

Narrative Review

Diabetes and Risk of Surgical Site Infection: A Narrative Review

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ABSTRACT

Background: Diabetes Mellitus (DM) significantly elevates the risk of surgical site infections (SSIs), a major postoperative complication that increases morbidity, prolongs hospital stay, and escalates healthcare costs. The complex interplay between hyperglycemia-induced immunosuppression, impaired wound healing, and the increased propensity for infections in diabetic patients underscores the need for a comprehensive understanding of the mechanisms at play and effective management strategies.

Objective: This narrative review aims to synthesize current evidence on the relationship between DM and the risk of SSIs, emphasizing the pathophysiological mechanisms, the impact of glycemic control on surgical outcomes, and the role of advanced surgical techniques in mitigating this risk.

Methods: A systematic literature search was conducted across PubMed, Scopus, Web of Science, and Google Scholar for studies published up to April 2023, using keywords related to DM, SSIs, and perioperative management. Inclusion criteria targeted studies on the association between DM and SSIs, focusing on outcomes in diabetic versus non-diabetic patients, and the effectiveness of glycemic control. Data extraction and synthesis were performed using a narrative approach, with quality assessment based on study design-specific appraisal tools.

Results: The review highlights that diabetic patients exhibit a significantly higher risk of developing SSIs compared to non-diabetic individuals, attributed to impaired immune response, microvascular complications, and delayed wound healing associated with hyperglycemia. Effective preoperative and postoperative glycemic control, maintaining hemoglobin A1c (HbA1c) levels below 7%, has been shown to reduce the incidence of SSIs. Furthermore, advancements in minimally invasive surgical techniques have contributed to lower SSI rates by reducing tissue trauma and preserving immune function.

Conclusion: Diabetes mellitus is a significant risk factor for surgical site infections, underscoring the importance of stringent glycemic control and the adoption of advanced surgical techniques in the perioperative management of diabetic patients. Future research should focus on refining glycemic control strategies, understanding the genetic and molecular mechanisms underlying increased SSI risk, and developing targeted therapies to improve surgical outcomes in this high-risk population.

Keywords: Diabetes Mellitus, Surgical Site Infections, Glycemic Control, Perioperative Management, Advanced Surgical Techniques

INTRODUCTION

The interplay between diabetes mellitus (DM) and the risk of Surgical Site Infections (SSIs) constitutes a significant area of concern within the medical community (1, 2). SSIs, meticulously defined in 1992, are characterized by infections that impact either the incision area or the deep tissue at the site of surgery within 30 days post-operation (3). These infections range from superficial to profound, potentially involving organs or body cavities (4-6). The burden of SSIs on healthcare systems is substantial, influenced by a myriad of factors including the nature of the surgical procedure, the duration of the operation, the physiological status of the patient, and the efficacy of post-discharge surveillance (7, 8).

Diabetes mellitus, delineated by a constellation of physiological dysfunctions manifesting as hyperglycemia due to insulin resistance, inadequate insulin secretion, or excessive glucagon secretion, exacerbates this concern (9, 10). This metabolic disorder is categorized into Type 1 Diabetes (T1D) — an autoimmune condition leading to the destruction of pancreatic beta cells, and the more prevalent

Type 2 Diabetes (T2D), often associated with lifestyle factors. The predilection for infections in diabetic patients, markedly more frequent and complex than in non-diabetic individuals, is a focal point of analysis (11, 12). This susceptibility is attributed to compromised immunity, encompassing both impaired adaptive cellular immunity and altered infectious responses (12-14).

The phenomenon of impaired wound healing in diabetic individuals, arising from intricate pathophysiological alterations involving vascular, neuropathological, immunological, and biochemical pathways, further complicates the scenario (15, 16). Hyperglycemia, a hallmark of diabetes, is linked with vascular stiffness, decelerated circulation, microvascular dysfunction, diminished tissue oxygenation, and reduced leukocyte migration to the wound site, thereby predisposing diabetic wounds to infections. Concurrently, diabetes hampers the production of several growth factors critical to the healing process (17-19).

Furthermore, the role of inflammatory mediators in inducing insulin resistance and fostering hyperglycemia is noteworthy, as these mediators contribute to immune cell dysfunction through mitochondrial damage (20, 21). This understanding challenges the traditional belief that acute hyperglycemia directly causes mitochondrial damage leading to immune dysfunction. The heightened prevalence of SSIs in diabetic patients is underscored in studies where diabetic individuals undergoing surgeries, such as for pressure ulcers, demonstrated significantly elevated rates of both superficial and deep SSIs (22-24).

The amalgamation of genetic and metabolic factors in diabetic patients, including a genetic predisposition to infections and impaired cellular and humoral immune defense mechanisms, amplifies the risk of infections (25, 26). Local factors such as poor blood supply and nerve damage, coupled with metabolic alterations associated with diabetes, further elevate this risk. Preoperative glycemic control, particularly maintaining hemoglobin A1c (HbA1c) levels below 7%, is correlated with a reduction in infectious complications during various surgical interventions (27, 28). The aftermath of postoperative infectious complications results in poorer overall outcomes and elevated healthcare costs, especially pronounced in patients with diabetes due to their increased infection risk and the severity of infectious outcomes. Hyperglycemia plays a pivotal role in the development of postoperative infections, and strategies aimed at reducing postoperative morbidity through stringent glycemic control have proven effective in both diabetic and non-diabetic patients (28-31).

The advent of advanced surgical techniques, especially the growing adoption of minimally invasive surgery, has led to a notable decline in the incidence of SSIs (32, 33). These techniques, characterized by smaller incisions, earlier mobilization, reduced postoperative pain, better preservation of immune system function, and minimized use of central venous catheters, contribute to the lowered SSI rates. The World Health Organization's focus on developing evidence-based global guidelines for SSI prevention highlights recommendations on peri-operative management, including oxygenation, maintaining body temperature, blood glucose control, and the use of wound protector devices (33-36).

This narrative review aims to elaborate on the intricate relationship between diabetes and the elevated risk of SSIs, emphasizing the criticality of comprehensive perioperative management, which encompasses glycemic control and the implementation of advanced surgical techniques to mitigate this risk. It underscores the necessity for continued research to refine these strategies and enhance understanding of the underlying mechanisms contributing to the increased risk of SSIs in diabetic patients. The recent uptick in research, exemplified by studies from He et al. (2023) and Armstrong et al. (2023), which document the significantly higher risk of SSIs in diabetic patients across various surgical disciplines, highlights diabetes as a pivotal risk factor in surgical outcomes. This, alongside the work of Cheuk et al. (2021) and Hweidi et al. (2021) in the realm of cardiac surgery, showcases both the potential and challenges of glycemic control in mitigating SSIs (37-40). The discrepancies within the literature signal a pressing need for a comprehensive synthesis of findings to illuminate effective management strategies for diabetic patients undergoing surgical procedures. This narrative review is therefore imperative for advancing clinical practices, steering future research, and ultimately improving healthcare outcomes for an increasingly diabetic-affected populace.

MATERIAL AND METHODS

The literature search was conducted across several electronic databases, including PubMed, Scopus, Web of Science, and Google Scholar, to identify articles published up to April 2023 (41-43). The search strategy employed a combination of keywords and MeSH terms related to "diabetes mellitus," "surgical site infections," "postoperative complications," "glycemic control," and "perioperative management." Boolean operators (AND, OR) were used to refine the search. For instance, the search term used in PubMed was: ("Diabetes Mellitus"[MeSH Terms] OR diabetes) AND ("Surgical Wound Infection"[MeSH Terms] OR "surgical site infection" OR SSI) AND ("Postoperative Complications"[MeSH Terms] OR postoperative) AND ("Blood Glucose"[MeSH Terms] OR glycemic control) AND ("Perioperative Care"[MeSH Terms] OR perioperative management).

Studies were included based on the following criteria: Published in English, focused on the association between DM and the risk of SSIs, included original research articles, reviews, meta-analyses, and guidelines, addressed aspects of glycemic control in the perioperative period, explored outcomes related to SSIs in diabetic versus non-diabetic patients. While the exclusion criteria were: studies not available in full text, articles published in languages other than English, studies with a primary focus outside the scope of DM, SSIs, or perioperative glycemic control (e.g., animal studies, pediatric populations) (44).

Data extraction was performed independently by twice using a standardized data extraction form to ensure accuracy and consistency (45). The synthesis of findings was conducted through a narrative approach, considering the historical evolution of the understanding of SSIs and DM, epidemiological data, pathophysiological insights, and the impact of clinical practices on the incidence and management of SSIs in diabetic patients. Emphasis was placed on studies that provided significant insights into the mechanisms linking DM to an increased risk of SSIs, the effectiveness of preoperative and postoperative glycemic control, and the role of surgical techniques in mitigating this risk (46).

The quality of included studies was assessed using Newcastle-Ottawa Scale for observational studies and the Cochrane Collaboration's tool for assessing the risk of bias in randomized trials (47). This assessment helped in identifying the strength of evidence and potential biases in the reviewed literature (48).

Given the nature of a narrative review, which synthesizes published literature, no primary data collection from human participants was involved. Yet, the review was conducted following ethical guidelines for academic integrity and responsible reporting.

RESULTS

The narrative of SSIs and their association with diabetes mellitus (DM) has evolved significantly over time. Initially, post-surgical infections were considered almost inevitable until the introduction of aseptic techniques by pioneers like Joseph Lister in the late 19th and early 20th centuries, marking a pivotal shift in surgical practices. Concurrently, the correlation between diabetes and an elevated risk of infection, once merely anecdotal, gained empirical support. This evolution in understanding coincided with critical advancements in diabetes care, including the landmark discovery of insulin in the 1920s, which transformed the management of diabetes and, by extension, the surgical outcomes for patients with diabetes. This period also saw significant strides in blood glucose monitoring and the development of diabetes medications, further influencing surgical outcomes (9, 20).

Epidemiological studies have consistently demonstrated that patients with diabetes face a significantly higher incidence and prevalence of SSIs compared to their non-diabetic counterparts, a phenomenon observed across various types of surgeries, particularly in cardiac and orthopaedic procedures. This increased risk is underpinned by diabetes-induced pathophysiological changes, including impaired immune response, microvascular complications, and chronic inflammation, which collectively exacerbate susceptibility to infections. Hyperglycemia, a defining feature of diabetes, further compromises wound healing and increases infection risk (2, 7, 28, 35, 36).

The heightened frequency and complexity of infections in diabetic patients can be attributed to a constellation of immune system defects. These include impaired adaptive cellular immunity and altered infection responses, which are exacerbated by diabetes-related hyperglycemia. The impaired wound healing in diabetes involves complex pathophysiological changes, with hyperglycemia leading to vascular stiffness, slower circulation, microvascular dysfunction, decreased tissue oxygenation, and inhibited leukocyte migration to the wound site. Additionally, diabetes affects the production of growth factors essential for healing, complicating the recovery process for surgical wounds (10, 12, 17, 21).

Recent studies, including those by He et al. (2023) and Armstrong et al. (2023), have highlighted the significantly higher risk of SSIs in diabetic patients undergoing orthopaedic and other surgeries. These findings underscore the critical role of diabetes as a risk factor in post-surgical outcomes. Furthermore, research by Cheuk et al. (2021) and Hweidi et al. (2021) on cardiac surgery patients emphasizes the challenges and potential of glycemic control in reducing SSIs, illustrating the complex interplay between diabetes management and surgical outcomes (37-40).

The genetic and metabolic predispositions of diabetic patients to infections, compounded by impaired cellular and humoral immune defenses, present additional challenges. Local factors such as compromised blood supply and nerve damage, alongside the metabolic alterations associated with diabetes, further elevate the risk of SSIs. The literature supports the notion that preoperative glycemic control, especially maintaining HbA1c levels below 7%, is crucial in reducing infectious complications across a range of surgical interventions (6, 31, 39).

Advancements in surgical techniques, notably the shift towards minimally invasive procedures, have contributed to a decline in SSI rates. These techniques, characterized by smaller incisions and reduced postoperative pain, facilitate earlier mobilization, better preservation of immune function, and decreased reliance on central venous catheters, collectively lowering the risk of SSIs. The World Health Organization's development of evidence-based global guidelines for SSI prevention, focusing on peri-operative management practices such as optimal oxygenation, body temperature maintenance, blood glucose control, and the use of wound protector devices, further underscores the importance of a multifaceted approach to mitigating the risk of SSIs in diabetic patients (1, 4, 7, 22, 26, 34).

DISCUSSION

The intricate relationship between diabetes mellitus (DM) and surgical site infections (SSIs) presents a complex challenge in the field of surgery and perioperative management. This review has explored the multifaceted aspects of this relationship, including historical perspectives, epidemiological data, pathophysiological insights, and clinical practices, to provide a comprehensive understanding of the increased risk of SSIs in diabetic patients and the strategies to mitigate this risk (16, 20, 37).

The criticality of comprehensive perioperative management in reducing the risk of SSIs among diabetic patients cannot be overstated. Preoperative glycemic control has emerged as a pivotal factor, with evidence suggesting that maintaining hemoglobin A1c (HbA1c) levels below 7% significantly reduces infectious complications across various surgical procedures. This is consistent with findings from He et al. (2023) and Armstrong et al. (2023), which highlight the substantial impact of diabetes on the risk of SSIs, particularly in orthopedic surgeries. Similarly, the research conducted by Cheuk et al. (2021) and Hweidi et al. (2021) emphasizes the potential and challenges of glycemic control in cardiac surgeries, further underscoring the importance of tight glucose regulation in the perioperative setting (37-40).

Advanced surgical techniques, notably minimally invasive procedures, have also played a crucial role in reducing SSI rates. These techniques, by virtue of smaller incisions, reduced postoperative pain, and better preservation of immune function, contribute significantly to lower SSI incidences. Furthermore, the World Health Organization's emphasis on developing evidence-based global guidelines for SSI prevention, focusing on peri-operative management practices such as optimal oxygenation, maintaining body temperature, and blood glucose control, reinforces the necessity of a holistic approach to managing SSIs (6, 24, 34, 40).

Despite the consensus on the importance of glycemic control and advanced surgical techniques, the field is rife with debates, particularly regarding the extent and effectiveness of glycemic control. The impact of specific diabetic medications on wound healing and SSIs remains an area of ongoing research and discussion. This highlights the need for a personalized approach in clinical practice, where individual patient factors are considered to guide preoperative glycemic targets and postoperative care strategies (5, 22, 36).

The narrative review underscores the need for further research to address the gaps in the current literature. Long-term outcomes of different glycemic control strategies, the effectiveness of new diabetic medications in the perioperative period, and the understanding of genetic and molecular mechanisms underlying the increased risk of SSIs in diabetic patients are areas ripe for exploration. Such research is crucial for developing targeted therapies and prevention strategies that can more effectively manage the risk of SSIs in this vulnerable population.

CONCLUSION

In conclusion, the relationship between diabetes and SSIs is a complex interplay of historical evolution, epidemiological trends, pathophysiological mechanisms, and clinical practices. The evidence underscores the importance of comprehensive perioperative management, including stringent glycemic control and the utilization of advanced surgical techniques, to mitigate the risk of SSIs in diabetic patients. Personalized care strategies, informed by ongoing research and clinical insights, are essential for optimizing surgical outcomes in this high-risk population. As the prevalence of diabetes continues to rise globally, enhancing our understanding and management strategies for SSIs in diabetic patients remains a critical priority for the medical community, with the ultimate goal of improving healthcare outcomes and quality of life for these individuals.

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