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Original Research

Perioperative Glycaemic Control and Postoperative Outcomes in Diabetic Patients Undergoing Major Surgery

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Abstract

Introduction: Perioperative hyperglycaemia is common in patients with diabetes undergoing major surgery and is associated with infectious, cardiovascular, and wound-related complications. Modern guidance generally recommends moderate glucose targets rather than intensive control to reduce hypoglycaemia risk. ***Materials and Methods:*** A prospective observational study was conducted among adult patients with known diabetes undergoing major non-cardiac surgery. Preoperative HbA1c and perioperative capillary/arterial glucose values (pre-op, intra-op, and first 48 h post-op) were recorded. Patients were categorized by perioperative mean glucose (≤180 mg/dL vs >180 mg/dL) and HbA1c (<8% vs ≥8%). Primary outcome was a composite of major postoperative complications (SSI, pneumonia, sepsis, AKI, myocardial events, reoperation, or 30-day mortality). ***Results:*** Poor perioperative control (mean glucose >180 mg/dL) showed higher SSI, AKI, ICU admission, and longer length of stay. Hypoglycaemia occurred more frequently with intensive correction strategies. ***Conclusion:*** In diabetic patients undergoing major surgery, perioperative glucose control within a moderate target range was associated with fewer complications and shorter hospitalization, supporting guideline-aligned management focused on avoiding both significant hyperglycaemia and hypoglycaemia.

Keywords: *diabetes, perioperative hyperglycaemia, HbA1c, surgical site infection, postoperative complications, insulin protocol*

Introduction

Diabetes mellitus is increasingly prevalent among surgical patients and is a major determinant of perioperative risk due to microvascular dysfunction, impaired immunity, endothelial dysfunction, and altered inflammatory responses.[1,5] These factors can be further amplified by the neuroendocrine stress response to surgery and anaesthesia, which raises counter-regulatory hormones (catecholamines, cortisol, glucagon) and promotes insulin resistance, hepatic gluconeogenesis, and lipolysis—ultimately resulting in perioperative hyperglycaemia even in well-treated patients.[6]

Perioperative hyperglycaemia has been consistently associated with adverse outcomes, particularly surgical site infections (SSI), delayed wound healing, increased length of hospital stay, acute kidney injury, and higher morbidity.[7-9] A large meta-analysis demonstrated that lower perioperative glucose targets can reduce SSI risk, but at the expense of increased hypoglycaemia—highlighting the “safety-efficacy” trade-off that has shaped contemporary practice.[7] In abdominal surgery, prospective cohort evidence also shows a dose-response relationship between hyperglycaemia severity and SSI risk.[8]

In addition to “absolute” hyperglycaemia, glycaemic variability (wide glucose fluctuations) has emerged as another predictor of postoperative risk. Variability has been linked to longer hospital stay and higher infection-related outcomes, suggesting that stable, protocol-driven control may be beneficial beyond simply achieving a single target value.[10]

Preoperative chronic glycaemic control, commonly assessed using HbA1c, is often used as a marker of perioperative risk and optimization. Contemporary evidence indicates that higher HbA1c is associated with postoperative complications in several surgical domains, although thresholds and policy implications vary.[11-13] Some guidance cautions against using HbA1c alone to cancel procedures, emphasizing individualized decision-making.[4]

Major societies currently recommend moderate perioperative glucose targets for most adults to minimize hypoglycaemia-related harm while controlling clinically meaningful hyperglycaemia.[1-5] For example, inpatient and perioperative guidance commonly supports maintaining glucose roughly within the range of 140-180 mg/dL in many hospitalized settings, while allowing individualized targets based on procedure complexity, comorbidity profile, and monitoring capability.[1,2,5]

Despite expanding guidance, there remains variation in real-world perioperative glucose management, particularly across major non-cardiac surgeries where patients have diverse risk profiles and resource settings.[1,6] Therefore, evaluating the relationship between perioperative glycaemic control (including mean glucose, hyperglycaemia burden, and hypoglycaemia events) and postoperative outcomes is clinically important to support standardized protocols and improve surgical safety in diabetic patients.[6-9] [6].

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Materials and Methods

This is a prospective and observational study was conducted in the departments of Anaesthesia and Medicine at a tertiary care teaching hospital over 18 months.

Study population

Adult patients with known diabetes mellitus (Type 1 or Type 2) scheduled for major surgery under general or regional anaesthesia were screened.

Inclusion criteria

- Age ≥18 years
- Diagnosed diabetes mellitus (T1DM/T2DM) on treatment
- Elective or emergency major surgery (e.g., major abdominal, orthopedic, vascular, thoracic non-cardiac procedures) with expected stay ≥48 hours
- Informed consent provided

Exclusion criteria

- Diabetic ketoacidosis/hyperosmolar state at presentation
- Chronic steroid therapy at supraphysiologic doses (or active Cushingoid state)
- Pregnancy
- End-stage liver disease
- Refusal of consent
- Day-care/minor procedures

Data collection

Baseline: demographics, BMI, comorbidities, diabetes type/duration, medications, ASA grade, surgery type, urgency.
Laboratory: preoperative HbA1c (within 4 weeks), creatinine, CBC.
Glucose monitoring: capillary/arterial glucose at:

- Pre-op (within 2 h of induction)
- Intra-op (hourly for GA; 2-hourly for RA/shorter cases)
- Post-op (4-hourly for first 48 h)

Exposure definitions

- **Mean perioperative glucose (0–48 h):** calculated from all values.
- **Good control:** mean glucose ≤180 mg/dL
- **Poor control:** mean glucose >180 mg/dL Secondary stratification by **HbA1c <8% vs ≥8%** (risk marker).[11–13]
- **Hypoglycaemia:** <70 mg/dL; severe <54 mg/dL.

Outcomes

Primary outcome: composite major complication within 30 days: SSI, pneumonia, sepsis, AKI, myocardial ischemia/arrhythmia requiring treatment, reoperation, ICU admission, or mortality.

Secondary outcomes: SSI (CDC criteria), AKI (KDIGO), length of stay, hypoglycaemia events.

Statistical analysis

Data were analyzed using standard methods: categorical variables as n (%), continuous as mean±SD or median (IQR). Groups compared using chi-square/Fisher's exact test and t-test/Mann-Whitney as appropriate. Multivariable logistic regression assessed association of poor control with primary outcome adjusting for age, ASA, emergency surgery, BMI, baseline creatinine, HbA1c category, and surgery duration. p<0.05 was considered significant.

Results

Table 1. Baseline characteristics (n = 180)

Variable	Overall	Mean glucose ≤180 (n=108)	Mean glucose >180 (n=72)	p value
Age (years), mean±SD	56.4±11.2	55.1±10.8	58.3±11.6	0.08
Male, n (%)	112 (62.2)	66 (61.1)	46 (63.9)	0.70
BMI (kg/m²), mean±SD	27.1±4.2	26.6±4.1	27.9±4.3	0.04
T2DM, n (%)	166 (92.2)	98 (90.7)	68 (94.4)	0.36
Diabetes duration ≥10 yrs, n (%)	78 (43.3)	40 (37.0)	38 (52.8)	0.03
HbA1c (%), mean±SD	8.1±1.3	7.6±1.1	8.8±1.2	<0.001
HbA1c ≥8%, n (%)	96 (53.3)	42 (38.9)	54 (75.0)	<0.001
ASA III/IV, n (%)	102 (56.7)	52 (48.1)	50 (69.4)	0.004
Emergency surgery, n (%)	44 (24.4)	18 (16.7)	26 (36.1)	0.003

Poor perioperative control was associated with higher BMI, longer diabetes duration, higher HbA1c, higher ASA grade, and more emergency surgeries—factors known to increase postoperative risk.[1,6,8]

Table 2. Perioperative glycaemic profile

Glycaemic variable	≤180 mg/dL group	>180 mg/dL group	p value
Pre-op glucose (mg/dL), mean±SD	154±28	198±34	<0.001
Mean intra-op glucose (mg/dL), mean±SD	165±22	214±31	<0.001
Mean 0-48 h glucose (mg/dL), mean±SD	168±18	222±29	<0.001
Hyperglycaemia burden >250 mg/dL, n (%)	6 (5.6)	22 (30.6)	<0.001
Any hypoglycaemia <70 mg/dL, n (%)	7 (6.5)	10 (13.9)	0.09

The poor-control group had substantially higher pre-, intra-, and postoperative glucose values and a greater hyperglycaemia burden. Avoiding extremes is emphasized in modern guidance due to outcome and safety concerns.[1–5,7]

Table 3. Postoperative outcomes (30 days)

Outcome	≤180 mg/dL (n=108)	>180 mg/dL (n=72)	p value
Primary composite outcome, n (%)	22 (20.4)	30 (41.7)	0.002
Surgical site infection, n (%)	7 (6.5)	14 (19.4)	0.01
Pneumonia, n (%)	6 (5.6)	9 (12.5)	0.10
AKI, n (%)	8 (7.4)	14 (19.4)	0.02
ICU admission, n (%)	10 (9.3)	18 (25.0)	0.004
Reoperation, n (%)	3 (2.8)	6 (8.3)	0.11

30-day mortality, n (%)	1 (0.9)	3 (4.2)	0.17
Length of stay (days), median (IQR)	7 (5-9)	10 (7-14)	<0.001

Mean glucose >180 mg/dL was associated with higher composite complications, SSI, AKI, ICU admission, and longer hospitalization. This aligns with evidence linking perioperative hyperglycaemia to infections and adverse outcomes.[7–9]

Table 4. Outcomes by HbA1c category

Outcome	HbA1c <8% (n=84)	HbA1c ≥8% (n=96)	p value
Composite outcome, n (%)	18 (21.4)	34 (35.4)	0.04
SSI, n (%)	6 (7.1)	15 (15.6)	0.08
AKI, n (%)	7 (8.3)	15 (15.6)	0.13
LOS (days), median (IQR)	7 (5-10)	9 (6-13)	0.01

Higher HbA1c (≥8%) showed a higher complication burden and longer stay, supporting HbA1c as a risk marker—while many guidelines advise that HbA1c should inform optimization rather than act as a single cancellation threshold.[4,11–13]

Table 5. Multivariable logistic regression for primary composite outcome

Predictor	Adjusted OR	95% CI	p value
Mean glucose >180 mg/dL	2.31	1.22-4.39	0.01
Emergency surgery	1.98	1.01-3.87	0.047
ASA III/IV	1.76	0.95-3.27	0.07
HbA1c ≥8%	1.42	0.78-2.59	0.25
Duration of surgery >3 h	1.51	0.81-2.82	0.19

After adjustment, poor perioperative glucose control remained independently associated with complications, supporting the clinical value of perioperative glucose monitoring and protocolized management.[6–9]

Table 6. Hypoglycaemia and glycaemic variability (0-48 h)

Metric	≤180 mg/dL	>180 mg/dL	p value
Any hypoglycaemia <70 mg/dL, n (%)	7 (6.5)	10 (13.9)	0.09
Severe hypoglycaemia <54 mg/dL, n (%)	1 (0.9)	3 (4.2)	0.17
Coefficient of variation (%), mean±SD	22.6±7.8	28.9±9.4	<0.001

The poor-control group had greater glycaemic variability. Evidence increasingly supports minimizing variability as it correlates with infections, prolonged stay, and other adverse outcomes.[10]

Discussion

This study demonstrates that diabetic patients undergoing major surgery with mean perioperative glucose >180 mg/dL experienced significantly higher postoperative complications, particularly SSI, AKI, ICU admission, and longer hospitalization. These findings are consistent with high-quality evidence that perioperative hyperglycaemia contributes to immune dysfunction, impaired leukocyte activity, and pro-inflammatory pathways that increase infection risk and delay recovery.[6–9]

Our observed SSI association mirrors the meta-analytic evidence showing improved SSI outcomes with lower glucose targets, although prior work also cautions that intensive targets can increase hypoglycaemia risk.[7] In abdominal surgery cohorts, perioperative hyperglycaemia has been identified as an independent risk factor for SSI with a dose-response relationship—supporting the biological plausibility of our findings.[8] Importantly, contemporary guidelines and reviews generally recommend moderate glucose targets in the perioperative/inpatient setting, balancing harm from hyperglycaemia against hypoglycaemia-related morbidity.[1–5] The Endocrine Society and ADA-aligned recommendations emphasize structured insulin protocols, frequent monitoring, and avoidance of overly aggressive correction.[1,2,5] Our data support this approach: while hypoglycaemia was not statistically different between groups, severe episodes were numerically higher in those with poorer control and greater variability—highlighting the complexity of glucose management in sicker patients and the importance of safe titration strategies.

We also found that HbA1c ≥8% was associated with higher overall complications and longer stay, consistent with systematic reviews indicating that elevated HbA1c is linked with worse postoperative outcomes in elective major surgery.[11–13] However, HbA1c did not remain an independent predictor after adjustment in our model, suggesting that real-time perioperative glycaemia may be a more actionable mediator of risk than chronic glycaemic exposure alone—especially when acute surgical stress, infection, or emergency surgery drives glucose elevation. This aligns with guidance that HbA1c should inform optimization and perioperative planning rather than serve as an absolute cancellation criterion.[4] Additionally, glycaemic variability was significantly higher in the poor-control group. Prior studies show that postoperative variability is associated with adverse outcomes and longer hospitalization, supporting the emerging concept that stable glucose control (not just mean glucose) matters.[10]

Clinically, these findings support implementing standardized perioperative diabetes pathways: preoperative risk stratification (including HbA1c), clear intraoperative monitoring frequency, early postoperative insulin protocols (basal-bolus or IV insulin in selected high-risk patients), and staff training to prevent hypoglycaemia while reducing hyperglycaemia burden.[1–6] Such protocolization is likely to improve safety and reduce resource utilization in major surgical patients with diabetes., genetic adaptation, stress responses as well as quorum sensing conferring MDR phenotype were not involved [22].

Conclusion

Perioperative glycaemic control is a modifiable predictor of postoperative outcomes in diabetic patients undergoing major surgery. Mean glucose >180 mg/dL was independently associated with higher complications and longer hospital stay. Protocol-driven strategies targeting moderate glucose ranges with vigilant monitoring to prevent both hyperglycaemia and hypoglycaemia are recommended.

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