40% of patients in the "tight control" group required treatment for postoperative hypoglycaemia[8]. Similar study using a modified insulin clamp technique, s reveal the safe and

effective use of this treatment in cardiac surgical patients [10] without hypoglycaemia with effective glycemic control.
Mean glucose levels were 115.50 ± 6.63 mg / dl in the intensive treatment group (group I) and191.62 ± 45.49 mg/dl in the conventionaltreatment group (group II). (table3)
Maximum insulin required in group I was 9 U/ hr. and in group II was 3 U/hr. (table 5). Mean insulin required in Group I was 3.77 ± 2.2 IU at the end of eight hour and in Group II was 2.27 ± 0.78 IU at end of eight hour.'p' value was 0.001 which was highly significant. So to maintain the tight control of blood sugar intraoperatively insulin requirements are nearly doubled than conventional control.
Both groups started with similar cardiac indices, group I- 2.43 ±0.46 L/min /m$^2$ vs. group II -2.58 ±0.61 L/min/m$^2$.(table 4). The 'p' value was 0.30 by 't'test which was statistically not significant. The patients in group I (tight sugar control) had higher cardiac indices at all time intervals vs. cardiac indices of patients in group II (conventional sugar control). At end of 8 hrs.cardiac index in group I was 3.78 ± 0.54 and in group II was 3.15 ± 0.74.The 'p' value was 0.001 by't' test which is highly significant statistically.% change in cardiac index after induction in group I was 55.56% and in group II was 21.96%.The 'p' value was 0.001 by't' test which was highly significant.(table 4, figure 1).
Comparison of inotropic scores revealed no statistical significance as number of patients with inotropic score 0 were 21(70%) in group I and in group II were 19 (63.3%), with inotropic score 1 were 8 (26.7%) in group I and in group II were 8 (26.7%), and with inotropic score 2 was 1(3.3%) in group I and in group II were 3 (10%).(figure 2)The 'p' value was 0.351which was insignificant. The mean inotropic score in Group I was 0.33± 0.55 and in Group II was 0.47 ± 0.68. But there is trend towards lesser need of inotropic agents with tight control of blood sugar than conventional control.
Juha K. Koskenkari and colleagues (2005)[3] havedone study to evaluate the effects of high-dose insulin 1U /kg /hr. in 40 patients scheduled for combined aortic valvereplacement and coronary artery bypass surgery. The blood glucoselevels were maintained within a targeted range at 108 to 180 mg/ dl. There was lesser need for dobutaminesupport and a trend toward better cardiac indices('p' value =0.053).
In study done by Turki Albacker et al [5]have shown that high dose insulin therapy (hyperinsulinemic normoglycemic clamp) was cardio protective, high dose insulin group had lower troponin I level 4 hours postoperatively, with greater improvement in cardiac indices.
Harold L. Lazar and colleagues [16] study patients undergoing CABGwho were treated with glucose-insulin-potassium solution had higher cardiacindices (2.8 ± 0.1 vs. 2.0 ± 1 L/ min per squaremeter; $p< 0.001$), lower inotrope scores.David W. Quinn and colleagues[21] have done study to assess the role of GIK inproviding myocardial protection in nondiabetic patients undergoingcoronary artery surgery. The results were, the GIK group high higher cardiacindices throughout infusion and reduced vascularresistance. Inotropeswere required in 18.8% of the glucose-insulin-potassiumgroup and 40.8% of the placebo group.Fewer patients in the glucose-insulin-potassium group (12.3%) versus those in the placebo group (23.4%)had significant myocardial injury.
Harold L. Lazar and colleagues [9] did a study of effect of tightglycemic control in diabetic CABG patients which showed lower inotropic score GIK -1.18 ±0.06 vs. Standard therapy-2.16± 0.08.
The possible explanation to higher cardiac indices in group I than in group II but having similar inotropic scores in our study could be, as both groups received insulin infusion, cardiac indices were maintained above the critical value i.e. > 2.2 L/min/ m$^2$ and the protective effect was demonstrated in both group. As there was tight glycemic control in group I, the required amount of insulin was almost doubled in group I than in group II, so the cardiac indices were maintained at higher levels group I than in conventional control group i.e. group II. This has been shown by various studies which demonstrate the cardio protective effects of high dose insulin (hyperinsulinemic normoglycemic clamp)[4,5,6,15].

## CONCLUSION

1. There was considerable level of hyperglycemia in non-diabetic patients undergoing off pump CABG.
2. Blood sugar levels can be tightly controlled (80-120mg/ dl) with the help of separate and continuous insulin infusion protocol in non-diabetic patients undergoing off Pump CABG without inducing hypoglycemia as compared to conventional GIK drip.
3. Tight control pf bold sugar intraoperatively in off pump CABG patients was having beneficial effects on contractile function of heart as revealed by better cardiac indices in group I and group II.
4. Inotropic requirements and arterial and arterial pH were comparable in both the groups because both the groups were treated with inulin which causes early clearance of lactate, early shifting towards aerobic metabolism and better myocardial preservation.
5. There was no patient with wound gaping or sternal wound infection in either of two groups, again due to protective effects of insulin in controlling blood sugar.

## REFERENCES

1. D Sodi-Pallares, M R Testelli, B L Fishleder, A Bisteni, G A Medrano, C Friedland et al. Effects of an intravenous infusion of a potassium-glucose-insulin solution on the electrocardiographic signs of myocardial infarction. Am J cardiol.1962;9:166-81
2. George Carvalho, Ann Moore, Turki Al-Backer, Kevin Lachapelle Thomas Schricker. Cardioprotective effect of insulin and maintenance of normoglycemia. Canadian Journal of Anesthesia 2006;53;26481.
3. Juha K. Koskenkari, Paivi K.kaukoranta, Kai T. Kiviluoma, M J Pekka Ratikainen, Pasi P.ohtonen, Tero I. Ala-Kokko. Metabolic and haemodynamic effects of high dose insulin treatment in aortic valve and coronary surgry. Ann.Thoracic surg 2005;80:511-7
4. Turki Albacker, George Carvalho, Thomas Schricker, Kevin Lachapelle High-dose insulin therapy attenuates systemic inflammatory response in coronary artery bypass grafting patients. J.athoracsur. 2008;86:20-27

5. Turki B Albacker George Carvalho, Thomas Schricker, Kevin Lachapelle Myocardial protection during elective coronary artery bypass grafting using high-dose insulin therapy j.athoracsur. 2007;84:1920-1927
6. Gunjan Y. Gandhi, Gregory A. Nuttall, Martin D. Abel, Charles J. Mullany. Intensive Intraoperative Insulin Therapy versus Conventional Glucose Management during Cardiac Surgery. Annals of Internal Medicine 2007;146:233-43
7. G van den Berghe P Wouters, F Weekers, C Verwaest, F Bruyninckx, M Schetz et al. Intensive insulin therapy in critically ill patients NEJM 2006;354:449-61.
8. M. Chaney, M. Nikolov, M. Bakhos. Attempting to maintain normoglycemia during cardiopulmonary bypass with insulin may initiate postoperative hypoglycemia. Anesthesia and analgesia 1999;89:1091-5
9. Lazar HL, Chipkin SR, Fitzgerald CA, Bao Y, Cabral H, Apstein CS. Tight glycemic control in diabetic coronary artery bypass graft patients improves perioperative outcomes and decreases recurrent ischemic events. Circulation. 2004;109:1497–1502
10. Carr JM, Sellke FW, Fey M, Doyle MJ, Krempin JA, de la Torre R, Liddicoat JR. Implementing tight glucose control after coronary artery bypass surgery. Ann Thorac Surg. 2005;80:902–909
11. W G Toller, J R Kersten, P S Pagel, D C Warltier Ischemic preconditioning, myocardial stunning and anesthesia. Am J Physiology Heart 2000;278:H1218-24.
12. Subodh Verma Paul W M Fedak, Richard D Weisel, Jagdish Butany, Vivek Rao, Andrew Maitland et al Fundamentals of reperfusion injury for the clinical cardiologist. Circulation. 2002;105:2332–2336
13. E. Gross, J. LaDisa, J. Kersten Reactive oxygen species modulate coronary wall shear stress and endothelial function during hyperglycemia. American journal of physiology. Heart and circulatory physiology 2003;284:H1552-9.
14. Mária Zsófia Koltai, Pál Hadházy, Ildikó Pósa, Erzsébet Kocsis, Gábor Winkler, Peter Rösen et al. Characteristics of coronary endothelial dysfunction in experimental diabetes. Cardiovascular Research, Volume 1997;34:157–163
15. Michael N.Sack, Derek M.Yellon. Insulin therapy as an adjunct toreperfusion after acute coronary ischemia: A proposed direct myocardial cell survival effect independent of metabolic modulation Journal of the American College of Cardiology 2003; 41:1404-1407
16. Harold L.Lazar, George Philippides, Carmel Fitzgerald, Diane Lancaster, Richard J.Shemin, Carl Apstein. Glucose-insulin-potassium solutions enhance recovery after urgent coronary artery bypass grafting. The Journal of Thoracic and Cardiovascular Surgery 1997; 113:354-362
17. Harold L. Lazar. Enhanced Preservation of Acutely lschemic Myocardium Using Glucose-Insulin-Potassium Solutions. Journal of cardiac surgery 1994;9:474-478.
18. Lazar HL, Chipkin S, Philippides G, et al. Glucose-insulin-potassium solutions improve outcomes in diabetics who have coronary artery operations. Ann Thorac Surg. 2000;70: 145–150.
19. Gunjan Y.Gandhi, Gregory A. Nuttall, Martin D. Abel, Charles J. Mullany, MS Hartzell, V. Schaff et al. Intraoperative Hyperglycemia and Perioperative Outcomes in Cardiac Surgery Patients Mayo Clin Proc. 2005;80:862-6.
20. Alexandre Ouattara Patrick Lecomte, Yannick Le Manach, Marc Landi, Sophie Jacqueminet, Igor Platonov et al. Poor intraoperative blood glucose control is associated with a worsened hospital outcome after cardiac surgery in diabetic patients Anaesthesiology 2005;103:687-94.
21. David W. Quinn, Domenico Pagano, Robert S. Bonser Michael E. Lewis, Peter Nightingale. Improved myocardial protection during coronary artery surgery with glucose-insulin-potassium. Cardiopulmonary support and physiology. 2006;131:34-42.


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