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# Evaluation Of Glycemic Variabilities During Cardiopulmonary Bypass And Post-Op Complications

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**Abstract**

**Background:** Cardiopulmonary bypass (CPB) in a heart operation causes a severe metabolic stress, which brings about glucose homeostasis imbalances. These changes are referred to as glycemic variability and occur as a result of hypothermia, hemodilution, release of stress hormones and have also been linked to poor postoperative events such as infections, neurological events, and extended hospitalization period.

**Objective** To assess the intraoperative changes in glycemia during cardiopulmonary bypass and whether these changes are related to post-operative complication in patients undergoing cardiac surgery

**Methodology** The study was a prospective observational study that was undertaken on 323 adult patients undergoing elective cardiac surgery using CPB in tertiary care hospitals. Non-probability consecutive sampling was used. The level of blood glucose was checked at fixed CPB phases (pre, during and post-CPB). The information on demographic variables, intraoperative and postoperative outcomes were gathered. The statistical analysis was done using SPSS version 27.0 with descriptive statistics, repeated measures ANOVA, Pearson correlation and multivariate regression analysis with a p value of 0.05 level of significance

**Results** The average age of the study participant was 58.30 +- 10.20 years old and equal proportion of diabetic and non-diabetic patients was used. Notable changes in glycemia were noted in CPB especially in diabetic patients. Glycemic variability was significantly positively correlated with the postoperative complications such as atrial fibrillation, stroke, acute kidney injury, surgical site infections, and mortality and did not have a significant relationship with reoperation. In multivariate analysis, diabetes

mellitus was found to be an independent predictor of adverse outcome, but age and duration of CPB were insignificant predictors.
**Conclusion** Glycemic variability in CPB is an important predictor of postoperative complications among cardiac surgery patients. The high risk is especially in diabetic patients as there are more glucose fluctuations. It is important that effective intraoperative glucose monitoring and specific glycemic control interventions are built in order to reduce complications and enhance the outcome of surgery.

## Introduction

Cardiovascular surgery which employs the use of cardiopulmonary bypass (CPB) places a considerable metabolic burden on the patient. Under the extracorporeal circuit, the non-physiological flow conditions, haemodilution, hypothermia and rewarming phases, homeostatic mechanisms are put under stress. One of them, in particular, glucose regulation is the most susceptible the balance between insulin secretion, hepatic glucose production and peripheral consumption is disturbed, which results in significant glycemic swings [1]. In healthy physiological states the range of plasma glucose is maintained relatively low by insulin and counter-regulatory hormones to provide sufficient energy to cells and prevent hypoglycemic injury [2].
During CPB a mechanical pump and oxygenator keep the circulation of the patient going, and in most cases, the body is cooled to lower metabolic demands. The hemodilution and the state of hypothermia is accompanied by the release of stress hormones and administration of exogenous glucose, which in turn, form an environment of metabolic instability [3].The patients often have huge differences in blood glucose levels, including hyperglycemia and hypoglycemia. The most frequent metabolic change that occurs during CPB is hyperglycemia. It occurs mainly as a result of the activation of the stress response that causes secretion of cortisol, catecholamines and glucagon. The combined effect of these hormones is the increased production of hepatic glucose and the decrease in insulin sensitivity in peripheral tissues [4].
Hyperglycemia is further worsened by the fact that the dextrose-containing priming solutions used during the bypass circuit and the stress associated with surgical trauma compounds hyperglycemia. This high level of glucose may continue during the operation period and may even be prolonged to the early postoperative period. Increased blood glucose facilitates oxidative stresses and endothelial pathologies, which damage microcirculatory flow and oxygenation of tissues. Hyperglycemia also increases the release of the pro-inflammatory cytokines, which increases the risk of developing systemic inflammatory response syndrome. Intraoperative hyperglycemia patients have been clinically reported to have increased wound infections, kidney dysfunction, atrial fibrillation and extended mechanical ventilation [4].
Recovery and prolonged hospitalization following cardiac surgery may thus be postponed by the metabolic load that is caused by persistence of hyperglycemia. In order to combat such risks, intraoperative glucose control protocols have been embraced by most institutions. Insulin therapy is the most prevalent measure used to achieve glucose levels at a safe range through the administration of insulin therapy by infusion pump. Tight glycemic control has shown to have certain advantages in the prevention of postoperative complications, it is accompanied by the emergence of new risks. Inappropriate use of insulin the excessive administration may result in hypoglycemia which is just as deadly as hyperglycemia [5].
The clinical difficulty does not only consist in the decrease of high glucose levels, but dangerous fluctuations also should be prevented. Hypoglycemia during CPB is a serious issue although it is less common than hyperglycemia. It may happen as an overcorrection using insulin or it may happen following a reduction in hepatic glucose production under hypothermia conditions. The glucose regulation is further complicated by hemodilution and low metabolic rate. Hypoglycemia is particularly

dangerous as its signs and symptoms are not obvious during the condition of anesthesia and thus it is hard to detect it. Hypoglycemia that remains unnoticed during the surgery can result in cognitive and neurological damage as well as high mortality [6].

Neurological outcomes affected by intraoperative hypoglycemia are usually poor in patients with vulnerable conditions like children and the elderly. The presence of low glucose prevents cerebral metabolism and can cause ischemic damage. Moreover, stress-related glucose variation may occur during the process of rewarming following CPB, which increases the threat of metabolic imbalance [7]. Therefore, the prevention of hypoglycemia has become as important as the glycemic maintenance of hyperglycemia. Glycemic variability is indicative of the unstable glucose metabolism in and after the surgery and has been directly linked with negative outcomes. Glucose variability is linked with longer ICU stay, and higher incidence of arrhythmias in non-diabetic patient. The average glucose concentration is within the target levels, large gaps between hyper- and hypoglycemia may elevate the level of oxidative stress, suppress immune activity. The reduced glucose variability has become the new therapeutic target in the management of CPB [8].

Intraoperative glucose testing has become a practical approach due to the developments made in this field. Once used in the care of diabetic patients, continuous glucose monitoring systems are now being applied in the operating room. These systems give real time feedback to clinicians enabling real time insulin changes and preventing glucose excursions [9]. Continuous technological advancement is geared towards making these monitoring equipment part of the normal cardiac surgical practice. Studies support keeping glucose under 180mg/dl in order to decrease the risk of infection whereas others propose more liberal levels to prevent hypoglycemia. Age, comorbid diabetes, nutritional condition, and period of bypass are some of the factors that affect the dynamics of glucose. Individualized glycemic management guidelines with self-monitoring and insulin dosage are becoming the new frontier in perioperative metabolic care [10].

The implication of glucose change during CPB is extended to general areas of cardiac surgery outcome. The inflammatory markers, myocardial protection, and rapid postoperative recovery have been linked to stable glycemic regulation. Undetected glucose imbalance may worsen ischemia-reperfusion lesion, weaken immunity, and predispose individuals to arrhythmia [5]. Therefore, accurate metabolic control in the course of CPB is not a biochemical objective but also a mainstay of patient safety and surgical outcome.

Perfusionist also has a major role in the preservation of physiological homeostasis in cardiopulmonary bypass (CPB), especially in the regulation of dynamics of perfusion that directly impact the glycemic homeostasis. The non-physiological flow of artificial circulation that is employed in the CPB process is only temporary in the place of the heart and lungs, yet the metabolic balance in the body is considerably disturbed by the non-physiological flow, hemodilution, and temperature changes. These causes provoke hormonal and inflammatory reactions resulting in alterations of the blood sugar level. These metabolic disturbances can be reduced by effective perfusion management, by having an accurate control of blood flow, oxygen delivery, temperature variations and glucose injection [11]. The work of the perfusionist is no longer mechanical circulation but active metabolic regulation of the conditions that provide optimal perfusion of tissues and normal glucose concentration.

Intervention of cardiac surgery with cardiopulmonary bypass support imposes a significant shock on the metabolic regulation in the body by replacing physiological circulation provision with an artificial extra-corporal circulation. The cessation of pulsatile blood flow, shear force changes and redistribution of perfusion during the CPB conditions disrupt endocrine and cellular processes involved in glucose homeostasis. These non-physiological disorders disrupt the insulin signaling pathways

and glucose transporter functions and lead to diminished peripheral glucose uptake and increased insulin resistance. The same change of metabolism has been noticed in the patients with already established diabetes, as well as in non-diabetic patients who have maintained a normal metabolism of glucose, which suggests that CPB itself is a potent and independent metabolic stressor. Glucose instability is also further worsened by the inflammatory response that is triggered during extracorporeal circulation. Interaction of blood and artificial surfaces of the bypass circuit triggers leukocytes, complement and cytokine release all of which lead to acute insulin resistance. The pro-inflammatory agents disrupt the activity of the pancreatic b- cell and inhibit the use of insulin in the uptake of glucose in the tissues [12].

Hormonal stimulation caused by stress stimulates the gluconeogenesis process in the liver resulting in excessive production of endogenous glucose. This interaction between inflammation and hormonal imbalance forms a very unstable metabolic state that carries into the bypass, and possibly, the after surgery [13]. Rewarming of cardiopulmonary bypass has become a very susceptible phase of metabolism. In this transition, the temperature changes rapidly which is linked with sudden changes in insulin sensitivity and glucose kinetics. It has been indicated that glucose instability during the time of rewarming is highly correlated with poor neurological outcomes in the form of postoperative delirium and cognitive impairment. The brain is particularly susceptible to changes in the availability of glucose, and even brief period of metabolic instability during anesthesia can cause cerebral energy deficits, especially in the populations of elderly and high-risk patients [14, 15].

Continuous glucose monitoring systems have been shown to be more sensitive in the detection of rapid glucose excursions and unrecognized hypoglycemic events in comparison to intermittent blood sampling. This is very necessary especially in anesthesia where hypoglycemia is concealed by some of its clinical signs. Real-time glucose trend data allows clinicians to tune up insulin therapy instead of turning down, which minimizes the risk of severe slow and fast glycemic events and improves the ease with which metabolic regulation is achieved during cardiopulmonary bypass support [16]. In this new clinical paradigm, the functions of the perfusionist have gone beyond preserving the circulatory mechanics. The parameters of perfusion that have a direct effect on the metabolic maintenance are blood flow rates, oxygen delivery, temperatures, and the composition of priming of the circuit. It has been found that optimized perfusion measures can reduce the release of stress hormones, decrease the activation of inflammatory processes, and decrease the fluctuation in glucose [17]. The perfusionist has thus become an important factor in metabolic control which leads to protection of tissues and better outcome of surgery under CPB.

The study aims at assessing the glucose changes dynamics during cardiopulmonary bypass (CPB) and examining its clinical implications. The research study will measure the degree of glycemic changes and their influence on the outcome following surgery through tracking of blood glucose levels at certain CPB phases, including initiation, maintenance and rewarming. The study will achieve this by determining the probability and the severity of intraoperative hypoglycemia and hyperglycemia to derive evidence based recommendations on the best intraoperative glucose management. Finally, the results should be useful in enhancing more effective and safer metabolic management protocols in cardiac surgery and hence, enhance the recovery and reduce post-operative complications.

## LITERATURE REVIEW

Gucose has increased during the initiation of CPB as a result of hemodilution, catecholamine discharge, and insulin resistance, where hyperglycemia surpassed 200mg/dl in more than 3,428 percent of the patients [18]. Hypothermia intraoperative conditions augment insulin resistance whereas hemodilution decreases plasma insulin level. But, in the course of rewarming, some patients are prone to hypoglycemia due

to a paradoxical rise in glucose metabolism [19]. Hyperglycemia, (over 200mg/dl) and hypoglycemia (below 70mg/dl) were separately correlated with postoperative cognitive dysfunction, which indicates that glucose extremes negatively affect cerebral autoregulation [20]. The role of insulin resistance, and variability in cerebral perfusion as factors that cause neuronal damage in both diabetic and non-diabetic cardiac patients. Hyperglycemia in CPB has always been associated with bad postoperative outcomes [21].30% cardiac surgery patients and discovered that glucose levels higher than 180mg/dL during bypass were associated with a high risk of wound and renal dysfunction [22]. Aggressive insulin therapy, although good at decreasing hyperglycemia, is a paradoxical therapy that can predispose patients to more neurological damage and hypoglycemia [23].

Moderate glucose control (target 120-180 mg/dL) resulted in fewer complications and improved neurological outcomes as compared to strict control (90-120mg/dL) [24]. Hypoglycemia during CPB is not as frequent, but it is also detrimental. According to the study, it was found that the number of patients developing postoperative delirium increased significantly in cases of intraoperative glucose below 70mg/dL [25]. Their statistics showed that even temporary hypoglycemia will lead to sympathetic reactions and cerebral vasoconstriction.Hypoglycemia was more common at the rewarming phase, especially among patients under high-dose insulin infusions, and hence the need to stick to continuous glucose monitoring at all stages of CPB [26].Some of the recent reports stress the significance of dynamic glucose monitoring and protocol-based insulin therapy in CPB.The use of the continuous insulin infusion guided by the real-time glucose sensors. The strategies decrease the number of hyper- and hypoglycemic events when compared to intermittent sampling [16].

Automated insulin delivery systems, have been proven to be better stable in the management of blood glucose during the extended cardiac procedures [27].The papers considered all emphasize that glycemic variability in CPB is complex as it is caused by metabolic stress, hypothermia, hemodilution, and inflammatory mediators. Nevertheless, there is still unanimity on the optimal glucose target. In addition, numerous studies consider diabetic cohorts, and there is a paucity of information on the non-diabetic patients. The further problem that makes direct comparison more difficult is that methodological diversity takes in the form of retrospective analyses or even heterogeneous RCT protocols.

Increased atrial fibrillation postoperative and longer intensive care unit (ICU) stay was attributed to glucose variability during the cardiopulmonary bypass (CPB) [28]. These results highlighted the fact that clinical outcomes are better reflected by intraoperative glucose changes, as opposed to fixed values. Targeted hypoglycemia and even short episodes of hypoglycemia (under 70mg/dl) had a significant effect with mortality and morbidity[29]. The authors emphasized the fact that the metabolic acceleration of rewarming increases insulin sensitivity, which puts patients at a risk of hypoglycemia unless glucose supplementation is intelligently adjusted.

Moderate and tight glucose control (<110 mg/dL) in patients undergoing cardiac surgery. Their collapsed findings showed that although tight control marginally decreased the risk of infection, it increased the cases of hypoglycemia two times, which did not lead to an overall better outcome in terms of mortality or neurological outcome [30]. Therefore, in the current cardiac anesthetic practice, moderate glucose targets (120-150 mg/dL) are now mostly favored.Improved interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-a) during CPB were associated with the severity of hyperglycemia and insulin resistance [31]. Their analysis has highlighted the fact that metabolic and inflammatory processes are mutually dependent and the cytokine surge during CPB increases the problem of glucose imbalance regardless of diabetic status.Continuous glucose sensors built onto CPB circuits, they were found to be more accurate and there was shorter response time than what was seen with standard intermittent testing which enabled anesthesiologists to adjust insulin and dextrose

infusion in real time [32]. Nair BG et al., 2016 study shows that continuous glucose monitoring (CGM) has thus become an encouraging system towards having optimal intraoperative control without undue hypoglycemia risk. Study have noted that intraoperative corticosteroid administration, which is usually used to alleviate inflammatory reactions, also increased hyperglycemia [33].

Metabolic effect of steroids versus the anti-inflammatory effect of steroids is one of the unresolved problems of perfusion medicine [34]. Hyperglycemia during CPB is not just a metabolic response to surgical stress but is also the result of altered insulin receptor sensitivity because of hypothermia, hemodilution, and non-pulsatile perfusion The temperature modulation during CPB also has an important role in glucose homeostasis [35]. These physiological changes make intraoperative glucose management very difficult and require real-time monitoring. During insulin infusion algorithms tailored to CPB stages, postoperative complications were significantly reduced, supporting the need for individualized glycemic control strategies [36]. On-pump CPB patients experienced greater glucose fluctuations owing to altered hepatic perfusion and stress hormone responses [37]. These findings suggest that physiological stress secondary to bypass contributes more to dysglycemia than surgical trauma.

Closed-loop system maintained glucose levels more consistently within a target range and reduced both hyper- and hypoglycemic episodes. Results underpin the potential of automated glucose control technology in cardiac operating theatres [38]. Less variable glucose levels were found among patients receiving volatile anesthetics compared to those receiving total intravenous anesthesia, indicating an additional role of anesthetic modulation in metabolic stability. The correlation between lactate in blood and glucose changes, observing that during CPB, hyperglycemia is often accompanied by hyperlactatemia, suggesting metabolic imbalance and potential tissue hypoxia [39].

High intraoperative glycemic variability during CPB was a more significant predictor of death, postoperative infections, and neurological events compared to the mean glucose concentration [40]. This pioneer piece of research highlighted that the cause of postoperative complication is dynamic alteration in glucose metabolism, and not a solitary hyperglycemia, which is an important contribution to our knowledge on metabolic instability in cardiac surgery. Study evaluated the performance of continuous glucose monitoring (CGM) systems and arterial glucose sampling in intermittent intervals during the CPB. CGM was more accurate and provided the opportunity to change insulin in real-time, which significantly decreased hyperglycemic and hypoglycemic events [41].

Clinical possibilities of combining continuous glucose sensors in perfusion circuits with the goal of attaining constant glycemic regulation without adding to the monitoring burdens. The interaction between inflammation and glycemic dysregulation is also a topic that has been studied over the past several years. High levels of glucose in CPB directly correlated with high levels of pro-inflammatory cytokines interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-a) instability of the metabolism supports the relevance of the temperature-adjusted insulin regimes to ensure the normalization of glucose levels in the safe range during all the bypass phases. The moderate glucose control has remained supported by comparative. The connection between the fluctuation of intraoperative glucose and postoperative atrial fibrillation and found that variability, rather than average glucose level was a strong predictor of postoperative arrhythmia and extended intensive care [42]. Glucose variations during the short term exert a direct arrhythmogenic and inflammatory outcome on the myocardium when exposed to cardiac surgical procedures. AI-assisted closed-loop insulin delivery system that could be used during an operation and constantly adjusted insulin infusion rates depending on real-time glucose levels. In their study, they found that this automated system decreased hyperglycemic events and hypoglycemic events as compared to the traditional manual procedures [43].

These findings highlight the possibility of artificial intelligence as a way of enhancing perioperative metabolic regulation and patient safety in CPB. Besides the level of glucose, the lactate metabolism has also become a counterpart of metabolic stress.

The high lactate levels during CPB were closely associated with hyperglycemia and the absence of efficiency in perfusion. It is a postulation that the joint study of glucose and lactate dynamics can give a better analysis of the tissue oxygenation and metabolic sufficiency during bypass. Lastly, non-diabetic patients have been highlighted that have been found to have significant glycemic excursions during CPB [44].The acceptable level of the mean glucose, rapid intraoperative changes in glucose were independently related to long mechanical ventilation and slow ICU discharge. Their results indicated that variability is indicative of physiological instability in bypass, and not just of lack of glucose control [45]. The cerebral metabolism of CPB and found that patients with a wide glucose oscillation portrayed poor cerebral oxygen uptake ratios. The authors hypothesized that variable glucose supply interferes with neuronal energy metabolism, and, thus, exposes the brain to postoperative neurocognitive dysfunction [46].

Large observational cohort, patients whose intraoperative glycemic variability was high had higher rates of acute kidney injury significantly. They have shown that renal microcirculation is very vulnerable to metabolic instability especially under conditions of non-pulsatile perfusion, and therefore, glucose fluctuation is a vital factor of renal dysfunction [47]. Significant glucose variations during CPB were linked to postoperative atrial arrhythmias and the necessity to receive inotropic support. They came to the conclusion that the myocardial substrate use proves to be ineffective when subjected to intermittent hyperglycemic and hypoglycemic conditions, which causes electrical instability [48]. The levels of inflammatory markers with the glucose profiles and concluded that patients with higher glycemic variability had much higher inflammatory mediators after the operation. Their study underlined the fact that glucose oscillations increase the release of the inflammatory cascade triggered by CPB, which aggravates endothelial damage and capillary break [49].

The group of patients exhibited unanticipated and significant glucose variability intraoperatively. Interestingly, the complication rates amongst these patients were similar to diabetic patients, which implied that stress-induced dysglycemia is also an independent prognostic factor irrespective of the initial glycemic state [50].The variability of intraoperative glucose was a more predictive variable of postoperative infection than the average concentration of glucose. Their results stressed the fact that the immune dysfunction is more associated with glucose instability than with isolated hyperglycemia [18]. The changes in the liver blood flow played a vital part of the unpredictable glucose release and insulin clearance. This research supported the idea of metabolic dysregulation as a result of CPB-associated physiological alterations and not necessary surgical trauma alone [35]. Decrease in extreme glucose excursions with the use of continuous monitoring. The authors pointed out that timely use of therapeutic interventions was possible because of early detection of trends, but not point values [51]. Automated insulin modulation during CPB and discovered that algorithm-controlled insulin administration decreased the variability of glucose and did not increase cases of hypoglycemia. Their paper justified the increasing importance of technology-based metabolic control in cardiac surgery [52].

The correlation between the postoperative length of stay and glycemic variability. Their findings revealed that unstable intraoperative glucose patterns resulted in patients having a longer ICU and hospital stay; hence, delayed physiological recovery [53]. The concept of glycemic variability was supposed to be viewed as a surrogate indicator of systemic stress in CPB. They contended that the use of numeric glucose targets only does not consider the dynamic metabolic variations that take place during bypass, and constrained the usefulness of existing glucose management approaches

[54]The intraoperative glucose dynamics in patients undergoing a lengthy period of cardiopulmonary bypass and found that the larger the glucose excursion, the higher the postoperative vasopressor needs. Their results indicated the possibility of glycemic instability to indicate compromised vascular responsiveness during bypass [55]. The variability of glucose levels during CPB was associated with endothelial activation, which suggests that a changing glucose level may cause direct harm to vascular endothelium and be linked to postoperative capillary leak syndrome [56].

In the absence of any actual ischemic events, patients exposed to rapid glucose changes during CPB experienced a substantially high postoperative troponin level. This implied subclinical myocardial metabolic stress-induced injury [57]. Old cardiac surgery patients and found out that glycemic variability was significantly linked to postoperative delirium among patients. Their results have pointed to the fact that aging brain is most susceptible to metabolic instability [58].The variability in intraoperative glucose was linked with the duration of stay in the ICU and the nursing workload. The authors hypothesized that postoperative critical care management is complicated by a metabolic instability [59]. Glucose variation in CPB was connected with the change in platelet reactivity and the tendencies to postoperative bleeding. This paper identified a potential correlation between variations in glucose and coagulation disequilibrium [60].

Excessive glucose variations were linked to slow wound recovery and shallow sternal infections. They proposed that tissue repair processes were disrupted by the immune cell malfunction caused by the metabolic instability [61]. The stress markers of metabolic processes and came to the conclusion that the fluctuations in glucose were associated with high levels of cortisol and catecholamine, indicating the notion that glucose changes are the indicators of the severity of stress reaction during surgery [62]. The glycemic variability in patients undergoing complex valve surgeries was higher than in isolated CABG operations showing that surgical complexity affects the metabolic control of bypass [63]. Postoperative infection rates and discovered that the variability of glucose was more predictive of sepsis than the mean values of glucose. They have found evidence of the importance of metabolic swings in immune dysregulation [64].Patients with a high intraoperative glucose variability demonstrated early increases in neutrophil gelatinase-associated lipocalin, which is the indication of subclinical renal injury [65]. Glucose fluctuations enhanced pro-inflammatory transcription pathways during CPB which reinforced the relationship between metabolic and inflammatory stress [66].

Author determine that glucose variability was linked with the long length of stay in the hospital irrespective of diabetic condition. In their analysis, the variability of glucose was supported as a universal perioperative risk marker [67]. In patients with unstable intraoperative glucose profiles. The authors proposed that synaptic recovery is damaged by repeated metabolic insults [68]. Myocardial metabolism with biochemical markers and found out that the use of substrates in patients with variable glucose levels was inefficient and this predisposed them to postoperative cardiac dysfunction [69]. More glucose changes in female patients undergoing CPB and more susceptibility to postoperative complications, which also suggests the presence of sex-specific metabolic responses [70]. Variability of glucose rose in the periods of rewarming and insisted that the phase-specific insulin adjustments, instead of the uniform infusion plans, were necessary [26]. Outcomes of arrhythmia and found that glucose variability was a more effective predictor of postoperative atrial fibrillation than electrolyte imbalance or length of the operation [71].

Artificial intelligence-based insulin algorithms with predictive glucose control and discovered that the variation and postoperative complications were lower than when clinician-based protocols are used [72]. Glycemic variability during CPB to be an independent predictor of readmission within 30 days, indicating that there are long-term implications of perioperative metabolic variability [73].

Glucose variability and microcirculatory perfusion by taking sublingual microvascular images. Their results revealed that there is a decreased capillary density of the patients with significant glycemic excursions, which suggest impaired tissue perfusion during bypass [74]. The hepatic function in the postoperative period and revealed that glycemic variability during CPB was linked to the temporary increase in liver enzymes. The hypothesis put forward in the study was that postoperative metabolic imbalance is attributed to altered hepatic glucose handling during bypass [75]. Patients with great intraoperative variations in glucose levels exhibited much higher postoperative scores in terms of inflammatory outcomes, although the cardiopulmonary bypass duration was equal. This implied that irregular metabolism enhances the effect of inflammatory reactions regardless of the period of surgery [76]. Greater variability in glucose levels was associated with high blood product consumption. In their analysis, they indicated the possibility of connection between dysglycemia, coagulation disturbance, and bleeding risk [77].

Patients who were subjected to profound glucose fluctuations during CPB had lower functional capacity three months later. This underscored the fact that intraoperative metabolic instability could have had long-term effects after hospital discharge [78]. Non-diabetic groups, and it was found that glycemic variability induced by stress was not adequately perceived in such patients, although very much linked with postoperative complications. The authors highlighted the issue of universal glucose monitoring irrespective of whether or not one is diabetic [79]. Patients with unstable glucose patterns, the levels of neuron-specific enolase are elevated, which argues in favor of subclinical neuronal injuries during bypass [80]. Lymphocyte activities of patients with excessive glucose variability were suppressed. The discovery offered a mechanistic reason as to why they were more prone to infections [81].Surgical trauma was lower, glycemic variability in a strong predictor of complications, which supported the prevailing importance of bypass-related physiology [48]. Postoperative respiratory outcome and found that the glycemic variability correlates with the highest postoperative pneumonia and the weaning off the ventilatory support [82]. Myocardial recovery parameters and discovered that cardiac enzymes took the longest time to normalize in patients with unstable glucose levels, which indicated a long period of myocardial stress [83].

Intraoperative glucose fluctuations were more importantly linked with postoperative mortality, infections, and neurological events as compared to mean glucose concentration. This change of emphasis shows the need to understand the dynamics of glucose instead of using only the values of glycemic thresholds that are not dynamic. The mechanisms responsible behind the glycemic variability in CPB are multifactorial [84]. Changes in hepatic perfusion during bypass significance, which contributes to the unpredictable release of glucose and insulin metabolism, support the idea that a physiological change rather than a surgical trauma is the primary cause of metabolic disregulation. The glucose instability is further enhanced by inflammation in CPB [85].Glucose oscillation increases the expression of pro-inflammatory genes, which worsen the endothelial dysfunction and capillary permeability. Glycemic variability has been demonstrated to be of particular sensitivity in regard to neurological outcomes [86]. Patients with large glucose swings during CPB exhibited a poor cerebral oxygen use, in spite of apparent ischemia [87].

Large glycemic variability during CPB was linked to the development of postoperative atrial arrhythmias and the need to use a greater amount of inotropic support [48]. Micro-cardiac substrate is ineffective in the presence of alternating hyperglycemia and hypoglycemia which put patients at risk of post-operative cardiac dysfunction [1]. High intraoperative glycemic variability was independently linked to higher occurrence of acute kidney injury [88]. Initial rise of renal biomarkers in patients with significant glucose excursions indicating the presence of subclinical renal impairment before dysfunction. The findings of these observations show that the

renal microcirculation is highly susceptible to changes in metabolism in cases of non-pulsatile perfusion. Notably, diabetic populations are not the only ones where glycemic variability is involved [89].In non-diabetic patients having on-pump cardiac surgery, the variability of intraoperative glucose levels was significant and the rates of complication were equal to those in diabetic patients [84]. Stress-related dysglycemia among non-diabetic patients has not been properly identified despite its close relationship with postoperative morbidity. The findings oppose the traditional approaches to glucose control and reinforce the idea of universal intraoperative glucose monitoring [90].

Tight glucose control did not lead to better overall mortality and neurological outcomes but reduced infection rates with a significant number of hypoglycemic episodes. As a result, less extreme glucose goals that reduce the variability rather than forceful reduction of glucose levels have become popular in the modern practice of cardiac anesthesia [91]. The use of technology has enhanced the capability of controlling glycemic variability in CPB greatly. Continuous glucose monitoring (CGM) is more accurate and can be used to adjust insulin in real-time, which leads to the reduction of glycemic excursions [92]. AI-assisted closed-loop insulin delivery systems are more successful than clinician-directed protocols in terms of the reduction of both hyperglycemic and hypoglycemic events. These inventions aid stage-specific and personalized glycemic management measures throughout CPB [93]. Retrospective and only concentrate on the individual outcomes and not the entire, multi-organ postoperative recovery. In addition, there is a lack of prospective data that assesses the variability of glucose in all CPB phases, especially in non-diabetic groups [59].

Intraoperative glucose variations were a surrogate indicator of global physiological stress, which combines the stimulation of the neurohormonal system, the inflammatory load, adequacy of perfusion, and the modulation of temperature. According to this conceptual framework, glycemic variability is an indicator of overall adaptability of the patient to the stress experienced due to CPB and not just glucose management weakness [4].

Glucose fluctuations during CPB track changes in cortisol and catecholamine concentration closely meaning that glucose variation is a reflection of how intense the surgical stress response is [1]. Patients with comparable CPB times had significantly varied inflammatory responses based on the extent of intraoperative glucose instability. This evidence helps reinforce the idea that the effect of CPB in relation to the length of the procedure is increased by glycemic variability [76]. The relationship between glycemic variability and microcirculatory perfusion has also been studied recently.A decreased capillary density and the heterogeneity of the flow in patients with marked glucose excursions in CPB. Systemic hemodynamics could not explain these microcirculatory disturbances, indicating a direct metabolic effect on the endothelial and capillary activity [94]. The mechanistic connection between metabolic instability and vascular injury by reporting endothelial activation as a response to oscillating glucose levels. Glycemic variability prognostic value has extended even beyond immediate postoperative outcomes [95].

Glucose dynamics during CPB were linked to the disturbances in platelet reactivation and high tendencies of postoperative bleeding [96]. Older patients are more prone to the development of neurocognitive complications associated with glucose, which is probably caused by lower cerebral metabolic reserve [97]. Insulin algorithms developed using artificial intelligence are more effective than traditional clinician-managed protocols because they predict the glucose patterns instead of responding to the threshold violations [98]. Predictive modeling will allow a more fluent glucose course and reduce the unforeseen changes in metabolism. These treatments are a paradigm shift between reactive glucose control and proactive metabolic control [99]. Rapid changes in glucose levels postoperative cardiac biomarkers were already high,

which pointed to inherent metabolic myocardial stress [100]. Timely intervention provided by early detecting the glucose trends will prevent the severe excursions of glucose instead of treating them after the fact [101]. Combined, these results indicate the need to incorporate the notion of continuous glucose analytics into the daily CPB management.

## MATERIAL AND METHODS

### Study Design:

This was a prospective study to evaluate the variations in blood glucose levels.

### Settings:

The study was conducted in the **Department of Cardiac Surgery, of** tertiary care cardiac
(Doctors hospital, Omer hospital & Cardiac center) center routinely performing heart surgeries using cardiopulmonary bypass.

### Duration of Study:

The total duration of the study was four **months**, commencing after the approval of the synopsis.

### Sample Size:

The sample size was **323.**
For sufficient sample to do the study, Cochran one-proportion sample size equation was used based on the ratio that was expected, the level of confidence and the level of error.

$$\boldsymbol{n = \frac{Z_1 - {a}/{2}\; p(p-1)}{d_2}}$$

Z1−α/2= Z for desired CI (1.96 for 95%)
P= anticipated proportion (0.30)
d=absolute precision (margin of error 0.05)

$$n = \frac{1.96^2 \times 0.3 \times 0.7}{0.05^2}$$

$$n \approx 323$$

Here p is 0.30 because Published cardiac surgery and CPB studies often report 20–40% of patients experiencing at least one episode of hyperglycemia or glycemic fluctuation during bypass.
So choosing a midpoint like 30% is a realistic assumption for illustration

### Sampling Technique:

Non-probability consecutive sampling technique was used.

### Sample Selection

### Inclusion Criteria:

Adult patients (≥18 years) undergoing elective cardiac surgery using cardiopulmonary bypass.
Patients providing informed written consent.
Known cases of diabetes mellitus (Type 1 or Type 2).

### Exclusion Criteria:

Patients undergoing emergency or redo cardiac surgeries.
Patients receiving preoperative insulin or glucose infusion.
Cases with incomplete intraoperative data or technical failure of blood sampling.

**Equipment**
Cardiopulmonary bypass machine with a standard oxygenator and perfusion setup.
Backup glucometer that is calibrated (for confirmation)
Data recording sheet for documentation of readings and postoperative outcomes.

## DATA COLLECTION PROCEDURE

To evaluate the intraoperative glycemic changes and postoperative clinical results in patients who underwent elective cardiac surgeries with cardiopulmonary bypass (CPB) over four months it was carried out in the department of cardiac surgery After obtaining informed consent, patients who fulfilled the inclusion criteria were recruited sequentially. Pre-CPB arterial blood glucose was recorded as baseline demographic and clinical data before surgery, which included age, gender, diabetic status, clinical history, laboratory investigations. Arterial glucose level was determined at three standardized CPB stages: initiation, during CPB and before termination of bypass at rewarming. Insulin therapy was administered as per institutional protocols, if blood glucose levels were above 180mg/dl, information about insulin type, dose, and time were recorded. Some other parameters during the operation such as perfusion flow rate and cumulative insulin use were also noted. Assessment was performed of postoperative outcome including infection, neurological complications, duration of mechanical ventilation, and hospital stay. Data was collected with the help of a structured proforma and checked each day by the principal investigator for accuracy and completeness.

## DATA ANALYSIS PROCEDURE

The SPSS version 27.0 were used to analyze the collected data by performing systematic coding and input. Descriptive and inferential statistics will be used based on the objectives of the studies. The demographic and clinical data of the participants was summed up with the use of descriptive statistics: continuous variables (age, blood glucose, CPB duration, hospital stay) will be presented in the form of mean +- SD, and nominal variables (gender, diabetes status, and infection incidence) was presented as frequencies and percentages.
To compare glucose levels in CPB phases, inferential analysis will involve. ANOVA (or Friedman test in non-parametric data) used to find the difference between the glucose levels in diabetic and non-diabetic populations, and independent t-tests to determine the difference between diabetic and non-diabetic groups.
Pearson correlation used to test the relationship between intraoperative glycemic variability and postoperative outcome, including infection, neurological recovery, ventilation period, and duration of stay. A multiple linear regression analysis model was used to determine the predictors of poor postoperative outcomes by applying age, diabetic status, and CPB duration as the independent variables. The statistical significance was established with $p \leq 0.05$ and the confidence interval of 95 percent to determine the accuracy of the results.

## RESULTS

Mean age of the study population was 58.30 with a standard deviation of 10.20 years, which represented a slightly aged to old cohort. The mean BMI of 27.60 0.49 kg/m 2 implies that the majority of participants were overweight. Besides, the average height and weight (164.77 ± 8.76 cm and 74.31 ± 10.84 kg) represent a rather uniform distribution of body habitus among the study participants (Table 1)

**Table: 1 Baseline Anthropometric and Demographic Characteristics of Study Population**

| Variable | Mean ± SD |
|---|---|
| **Age (years)** | 58.30 ± 10.20 |
| **Height (cm)** | 164.77 ± 8.76 |
| **Weight (kg)** | 74.31 ± 10.84 |
| **BMI (kg/m²)** | 27.60 ± 4.99 |

Majority were the females in this cohort as shown in figure 1.

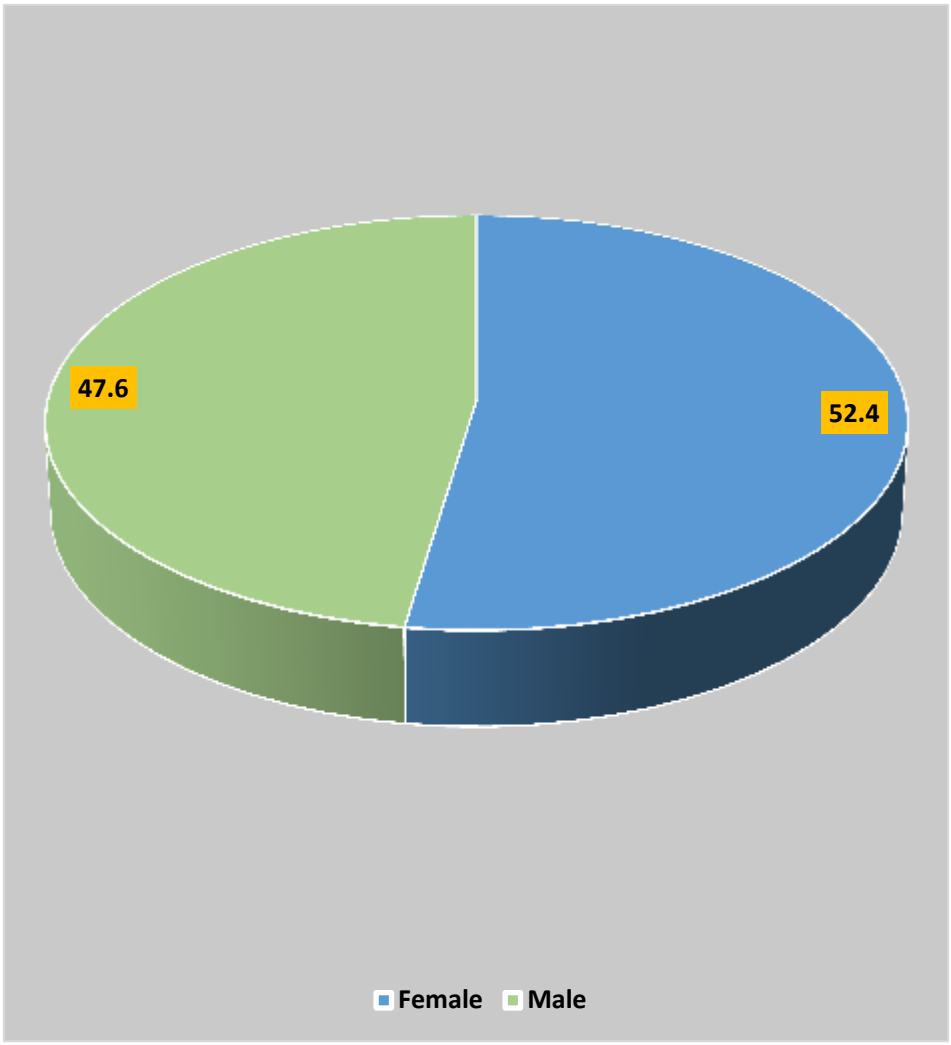


**Figure 1 Gender Distribution of study population.**

Diabetes mellitus was present in 50.0% of the patients, indicating an equal distribution between diabetic and non-diabetic groups. Chronic kidney disease was observed in 22.3%, while 38.4% of patients had a history of smoking, reflecting a considerable burden of comorbid risk factors in the study population showed by Figure 1.

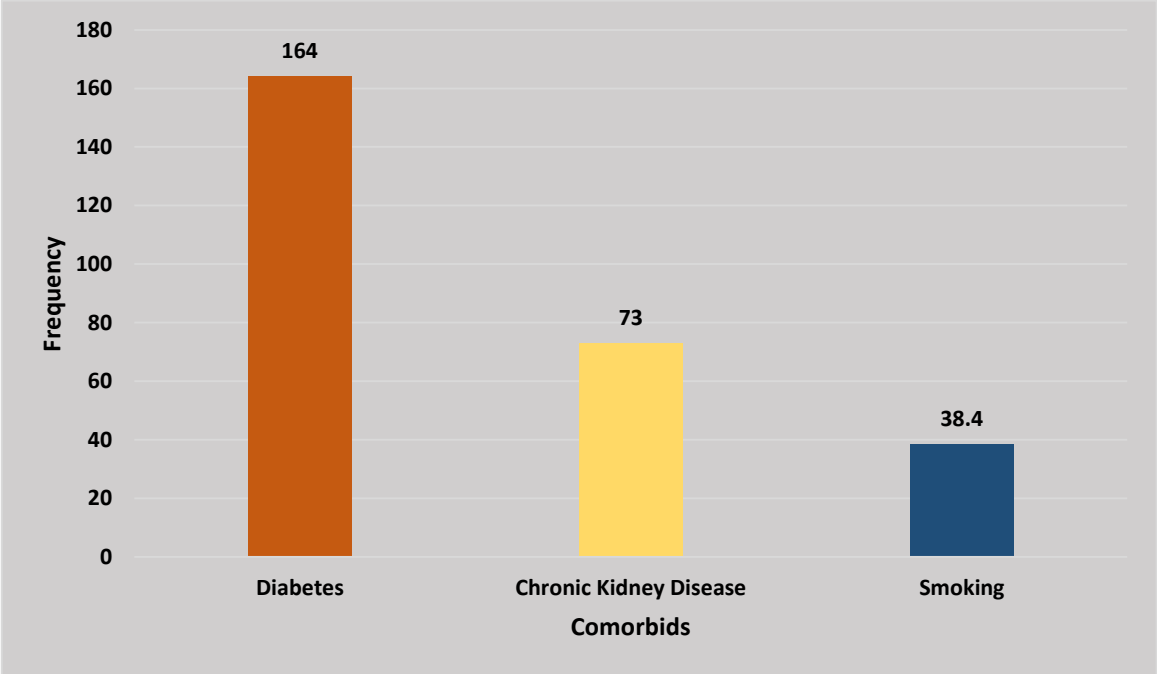


**Figure 2 Clinical Characteristics of Study Population**

Figure 2 shows majority of patients had no chronic kidney disease (77.7%), while among those affected, most were in the early stages. Advanced CKD (Stage IV–V) was rare, accounting for less than 1% of the study population.

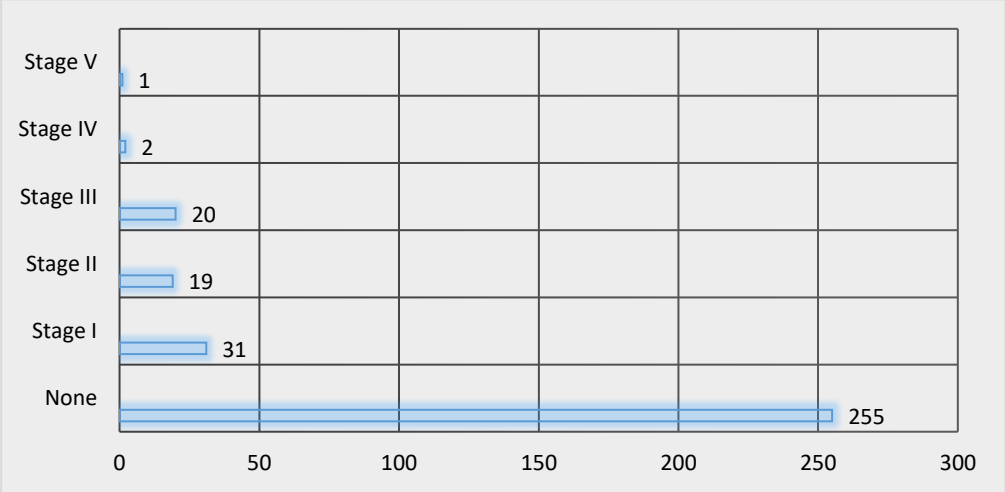


**Figure 3 Stages of Chronic Kidney Disease of study population.**

The average HbA1c of 7.154801.67 is below the expected optimal level of glycemic control in the participants of the study. Hemoglobin and hematocrit rates were acceptable, and coagulation parameters (PT and INR) were also in the norm range, which indicates a sufficient level of baseline hematological and coagulation conditions as illustrated in Table 2.

**Table: 2 Baseline Biochemical and Coagulation Profile**

| Variables | Mean ± SD |
|---|---|
| **HbA1c (%)** | 7.15 ± 1.67 |
| **Hemoglobin (g/dL)** | 12.97 ± 1.35 |

| | |
|---|---|
| **Hematocrit (%)** | 42.38 ± 4.16 |
| **PT (sec)** | 12.44 ± 0.82 |
| **INR** | 1.09 ± 0.11 |
| **PTT (sec)** | 32.00 ± 4.26 |

HbA1c = Glycated Hemoglobin; PT = Prothrombin Time;
INR =International Normalized Ratio; PTT= Partial Thromboplastin Time.

The mean CPB time of **107.83 ± 21.38 minutes** reflects a moderate duration of cardiopulmonary bypass. Cross-clamp time showed considerable variability (**21.07 ± 33.38 minutes**), suggesting heterogeneity in procedural complexity. The mean intraoperative temperature (**36.89 ± 0.24°C**) indicates that normothermia was well maintained during surgery (Table 3)

**Table: 3 Intraoperative Characteristics of Study Population**

| Variables | Mean ± SD |
|---|---|
| **CPB Time (min)** | 107.83 ± 21.38 |
| **Cross Clamp Time (min)** | 21.07 ± 33.38 |
| **Temperature (°C)** | 36.89 ± 0.24 |

CPB = Cardiopulmonary Bypass; °C = Degree Celsius.

Mean blood glucose values reveal the highest volume of levels during the cardiopulmonary bypass (181.63 ± 41.68 mg/dL) and gradual decrease after surgery. Pre-CPB glucose was moderately elevated (144.66 +-39.70 mg/dl), with the levels at 24, 48 hours post-surgical (134.53 +-26.60 mg/dl and 122.38 +-26.60mg/dl) pointing out to good management of the glucose in the early postoperative period. In general there is a significant level of intraoperative variability of glucose levels as it is depicted in figure 4.

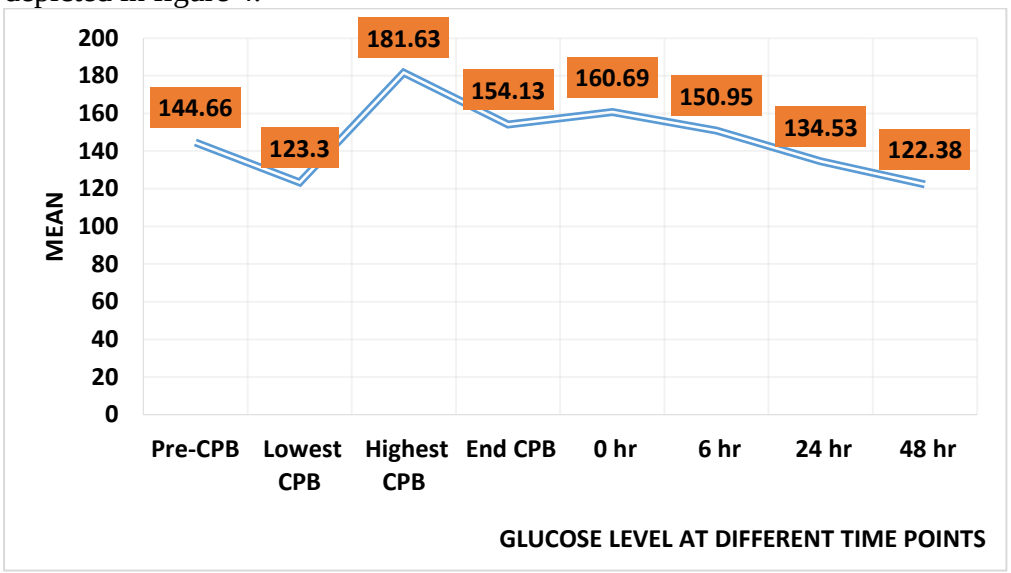


**Figure 4 Perioperative Blood Glucose Levels (mg/dL) of Study Population**

Most patients had a short ICU stay (median 3 days) and moderate ventilation duration (median 6 hours). Hospital stay and wound healing were slightly longer, with medians of 8 and 14 days, reflecting typical postoperative recovery as shown in table 4

**Table: 4 Postoperative Recovery Outcomes of Study Population**

| Variables | Median [IQR] |
|---|---|
| **ICU Stay (days)** | **3 [3–3]** |
| **Ventilation (hours)** | **6 [4–8]** |
| **Hospital Stay (days)** | **8 [6–9]** |
| **Wound Healing (days)** | **14 [10–18]** |

Surgical site infection (29.3%), acute kidney injury (28.4%), and stroke (24.7) were the most prevalent complications that occurred after the operation. Atrial fibrillation was found in 18.3 percent of the patients, mortality (6.1), re-operation (2.7) and diabetic foot (3.0) were less common. Generally, the complications were not quite frequent, and most of the patients were able to recover without any severe incidences as indicated in the figure 5.

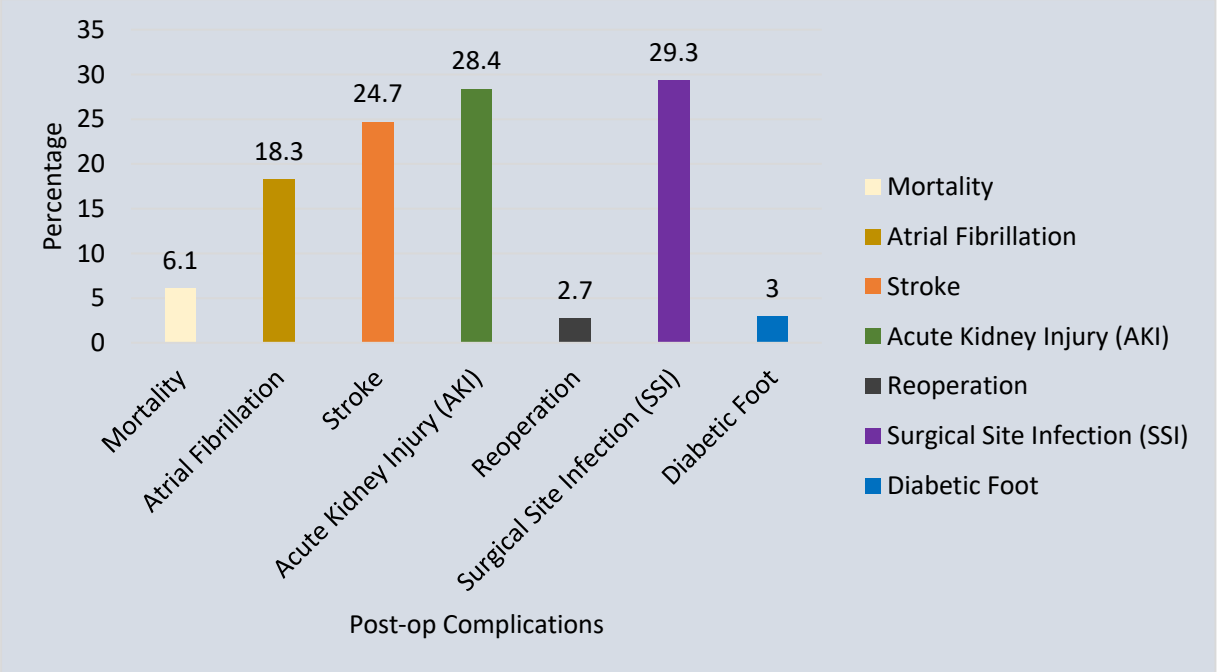


**Figure 5 Distribution of post-operative complications**

ANOVA showed that there was a significant time-effect on blood glucose ($F = 363.55$, $p < 0.001$). The cardiopulmonary bypass (CPB Highest: 181.63 ± 41.68 mg/dL) and then gradually decreased to 122.38± 26.60mg/dL after the operation. This signified elevated intraoperative and early postoperative variability glucose, there was a need to monitor and thus manage the glycemic oscillations during and after surgery as indicated in table 5.

**Table: 5 Perioperative Blood Glucose Levels**

| Time Point | Mean ± SD (mg/dL) | F | p-value |
|---|---|---|---|
| **Pre-CPB** | 144.66 ± 39.70 | 363.55 | <0.001 |
| **CPB Lowest** | 123.30 ± 30.67 | | |
| **CPB Highest** | 181.63 ± 41.68 | | |
| **End CPB** | 154.13 ± 38.65 | | |
| **0 hr** | 160.69 ± 40.38 | | |
| **6 hr** | 150.95 ± 36.12 | | |
| **24 hr** | 134.53 ± 31.28 | | |
| **48 hr** | 122.38 ± 26.60 | | |

***CPB=Cardiopulmonary Bypass Time***

The level of blood glucose of diabetic patients was much higher than it was in non-diabetics at every point of perioperative time (all $p < 0.001$) and was the greatest during cardiopulmonary bypass. As demonstrated in postoperative recovery, the diabetics took longer before they could be ventilated (8.66 ± 6.13 vs. 4.75 ± 3.96 hours, $p < 0.001$) and elevated wound healing (15.58 ± 5.87 vs. 11.04 ± 2.64 days, $p < 0.001$), but the ICU stay and the length of stay in hospital were no different among the groups. This underscores the effects of diabetes on perioperative glycemic regulation and some part of postoperative recovery including ventilation duration and wound healing (Table 6)

**Table: 6 Glucose Levels and Postoperative Recovery between Diabetic and Non-Diabetic Patients**

Table 7 presents the analysis of the Spearman correlation results that indicated that increased intraoperative glycemic variability was statistically connected with numerous adverse outcomes. The least significant correlation was identified with stroke ($r = 0.225$, $p < 0.001$), then it was with AKI ($r = 0.199$, $p = 0.001$), SSI ($r = 0.184$, $p = 0.001$), mortality ($r = 0.167$, $p = 0.002$), and atrial fibrillation ($r = 0.140$, $p = 0.011$). It did not show any significant relationship with reoperation ($r = 0.051$, $p = 0.358$). The results indicate that large changes in glucose during the process of surgery increase the likelihood of significant adverse events during the postoperative period, and the fact that glucose level is subjected to intense control is vital.

**Table:7 Spearman Correlation between Intraoperative Glycemic Variability and Postoperative Outcomes**

| Outcome | Spearman's rho (r) | p-value |
|---|---|---|

| Parameter | Non-Diabetic (N=164) | Diabetic (N=164) | p-value |
|---|---|---|---|
| | Mean ± SD | | |
| Glucose Pre CPB | 110.09 ± 12.11 | 179.24 ± 24.70 | <0.001 |
| Glucose CPB Lowest | 96.02 ± 8.81 | 150.59 ± 17.67 | <0.001 |
| Glucose CPB Highest | 144.49 ± 14.47 | 218.76 ± 22.37 | <0.001 |
| Glucose End CPB | 119.82 ± 10.56 | 188.43 ± 22.73 | <0.001 |
| Glucose_0h | 126.97 ± 14.23 | 194.40 ± 27.93 | <0.001 |
| Glucose_6h | 120.15 ± 12.00 | 181.75 ± 23.74 | <0.001 |
| Glucose_24h | 108.88 ± 11.56 | 160.18 ± 22.47 | <0.001 |
| Glucose_48h | 101.19 ± 10.27 | 143.57 ± 20.24 | <0.001 |
| ICU Stay (days) | 5.10 ± 11.34 | 3.53 ± 4.06 | 0.12 |
| Ventilation (hours) | 4.75 ± 3.96 | 8.66 ± 6.13 | <0.001 |
| Hospital Stay (days) | 7.51 ± 1.81 | 7.69 ± 3.07 | 0.55 |
| Wound Healing (days) | 11.04 ± 2.64 | 15.58 ± 5.87 | <0.001 |

| | | |
|---|---|---|
| Mortality | 0.167 | 0.002 |
| Atrial Fibrillation (AF) | 0.140 | 0.011 |
| Stroke | 0.225 | 0.000 |
| Acute Kidney Injury (AKI) | 0.199 | 0.000 |
| Reoperation | 0.051 | 0.358 |

| | | |
|---|---|---|
| **Surgical Site Infection (SSI)** | 0.184 | 0.001 |

The odds ratio of diabetes mellitus (DM_CAT) was strong and at unadjusted (OR 0.061, 95% CI 0.0340.109, p < 0.001) and adjusted (OR 0.057, 95% CI 0.0310.105, p < 0.001) odds ratios, the odds ratio of having adverse postoperative outcomes were significantly high. Neither age nor CPB time showed a significant effect of the outcomes in the unadjusted or the adjusted analysis pointing to the fact that these variables had a limited independent effect when corrected by diabetes. (Table 8)

**Table: 8 Predictors of Postoperative Outcomes**

| Variable | Unadjusted OR (95% CI) | p-value | Adjusted OR (95% CI) | p-value |
|---|---|---|---|---|
| **Age** | 0.984 (0.963–1.006) | 0.150 | 1.006 (0.979–1.033) | 0.662 |
| **DM** | 0.061 (0.034–0.109) | <0.001 | 0.057 (0.031–0.105) | <0.001 |
| **CPB Time (min)** | 0.998 (0.987–1.008) | 0.669 | 1.006 (0.993–1.019) | 0.375 |

## DISCUSSION

This research compared perioperative trends of glucose, outcomes after the surgery and their relationship among cardiac surgery patients, undergoing cardiopulmonary bypass surgery. The mean age of the cohort was 58 years, male and female representation was equal, and an equal number of the cohort was diabetic. There was a significant fluctuation in intraoperative glucose levels and the variations were high in CPB and peaked and declined gradually in the first 48 hours after surgery. Diabetic patients always followed high glucose levels throughout the perioperative time and there was a tendency of worsening of the wound healing time and mechanical ventilation duration during the ICU and overall hospital stay were equal by diabetic and non-diabetic groups. Glycemic variability analysis showed that the outcomes had significant positive correlation as to atriatal fibrillation, acute kidney injury, stroke, surgical site infection, mortality, and adverse outcomes, but not reoperation. Multivariate analysis was used to determine that diabetes was independent of postoperative complications, but age and CPB duration were not independent predictor

The results of the monitored intra-operative changes in glucose levels are consistent with the previous research, which also has shown that cardiac surgery and CPB provoke stress-associated hyperglycemia. Karunarathna, I., (2024) has found similar levels of peaks in peri operative glucose with the effect of surgical stress and anesthesia as well as CPB on glucose homeostasis [105]. Sun B et al., (2021) We confirm that diabetic patients were found to be especially prone to increased glucose swings, which is supported by other researchers [106]. A number of studies have brought out the association between operative perioperative glycemic variability and poor postoperative outcomes. In their case, Nair BG et al., (2019) and Clement KC et al., (2012) have discovered that increased GV, regardless of mean glucose, relative to complications like stroke, AKI, infection and mortality. These studies are in line with our findings since these studies reported a significant association between Glycemic variabilty and stroke, AKI, SSI, mortality, and atrial fibrillation that it is the fluctuations which not absolute hyperglycemia may drive postoperative morbidity [59, 107].

The findings of the current study are in line with those of Ahmed A et al., (2016) which indicated that diabetic patients undergoing CABG experienced delayed

mechanical ventilation and wound healing because of microvascular impairment and dysfunctional immune response [108]. Avogaro., et al (2019) Surprisingly, the ICU, and hospital stay, did not have significant differences between diabetic and non-diabetic populations, which is in agreement with the effects of standardized perioperative care and glycemic control on the results of extended hospitalization regardless of diabetes demonstrated by yet the overall glycemic fluctuations were also independent predictors of adverse events [109]. Mortality in our cohort (6.1) was reasonably low, in line with the modern outcomes of cardiac surgery, although the glycemic variations have the current study also supports the findings of the previous studies that diabetes is still an independent predictive factor of postoperative complications with a strong adjusted OR indicating adverse outcomes.

Moreover, though reoperation was not found to be significantly correlated with GV, this is in keeping with the literature that explains that surgery complications which necessitate reoperation are rather technical than metabolic in nature. The favorable correlations of GV and atrial fibrillation are in line with the results of Lorenzo-Almoros et al., (2023) who found that intraoperative hyperglycemia and variability can raise the rate of postoperative AF via oxidative stress and inflammatory mechanisms [110].

To conclude, this research has established that diabetes and intraprocedural glycemic fluctuations are paramount predictors of outcome after cardiac surgery in patients. Diabetic patients demonstrate greater perioperative glucose fluctuation and longer ventilation time and slow wound healing. It was found that glycemic variability was greatly associated with giant complications, such as stroke, AKI, SSI, mortality, and atrial fibrillation, which explains the importance of careful intraoperative glucose control and personalized insulin treatment. Logistic regression validates that diabetes is an independent risk factor of high strength whereas age and CPB duration were not significant predictors.

## Conclusion

Intraoperative blood glucose varies much among patients who have undergone cardiac surgery using cardiopulmonary bypass, which shows that diabetics have distinctly higher glucose levels than non-diabetics. Higher intraoperative glycemic fluctuations are linked with negative after-surgery consequences which comprise stroke, acute kidney injury, surgical site infection, and atrial fibrillation. The strong independent predictors of these complications are diabetes and neither age nor CPB duration should be considered independent of each other. Intraoperative glycemic optimization could potentially result in a significant role in enhancing postoperative outcomes and eliminating complications in this group.

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