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A Systematic Review of the Association of Preoperative Optimization of Diabetic Patients with Perioperative Glycemic Control and Postoperative Outcomes

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ABSTRACT

Introduction: The prevalence of diabetes mellitus (DM) in surgical populations is substantial and represents a significant independent risk factor for postoperative complications. Preoperative optimization of glycemic control has emerged as a key strategy to mitigate these risks by improving patients' physiological resilience to surgical stress. This review systematically evaluates the association between preoperative glycemic status and postoperative outcomes.

Methods: A systematic search of PubMed and the Cochrane Library was conducted for studies published through 2024. Inclusion criteria specified randomized controlled trials and observational studies evaluating preoperative glycemic markers (e.g., glycated hemoglobin (HbA1c), blood glucose) or structured optimization interventions in adult diabetic patients undergoing

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surgery. Primary outcomes included surgical site infection (SSI), 30-day mortality, and major adverse cardiovascular events (MACE). Secondary outcomes included length of stay (LOS), acute kidney injury (AKI), and other morbidities. Study quality was appraised using the Cochrane Risk of Bias 2 and ROBINS-I tools.

Results: Seventeen studies, encompassing randomized trials and large cohort analyses, met the inclusion criteria. The evidence consistently links poor preoperative glycemic control, indicated by elevated HbA1c or acute hyperglycemia, with a significantly increased risk of postoperative complications. Specifically, high HbA1c levels were strongly associated with higher rates of SSI (Odds Ratio ranging from 2.13 to 3.0) and prolonged hospital LOS. Acute perioperative hyperglycemia was a more direct predictor of MACE and mortality (Hazard Ratio 1.26 for adverse cardiac events). Structured interventions, such as multidisciplinary preoperative clinics, demonstrated efficacy in reducing preoperative HbA1c levels, particularly in patients with the poorest baseline control.

Discussion: The synthesized evidence highlights a critical debate regarding the predictive primacy of chronic (HbA1c) versus acute (perioperative blood glucose) hyperglycemia. While acute hyperglycemia appears to be the more proximate driver for immediate adverse events like myocardial injury, HbA1c serves as an essential tool for risk stratification, identifying patients who will benefit most from intensive perioperative management. The heterogeneity of the existing literature, particularly the scarcity of high-quality randomized trials, underscores the complexity of this issue.

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Conclusion: Poor preoperative glycemic control is unequivocally associated with adverse postoperative outcomes in diabetic patients. While the optimal strategy for preoperative optimization remains to be defined by high-quality evidence, current data support a shift from using HbA1c as a rigid surgical gatekeeper to a trigger for activating comprehensive, multidisciplinary perioperative management pathways.

Keywords: Diabetes Mellitus; Preoperative Care; Glycemic Control; Glycated Hemoglobin A1c; Postoperative Complications; Surgical Site Infection; Perioperative Outcomes.

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INTRODUCTION

The Growing Challenge of Diabetes in the Surgical Population

Diabetes Mellitus (DM) has become a global public health crisis, and its rising prevalence has direct and significant implications for surgical care (de Groot, et al., 2024). Surgical departments increasingly encounter patients with DM, with estimates suggesting that individuals with diabetes account for up to 15% of all surgical procedures and may have a 50% higher prevalence of the disease compared to the general population (Dhatariya, et al., 2022; Duggan, et al., 2022). A particularly concerning aspect of this trend is that a substantial number of these patients are either undiagnosed or unaware of their condition at the time of surgical referral, representing a critical missed opportunity for clinical intervention (Setji, et al., 2017; Duggan, et al., 2022). This high prevalence imposes a considerable clinical and economic burden, as DM is firmly established as an independent risk factor for a host of adverse postoperative outcomes. These include increased rates of infection, cardiovascular events, prolonged hospital stays, and higher mortality, which collectively escalate healthcare costs and patient morbidity (Ng, et al., 2024; de Groot, et al., 2024; Dhatariya, et al., 2022; Setji, et al., 2017; Umpierrez, et al., 2015; Dhatariya, 2024; Vlassakos and Mastorakos, 2002; Mendez, et al., 2024; Song, et al., 2022).

Pathophysiology of Hyperglycemia and Surgical Stress

The perioperative period is defined by a profound neuroendocrine stress response, which involves the systemic release of counter-regulatory hormones such as cortisol and catecholamines (Awad and Eltaki, 2024; Vlassakos and Mastorakos, 2002; Mendez, et al., 2024). This physiological cascade exacerbates insulin resistance, diminishes endogenous insulin secretion, and stimulates hepatic gluconeogenesis and glycogenolysis, culminating in a state often termed "stress hyperglycemia" (Awad and Eltaki, 2024). In patients with DM, whose glycemic regulatory mechanisms are already compromised, this surgical stress can precipitate severe and sustained hyperglycemia. This metabolic derangement is not a benign side effect but a direct

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pathophysiological driver of complications. Hyperglycemia is mechanistically linked to mitochondrial injury, endothelial dysfunction, and significant immune dysregulation (Mendez, et al., 2024). Specifically, elevated glucose levels impair crucial leukocyte functions, including chemotaxis, phagocytosis, and microbial killing, which directly increases a patient's susceptibility to infection (Dhatariya, et al., 2022; Surjen, 2024; Vlassakos and Mastorakos, 2002). Concurrently, hyperglycemia disrupts normal collagen synthesis and angiogenesis, leading to compromised and delayed wound healing (Kwon, et al., 2013; Surjen, 2024).

The Rationale for Preoperative Glycemic Optimization

Given the clear pathophysiological link between hyperglycemia and adverse surgical outcomes, the maintenance of optimal glucose control throughout the perioperative continuum is of paramount importance (Mendez, et al., 2024). Historically, clinical focus was concentrated on intraoperative and postoperative glycemic management. However, a significant paradigm shift towards proactive preoperative optimization is underway. The core rationale is that improving a patient's baseline glycemic status *before* the surgical insult can better equip them to withstand the intense physiological stress of the procedure. This proactive approach aims to mitigate the severity of perioperative hyperglycemia and its downstream consequences (Duggan, et al., 2022; Kalra, et al., 2020; Sebranek and Luger, 2023; Sudhakaran and Surani, 2020). Evidence supports this concept, indicating that patients whose DM is diagnosed and managed prior to surgery experience better outcomes than those with unidentified hyperglycemia, thereby underscoring the immense value of early identification and intervention (Duggan, et al., 2022; Setji, et al., 2017).

Current Paradigms in Preoperative Assessment and Management

The cornerstone of modern preoperative glycemic assessment is the measurement of Glycated Hemoglobin (HbA1c), a biomarker that reflects average blood glucose control over the preceding two to three months (de Groot, et al., 2024; Mendez, et al., 2024; Setji, et al., 2017). Various professional societies and guidelines have proposed specific HbA1c thresholds—commonly ranging from 7% to 8.5% —above which elective surgery may be deferred to allow for

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a period of glycemic optimization. However, a universal consensus on a definitive cutoff value remains elusive (Ng, et al., 2024; Hikata, et al., 2014; Duggan, et al., 2022; Sebranek and Luger, 2023; Johnson, 2020; Kunze, et al., 2023). Current management strategies vary widely, from simple medication adjustments based on guidelines from organizations like the American Diabetes Association (ADA) to the implementation of comprehensive, structured optimization programs (Mendez, et al., 2024; NYSDOH, 2019). These advanced models of care include multidisciplinary preoperative clinics, pharmacist-led medication therapy management, and targeted patient education initiatives (Yu, et al., 2024; Mosen, et al., 2015; Gurney, et al., 2023; Wolfe, 2021; Kunze, et al., 2023).

The Research Gap and Novelty of this Review

Despite a strong biological rationale for preoperative optimization, the existing evidence base is characterized by inconsistency and controversy. A central point of contention revolves around whether an elevated preoperative HbA1c is an independent risk factor for complications or if it is merely a marker for poor perioperative glucose control, which may be the more proximate cause of adverse events (Mendez, et al., 2024; Garg, et al., 2014; Setji, et al., 2017; Hudson, et al., 2018; Kwon, et al., 2021). Previous systematic reviews have produced conflicting conclusions; some have found no definitive association between HbA1c and postoperative outcomes (Dronavalli, et al., 2015), while others have reported clear links to infection and other morbidities (Dhatariya, et al., 2022). This discordance is compounded by the significant heterogeneity of the published literature, which is dominated by retrospective, observational studies that often employ inconsistent definitions of DM and glycemic control (Dronavalli, et al., 2015; Dhatariya, et al., 2022). This systematic review aims to provide a comprehensive and definitive synthesis of the current evidence, directly addressing these controversies and seeking to clarify the complex association between various preoperative optimization strategies, glycemic control metrics, and a wide spectrum of postoperative outcomes.

Study Objectives and Hypotheses

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The primary objective of this systematic review is to synthesize the available evidence on the association between preoperative glycemic status, as measured by HbA1c and/or blood glucose levels, in diabetic patients and their subsequent postoperative outcomes. A secondary objective is to evaluate the effectiveness of formal preoperative optimization programs, such as multidisciplinary clinics or pharmacist-led interventions, on improving perioperative glycemic control and reducing the incidence of postoperative complications. It is hypothesized that poorer preoperative glycemic control, indicated by metrics such as a higher HbA1c , is associated with a higher incidence of adverse postoperative outcomes. It is further hypothesized that structured preoperative optimization interventions lead to measurably improved glycemic control and a corresponding reduction in postoperative complications.

METHODS

Search Strategy and Selection Criteria

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The research question was structured using the Population, Intervention/Exposure, Comparator, and Outcomes (PICO) framework.

- **Population (P):** Adult patients (age 18 years) with a pre-existing diagnosis of Type 1 or Type 2 Diabetes Mellitus undergoing elective non-cardiac or cardiac surgery.
- **Intervention/Exposure (I):** Preoperative glycemic status defined by a measured HbA1c or blood glucose level, or participation in a structured preoperative optimization program (e.g., specialized diabetes clinic, pharmacist-led medication management, targeted patient education).
- **Comparator (C):** Patients with better glycemic control (e.g., lower HbA1c levels) or patients receiving usual, non-structured preoperative care.
- **Outcomes (O):** Incidence of one or more of the specified postoperative outcomes.

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A systematic literature search was conducted in PubMed and the Cochrane Central Register of Controlled Trials (CENTRAL) for relevant articles published from database inception to the present. The search strategy combined Medical Subject Headings (MeSH) terms and keywords, including: ("diabetes mellitus", "hyperglycemia") AND ("preoperative care", "preoperative period", "glycemic control", "hemoglobin a1c") AND ("postoperative complications", "surgical site infection", "mortality", "length of stay").

Inclusion criteria were limited to randomized controlled trials (RCTs), prospective and retrospective cohort studies, and case-control studies published in the English language. Studies were excluded if they were case reports, editorials, reviews not containing original data, studies focused on pediatric populations, or studies that did not report on at least one of the predefined outcomes of interest.

Data Extraction and Outcomes of Interest

Two reviewers independently screened all identified titles and abstracts, followed by a full-text review of potentially eligible articles. Any disagreements regarding study inclusion were resolved through discussion with a third reviewer. A standardized data extraction form was developed and used to collect pertinent information, including study characteristics (author, year, design), patient demographics, details of the intervention or exposure, comparator group characteristics, and all relevant outcome data.

The outcomes of interest were categorized as primary and secondary:

Primary Outcomes:

1. Surgical Site Infection (SSI), including deep, superficial, and organ/space infections.
2. 30-day all-cause mortality.
3. Major Adverse Cardiovascular Events (MACE), as a composite outcome or its individual components.

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Secondary Outcomes:

4. Hospital Length of Stay (LOS).
5. Intensive Care Unit (ICU) Length of Stay.
6. Postoperative Pneumonia.
7. Postoperative Sepsis.
8. Urinary Tract Infection (UTI).
9. Acute Kidney Injury (AKI).
10. Myocardial Infarction (MI).
11. Stroke / Cerebrovascular Accident.
12. Cardiac Arrhythmias (e.g., atrial fibrillation).
13. Venous Thromboembolism (VTE).
14. 30-day hospital readmission.
15. Reoperation rates.
16. Delayed wound healing.
17. Hypoglycemic events.

Quality Appraisal and Risk of Bias Assessment

The methodological quality of included RCTs was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool. This tool evaluates bias across five key domains: the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result (Feng, et al., 2020). For non-randomized observational studies, the Risk of Bias in Non-randomised Studies - of Interventions (ROBINS-I) tool was used to assess bias arising from confounding, participant selection, classification of interventions, deviations from intended interventions, missing data, outcome measurement, and selection of reported results. The overall certainty of the evidence for key outcomes was graded using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (Feng, et al., 2020).

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Data Synthesis

Given the anticipated clinical and methodological heterogeneity across the included studies—such as variations in HbA1c cutoff values, diverse surgical populations, and different study designs—a formal meta-analysis was not deemed appropriate for all outcomes (Dronavalli, et al., 2015; Dhatariya, et al., 2022). Therefore, a narrative synthesis was employed as the primary method of analysis. The findings were grouped by outcome and stratified by the metric of glycemic control (HbA1c versus blood glucose) and by the type of intervention evaluated. Key findings are presented in summary tables to facilitate comparison across studies. In instances where a subset of studies was sufficiently homogenous in terms of population, intervention, and outcome measurement, a random-effects meta-analysis was performed to calculate pooled odds ratios (OR) or mean differences (MD) with their corresponding 95% confidence intervals (CI).

RESULTS

Study Selection and Characteristics

The initial database search yielded 2,363 records. After removing duplicates and screening titles and abstracts, 61 full-text articles were assessed for eligibility. Following a detailed review, 17 studies met the predefined inclusion criteria and were included in this systematic review. The selection process is detailed in a PRISMA flow diagram (not shown). The included studies comprised a mix of RCTs, meta-analyses, and prospective and retrospective cohort studies, covering a wide range of surgical specialties including cardiac, orthopedic, general, and vascular surgery. The characteristics of these 17 key studies are summarized in Table 1.

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Table 1: Characteristics of Included Studies

Author (Year)	Study Design	Population (N, Surgery Type)	Intervention/ Exposure	Comparator	Key Outcomes Measured
Dronavalli, et al. (2015)	Systematic Review	19,514; Various specialties	Elevated preoperative HbA1c	Lower preoperative HbA1c	Mortality, Stroke, VTE, AKI, SSI, LOS
Garg, et al. (2014)	Retrospecti ve Cohort	622; Major non-cardiac	HbA1c >8% or ≤6.5%	HbA1c 6.5-8%	Hospital LOS, Death, Infections, Readmissio n
Hikata, et al. (2014)	Retrospecti ve Cohort	345; Spinal instrumentat ion	HbA1c ≥7.0%	HbA1c <7.0%	SSI
Umpierrez, et al. (2015)	RCT	303; Cardiac surgery	Intensive glucose control (100-140 mg/dL)	Conservative control (141-180 mg/dL)	Mortality, MACE, SSI, AKI, Pneumonia

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Author (Year)	Study Design	Population (N, Surgery Type)	Intervention/ Exposure	Comparator	Key Outcomes Measured
Richards, et al. (2016)	Retrospecti ve Cohort	203; Total joint arthroplasty	APC referral for HbA1c ≥8-10%	No referral / Uncontrolled HbA1c	Complicatio n rate, Prolonged LOS
Everett, et al. (2018)	Retrospecti ve Cohort	10,581,621; Major non-cardiac	Presence of DM	No DM	MACE (Mortality, MI, Stroke)
Hudson, et al. (2018)	Retrospecti ve Cohort	13,077; Cardiac & non-cardiac	Preoperative HbA1c level	N/A (association study)	Perioperativ e glucose, 30-day mortality
Song, et al. (2019)	Retrospecti ve Cohort	108,133; Various specialties	Presence of T2DM	No DM	Postoperativ e pneumonia, Mortality
Feng, et al. (2020)	Meta-analysis of	6 RCTs; Cardiac	Strict glycemic control (<140	Moderate control (140-	Mortality, Stroke,

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Author (Year)	Study Design	Population (N, Surgery Type)	Intervention/ Exposure	Comparator	Key Outcomes Measured
	RCTs	surgery	mg/dL)	180 mg/dL)	Atrial fibrillation, SSI
Holt, et al. (2021)	RCT Protocol	N/A; Elective cardiac	OCTOPuS outpatient intervention	Usual care	Time to clinical fitness for discharge
Kwon, et al. (2021)	Retrospecti ve Cohort	12,304; Non-cardiac	Preoperative hyperglycemia	Normoglyce mia	Myocardial injury (MINS), 30-day mortality
Underwoo d, et al. (2021)	QI Project (Matched Cohort)	60; Various specialties	POET diabetes pathway	Matched controls (usual care)	Glycemic control, LOS, Complicatio ns

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Author (Year)	Study Design	Population (N, Surgery Type)	Intervention/ Exposure	Comparator	Key Outcomes Measured
Dhatariya, et al. (2022)	Scoping Review	61 studies; Various specialties	Presence of DM	No DM	Mortality, Composite complications, Infection
Kwon, et al. (2022)	Retrospective Cohort	111,110; Non-cardiac	Preoperative hyperglycemia	Normoglycemia	Adverse cardiac events (1-year)
Kunze, et al. (2023)	Systematic Review	12 studies; Abdominal, Bariatric	Preoperative patient education	Standard care	LOS, Complications, Anxiety
Pang, et al. (2024)	Retrospective Cohort	39,986; Non-cardiac	Preoperative fasting glucose level	N/A (association study)	Postoperative AKI
Yu, et al. (2024)	Prospective Cohort	79; Elective non-cardiac	Multidisciplinary diabetes clinic	N/A (pre-post design)	HbA1c reduction, LOS,

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Author (Year)	Study Design	Population (N, Surgery Type)	Intervention/ Exposure	Comparator	Key Outcomes Measured
					Infections, Readmissions

Abbreviations: APC, Anesthesia Preoperative Clinic; DM, Diabetes Mellitus; LOS, Length of Stay; MACE, Major Adverse Cardiovascular Events; MI, Myocardial Infarction; MINS, Myocardial Injury after Noncardiac Surgery; N/A, Not Applicable; OCTOPuS, Optimising Cardiac Surgery ouTcOmes in People with diabeteS; POET, Perioperative Enhancement Team; QI, Quality Improvement; RCT, Randomized Controlled Trial; SSI, Surgical Site Infection; T2DM, Type 2 Diabetes Mellitus; VTE, Venous Thromboembolism.

Risk of Bias in Included Studies

The methodological quality of the included studies was variable. The RCT by Umpierrez, et al. (2015) was generally well-conducted, though blinding of personnel to glucose targets is inherently challenging. The meta-analysis by Feng, et al. (2020) highlighted significant methodological limitations in the primary RCTs it included, particularly a high risk of bias related to the lack of blinding of participants, personnel, and outcome assessors across all six trials (Feng, et al., 2020). The quality improvement project by Underwood, et al. (2021) was non-randomized and relied on matching, which carries an inherent risk of residual confounding despite the rigorous matching process (Underwood, et al., 2021). The majority of the evidence was derived from large retrospective cohort studies, which are susceptible to selection bias, measurement bias, and confounding by unmeasured variables. A summary of the risk of bias assessment for key RCTs is

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presented in Table 2.

Table 2: Cochrane Risk of Bias Assessment for Included Randomized Controlled Trials

Study	Randomization Process	Deviations from Intervention	Missing Outcome Data	Measurement of Outcome	Selection of Reported Result	Overall Bias
Umpierrez, et al. (2015)	Low Risk	Low Risk	Low Risk	Some Concerns	Low Risk	Some Concerns
Feng, et al. (2020) (pooled RCTs)	Some Concerns	Low Risk	Low Risk	High Risk	Low Risk	High Risk

Note: Judgments are based on information provided in the source articles. "Some Concerns" for Measurement of Outcome in Umpierrez, et al. (2015) reflects the inherent difficulty in blinding personnel to glycemic targets. "High Risk" for Feng, et al. (2020) reflects the authors' own assessment of the primary trials, noting a universal lack of blinding for participants, personnel, and outcome assessors (Feng, et al., 2020).

Synthesis of Findings by Outcome Domain

The relationship between preoperative glycemic control and postoperative outcomes was analyzed across several key domains. The findings are detailed below and summarized in Tables 3

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through 7.

Association with Infectious Complications

The evidence consistently and strongly demonstrates an association between poor glycemic control and an elevated risk of infectious complications, particularly Surgical Site Infection (SSI). The mere presence of DM was found to be a significant risk factor for SSI (Shoji, et al., 2023). This risk is magnified in patients with poor glycemic control, with studies utilizing HbA1c as the primary metric revealing a clear dose-response relationship. Acute perioperative hyperglycemia is also a powerful predictor of infection, though this risk appears to be mitigated by the timely administration of insulin (Kwon, et al., 2013). Poor glycemic control is also linked to a higher risk of a composite of infectious complications that includes pneumonia, urinary tract infection (UTI), and sepsis (Dronavalli, et al., 2006; Song, et al., 2019).

Table 3: Summary of Key Findings on Infectious Complications

Author (Year)	Glycemic Metric	Key Finding	Effect Size (OR/RR/HR)
Hikata, et al. (2014)	HbA1c >7.0%	Increased SSI rate in spinal surgery (35.3% vs 0.0%)	Not Reported
Yong, et al. (2019)	HbA1c >8.0%	Increased odds of 30-day SSI	OR 2.4-3.0
Kwon, et al. (2013)	BG >180 mg/dL	Increased risk of	OR 2.0

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Author (Year)	Glycemic Metric	Key Finding	Effect Size (OR/RR/HR)
		infection	
Dronavalli, et al. (2006)	HbA1c <7%	Decreased composite infectious complications	Adjusted OR 2.13
Song, et al. (2019)	Presence of T2DM	Higher incidence of postoperative pneumonia (3.2% vs 1.7%)	Not Reported
Feng, et al. (2020)	Strict Glycemic Control	Significant reduction in sternal wound infection	OR 0.28
Shoji, et al. (2023)	Presence of DM	Increased risk of SSI in lower extremity fractures	OR 1.79

Association with Cardiovascular and Cerebrovascular Events

The data confirm that patients with DM experience a higher rate of perioperative Major

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Adverse Cardiovascular and Cerebrovascular Events (MACE) compared to their non-diabetic counterparts (Everett, et al., 2018). Preoperative hyperglycemia has been identified as a significant predictor of adverse cardiac events for up to one year post-surgery (Kwon, et al., 2022). In contrast, some studies suggest that while acute hyperglycemia is associated with myocardial injury, the long-term marker HbA1c is not (Kwon, et al., 2021). Intensive perioperative glycemic control may reduce the risk of cardiovascular events, though this finding is based on low-certainty evidence (Bellon, et al., 2023).

Table 4: Summary of Key Findings on Cardiovascular and Cerebrovascular Events

Author (Year)	Glycemic Metric	Key Finding	Effect Size (OR/RR/HR)
Everett, et al. (2018)	Presence of DM	Higher rate of MACE (3.3% vs 2.8%)	Not Reported
Kwon, et al. (2022)	Preoperative Hyperglycemia	Increased risk of 1-year adverse cardiac events	HR 1.26
Kwon, et al. (2021)	Preoperative Hyperglycemia	Increased risk of MINS	OR 1.29
Feng, et al. (2020)	Strict Glycemic Control	Significant reduction in	OR 0.48

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		postoperative atrial fibrillation	
Bellon, et al. (2023)	Intensive Glycemic Control	Potential reduction in cardiovascular events	RR 0.73

Association with Resource Utilization

Prolonged Length of Stay (LOS) is one of the most consistently reported outcomes associated with poor glycemic control. A notable study by Garg, et al. (2014) identified a U-shaped relationship, where both very low and high HbA1c levels were associated with significantly longer hospital LOS. Interventions such as multidisciplinary preoperative clinics have demonstrated the ability to reduce preoperative HbA1c and are associated with shorter LOS (Yu, et al., 2024). Similarly, DM is a significant risk factor for 30-day hospital readmission, an outcome that can be improved with structured interventions (Song, et al., 2022; Mosen, et al., 2015).

Table 5: Summary of Key Findings on Resource Utilization

Author (Year)	Glycemic Metric / Intervention	Key Finding	Effect Size (OR/RR/HR)
Garg, et al. (2014)	HbA1c >8%	Significantly longer hospital LOS	Not Reported
Richards, et al.	Uncontrolled	Associated with	Not Reported

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(2016)	HbA1c	prolonged hospitalization	
Song, et al. (2022)	Presence of DM	Increased risk of 30-day hospital readmission	OR 1.404
Mosen, et al. (2015)	Pharmacist-led Program	Reduced 3-month readmission rates	Not Reported
Yu, et al. (2024)	Multidisciplinary Clinic	Low median LOS of 2 days post-intervention	Not Reported

Association with Mortality and Other Surgical Morbidities

The evidence regarding the impact of preoperative glycemic control on short-term mortality is mixed. Several large reviews found that an elevated preoperative HbA1c was not definitively associated with 30-day mortality (Dronavalli, et al., 2015; Feng, et al., 2020; Bellon, et al., 2023). In stark contrast, acute perioperative hyperglycemia has been linked to a significantly increased risk of death (Kwon, et al., 2013). The relationship with Acute Kidney Injury (AKI) is also conflicting, with some studies showing an association with HbA1c and others with acute glucose, particularly in non-diabetic patients (Li, et al., 2022; Pang, et al., 2024).

Table 6: Summary of Key Findings on Mortality and Other Morbidities

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Author (Year)	Glycemic Metric	Key Finding	Effect Size (OR/RR/HR)
Kwon, et al. (2013)	BG >180 mg/dL	Increased risk of death (negated by insulin treatment)	OR 2.71
Frisch, et al. (2013)	Preoperative Hyperglycemia	Associated with higher 1-year mortality	Not Reported
Dronavalli, et al. (2015)	Elevated HbA1c	No definitive association with 30-day mortality	Not Reported
Pang, et al. (2024)	Fasting Glucose	Predicts AKI in non-DM patients, but not in DM patients	Not Reported
Li, et al. (2022)	HbA1c >7.2\%	Independent predictor for postoperative AKI	OR 2.869
Song, et al. (2022)	Presence of DM	Increased risk of	OR 1.568 / OR

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Author (Year)	Glycemic Metric	Key Finding	Effect Size (OR/RR/HR)
		reoperation and wound healing disorders	2.010

Efficacy of Preoperative Optimization Interventions

Structured preoperative optimization programs show considerable promise in improving glycemic control and associated outcomes. Multidisciplinary clinics and pharmacist-led interventions have demonstrated success in reducing preoperative HbA1c levels and improving clinical outcomes such as LOS and readmission rates (Yu, et al., 2024; Mosen, et al., 2015). Patient education, a key component of these programs, is also independently associated with better outcomes (Kunze, et al., 2023).

Table 7: Summary of Preoperative Optimization Intervention Studies

Author (Year)	Intervention Type	Key Impact on Glycemic Control	Key Impact on Clinical Outcomes
Yu, et al. (2024)	Multidisciplinary Clinic	Significant reduction in preoperative HbA1c	Low median LOS (2 days), low incidence of infections/readmissions

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Author (Year)	Intervention Type	Key Impact on Glycemic Control	Key Impact on Clinical Outcomes
Richards, et al. (2016)	APC Referral for high HbA1c	Implicitly improved control	Reduced complication rate and prolonged LOS
Underwood, et al. (2021)	POET Diabetes Pathway	Improved perioperative glucose control	Not specified
Mosen, et al. (2015)	Pharmacist-led Program	Improved perioperative glycemic control	Reduced 3-month readmission rates and medical costs
Kunze, et al. (2023)	Patient Education (Systematic Review)	Not directly measured	Reduced LOS and postoperative complications

DISCUSSION

Summary and Interpretation of Principal Findings

This systematic review synthesizes a broad range of evidence, confirming that Diabetes Mellitus is a potent and independent risk factor for a wide array of adverse postoperative outcomes, most notably infections, cardiovascular events, and increased healthcare resource utilization (Ng, et al., 2024; de Groot, et al., 2024; Song, et al., 2022). The central theme that emerges from the data is

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that the hyperglycemic state, whether it reflects chronic dysglycemia or an acute perioperative surge, is a key physiological mediator of this increased risk. The period between the decision for elective surgery and the procedure itself represents a crucial, often underutilized, window for intervention. This is not merely a passive waiting period for risk assessment but an active therapeutic phase. The high prevalence of undiagnosed diabetes among surgical candidates further underscores this period as a critical point for public health screening and the initiation of care (Duggan, et al., 2022; Setji, et al., 2017). Framing this timeframe as a "critical intervention window" shifts the clinical mindset from a simple "go/no-go" decision based on a single biomarker to a proactive, goal-directed therapeutic process. This has profound implications for healthcare system design, necessitating integrated care pathways that connect surgical, anesthesia, primary care, and endocrinology services to effectively utilize this opportunity (Richards, et al., 2016; Setji, et al., 2017; Underwood, et al., 2021).

The Predictive Value of Glycemic Markers: HbA1c vs. Acute Glucose

A major point of contention within the literature is the relative importance of long-term glycemic control, reflected by HbA1c , versus short-term control, indicated by perioperative blood glucose levels. A compelling body of evidence suggests that acute perioperative hyperglycemia is the more direct and powerful predictor of immediate postoperative complications such as myocardial injury, AKI (particularly in non-diabetics), and short-term mortality (Kwon, et al., 2013; Pang, et al., 2024; Kwon, et al., 2021; Frisch, et al., 2013). This is strongly supported by findings that the timely administration of insulin to treat acute hyperglycemia effectively mitigates the associated risks of these adverse outcomes (Kwon, et al., 2013).

However, the role of HbA1c should not be dismissed. Its primary value may lie not as a direct causal agent for all acute complications, but as an excellent predictor of which patients are most likely to experience poor *perioperative* glucose control (Setji, et al., 2017; Hudson, et al., 2018). Furthermore, several high-quality studies demonstrate a clear, often dose-dependent, relationship between higher preoperative HbA1c levels and increased risks of SSIs and prolonged

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LOS (Hikata, et al., 2014; Garg, et al., 2014; Yong, et al., 2019). The "U-shaped" risk curve observed in some studies, where both very low and very high HbA1c levels are associated with worse outcomes, adds a layer of complexity, suggesting that factors such as hypoglycemia risk in tightly controlled patients also contribute to overall morbidity (Ng, et al., 2024; Garg, et al., 2014).

This evidence suggests a necessary evolution in the clinical paradigm. An elevated HbA1c should not be used as a rigid, arbitrary gatekeeper to deny or indefinitely postpone necessary surgery. Instead, its primary utility is as a risk stratification tool. An HbA1c level above a certain threshold (e.g., 8%) should not trigger an automatic cancellation but rather an automatic activation of a dedicated "high-risk" perioperative management pathway. This pathway would encompass more intensive preoperative education, medication optimization, and, crucially, a predefined, aggressive protocol for intra- and postoperative glycemic control. This reframes HbA1c from a barrier to surgery into a trigger for enhanced, targeted care.

Efficacy of Preoperative Optimization Models

The evidence, though derived largely from non-randomized studies, strongly supports the implementation of structured preoperative optimization programs. Multidisciplinary clinics that bring together diabetologists, specialist nurses, and clinical pharmacists have demonstrated significant success in reducing preoperative HbA1c levels, with the greatest improvements seen in patients who have the poorest baseline glycemic control (Yu, et al., 2024).

Pharmacist-led interventions appear particularly promising. These programs have been associated with improved perioperative glycemic control, reduced rates of hypoglycemia, lower 3-month readmission rates, and decreased overall medical costs (Mosen, et al., 2015). Clinical pharmacists are uniquely positioned to manage complex medication adjustments, provide detailed patient education, and implement proactive protocols to identify and treat hyperglycemia in the immediate preoperative phase (Gurney, et al., 2023). Patient education is a cornerstone of these programs and is independently associated with improved glycemic control, enhanced self-care practices, and better medication adherence (Wolfe, 2021; Alrasheedy, et al., 2022). When integrated

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into Enhanced Recovery After Surgery (ERAS) protocols, preoperative education has been shown to reduce both LOS and postoperative complications (Kunze, et al., 2023; Patel, et al., 2024).

Strengths and Limitations of the Evidence Base

A key strength of this review is the large and growing body of literature available for synthesis, which allows for the evaluation of a wide range of outcomes across diverse surgical specialties. The consistency of findings regarding the increased risk of SSIs and prolonged LOS provides a strong and reliable signal that poor glycemic control is detrimental.

The primary limitation, however, is the predominance of retrospective observational studies in the literature (Dronavalli, et al., 2015). This introduces a significant risk of selection bias and confounding from unmeasured variables. There is marked heterogeneity across studies in the HbA1c thresholds used for risk stratification, the specific definitions of outcomes, and the characteristics of patient populations, which makes direct comparisons and formal meta-analysis challenging (Dronavalli, et al., 2015; Dhatariya, et al., 2022). Furthermore, many studies are underpowered to detect differences in less frequent but critical outcomes like mortality (Garg, et al., 2014). The scarcity of high-quality, large-scale RCTs, such as the ongoing OCTOPuS trial, represents a major evidence gap that needs to be addressed (Holt, et al., 2021).

Implications for Clinical Practice and Future Research

For clinical practice, the evidence supports screening all surgical patients for DM and obtaining an HbA1c measurement if one has not been performed in the preceding three months (Mendez, et al., 2024). An elevated HbA1c (e.g., >8%) should serve as a trigger for referral to a structured optimization pathway rather than an automatic cancellation of surgery. This pathway should focus on comprehensive medication management, targeted patient education, and the establishment of a clear plan for intensive *perioperative* glucose monitoring and management. A target blood glucose range of 80–180 mg/dL remains a reasonable and widely accepted goal for most patients throughout the perioperative period (Mendez, et al., 2024; NYSDOH, 2019).

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For future research, there is a critical need for large, multicenter RCTs to definitively evaluate the clinical and cost-effectiveness of various preoperative optimization strategies. Future trials should emulate the design of studies like the OCTOPuS trial, comparing a standardized, multidisciplinary intervention against usual care and measuring a comprehensive set of patient-centered outcomes, including quality of life, LOS, readmissions, and specific complications (Holt, et al., 2021). Further investigation is also required to clarify the mechanisms behind the U-shaped risk curve and to determine optimal, individualized glycemic targets for different surgical populations and procedures.

CONCLUSION

Conclusive Summary

The available evidence overwhelmingly supports a strong and consistent association between poor glycemic control in patients with diabetes mellitus and an increased risk of a broad spectrum of adverse postoperative outcomes. The most robust evidence links dysglycemia to higher rates of surgical site infections and prolonged hospital length of stay. While acute perioperative hyperglycemia appears to be a more proximate driver of immediate cardiovascular and mortality risk, the preoperative HbA1c level remains a crucial and indispensable tool for identifying high-risk individuals in need of focused intervention. Structured preoperative optimization programs, particularly those employing a multidisciplinary or pharmacist-led approach, have proven effective at improving glycemic control prior to surgery, though their direct impact on hard clinical outcomes requires further validation through rigorous trials.

Recommendations

Based on this synthesis, the following recommendations are proposed:

1. **For Health Systems:** Investment should be directed towards the development and implementation of integrated preoperative diabetes optimization pathways. These pathways should be designed to systematically identify, risk-stratify, and manage high-risk surgical

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patients, ensuring seamless coordination between surgical, medical, and anesthesia services.

2. **For Clinical Practice:** Clinical practice guidelines should evolve to emphasize the role of HbA1c as a trigger for activating enhanced perioperative care protocols rather than as a rigid cutoff for proceeding with elective surgery. The focus should shift from a simple preoperative threshold to a comprehensive perioperative management strategy.
3. **For Future Research:** The research community must prioritize well-designed, adequately powered randomized controlled trials. These studies are essential to establish a definitive causal link between specific optimization strategies and improved clinical outcomes, which will be fundamental for guiding future evidence-based clinical practice and health policy.

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