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ORIGINAL ARTICLE

Influence of Perioperative Hemodynamic Instability and Glycemic Control on Postoperative Complications in Patients Undergoing Major Abdominal Surgery

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ABSTRACT

Background: Major abdominal surgeries are physiologically demanding and frequently associated with perioperative hemodynamic fluctuations and glycemic disturbances. Both hypotension and hyperglycemia have been independently linked to poor surgical outcomes. However, their combined impact on postoperative complications remains underexplored, particularly in resource-limited settings.

Objective: To evaluate the influence of perioperative hemodynamic instability and glycemic control on the incidence and severity of postoperative complications in patients undergoing major abdominal surgeries.

Methods: This prospective observational study was conducted from June 2022 to May 2023 at Prime Teaching Hospital, Peshawar, and Combined Military Hospital (CMH), Rawalpindi. A total of 100 adult patients undergoing elective major abdominal surgeries were enrolled. Intraoperative hemodynamic instability was defined as a sustained mean arterial pressure (MAP) <65 mmHg for more than 10 minutes. Hyperglycemia was defined as any blood glucose level >180 mg/dL in the perioperative period. Postoperative complications were monitored for 30 days and included surgical site infections, delayed wound healing, ICU admission, acute kidney injury, and prolonged hospital stay.

Results: Hemodynamic instability occurred in 31% of patients and perioperative hyperglycemia in 44%. Postoperative complications were significantly higher in patients with hypotension (80.6%) compared to those without (24.6%; $p < 0.001$), and in hyperglycemic patients (68.2%) compared to normoglycemic patients (21.4%; $p < 0.001$). The most common complications were surgical site infections (24%), delayed wound healing (18%), and ICU admission (16%). Dual presence of hypotension and hyperglycemia was associated with the highest complication burden.

Conclusion: Perioperative hemodynamic instability and hyperglycemia are strong, independent predictors of postoperative complications in major abdominal surgery. Early recognition and management of these modifiable parameters are critical to improving surgical outcomes, especially in high-risk and resource-constrained environments.

Keywords: Hemodynamic instability, hyperglycemia, abdominal surgery, postoperative complications, mean arterial pressure, surgical site infection

INTRODUCTION

Major abdominal surgeries, such as colectomies, gastrectomies, hepatectomies, and pancreatectomies, are among the most physiologically demanding surgical procedures, requiring meticulous perioperative management to prevent complications and ensure favorable outcomes[1]. These surgeries are associated with significant blood loss, fluid shifts, metabolic stress, and inflammatory responses that can destabilize cardiovascular and endocrine homeostasis. As a result, perioperative complications remain a major concern in surgical practice, contributing substantially to patient morbidity, prolonged hospital stays, higher costs, and even mortality[2].

One of the most critical perioperative concerns is hemodynamic instability, particularly intraoperative hypotension, which has been shown to compromise end-organ perfusion and oxygen delivery. When mean arterial pressure (MAP) falls below 65 mmHg for extended periods, there is a heightened risk of ischemia in vital organs such as the kidneys, brain, and heart[3]. Multiple studies have demonstrated a clear association between intraoperative hypotension and postoperative complications, including acute kidney injury (AKI), myocardial infarction, stroke, and increased need for intensive care unit (ICU) support. Yet, despite the availability of advanced hemodynamic monitoring tools, episodes of uncontrolled hypotension continue to occur, especially in high-risk surgeries, indicating a need for stricter intraoperative blood pressure management protocols[4].

Parallel to hemodynamic concerns, glycemic control during the perioperative period has also emerged as a vital determinant of surgical outcomes. Surgical stress induces a neuroendocrine response that increases the secretion of counter-regulatory hormones such as cortisol, epinephrine, glucagon, and growth hormone[5]. These hormones promote insulin resistance, leading to elevated blood glucose levels even in non-diabetic individuals. Hyperglycemia has deleterious effects on immune function, inflammation, and endothelial integrity, which impairs wound healing, increases susceptibility to infections, and delays recovery. Evidence suggests that both diabetic and non-diabetic patients with perioperative hyperglycemia are at increased risk for surgical site infections (SSIs), delayed wound healing, sepsis, and even mortality. Moreover, glucose variability frequent fluctuations between hypo- and hyperglycemia has also been associated with adverse postoperative outcomes, independent of absolute glucose levels[6, 7].

While several studies have independently examined the impact of hemodynamic instability and hyperglycemia on surgical outcomes, there is limited research investigating their combined influence in the context of major abdominal surgeries[8]. Given the complexity and invasiveness of these procedures, patients are especially vulnerable to intraoperative blood pressure fluctuations and glycemic derangements. The dual burden of hemodynamic and metabolic instability may act synergistically to impair tissue perfusion, compromise immune defenses, and delay tissue repair, thereby increasing the risk of adverse postoperative events[9].

Furthermore, developing nations, including many healthcare institutions in South Asia, often face resource constraints that limit advanced perioperative monitoring and intensive postoperative care. Therefore, identifying simple yet powerful physiological predictors of poor outcomes such as MAP and glucose levels can help optimize patient care, even in low-resource settings[10].

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This study aims to bridge this critical knowledge gap by evaluating the influence of perioperative hemodynamic instability and glycemic control on the development of postoperative complications in patients undergoing major abdominal surgery. By establishing clear associations between these modifiable perioperative parameters and patient outcomes, this research seeks to inform perioperative management strategies, promote the adoption of evidence-based monitoring protocols, and ultimately enhance the safety and efficacy of surgical care[11].

MATERIALS AND METHODS

Study Design and Study Sites: This prospective observational clinical study was conducted to assess the influence of perioperative hemodynamic instability and glycemic control on the development of postoperative complications in patients undergoing major abdominal surgeries. The study was carried out at two tertiary care institutions in Pakistan: Prime Teaching Hospital, Peshawar, and Combined Military Hospital (CMH), Rawalpindi. Both centers were selected for their high surgical caseloads, availability of intensive monitoring during surgery, and well-equipped postoperative care units, making them ideal for studying complex surgical outcomes.

Study Duration and Sampling: The study was conducted over a one-year period, from June 2022 to May 2023. A total of 100 patients were enrolled using a non-probability consecutive sampling technique. All patients who fulfilled the eligibility criteria and underwent major abdominal surgeries during the defined study period were included until the target sample size was achieved.

Eligibility Criteria: The study included adult patients aged between 18 and 75 years who were scheduled for elective major abdominal surgeries such as colectomies, gastrectomies, hepatic resections, or pancreatic surgeries under general anesthesia. Only patients classified as ASA physical status I to III were considered. Patients were required to provide written informed consent before enrollment. Exclusion criteria included patients undergoing emergency surgeries, those with advanced organ failure such as end-stage renal disease on dialysis or NYHA class IV heart failure, individuals with endocrine disorders affecting glucose homeostasis apart from type 2 diabetes mellitus, patients on long-term corticosteroid therapy, and pregnant women.

Preoperative Evaluation and Baseline Data Collection: All patients underwent a thorough preoperative assessment one day before surgery. This included a detailed medical history, physical examination, and baseline laboratory investigations such as complete blood count, renal function tests, and fasting blood glucose levels. Relevant clinical variables including age, gender, comorbidities (especially hypertension and diabetes), ASA status, and the type of surgery were recorded on a structured proforma.

Perioperative Monitoring Protocol: Hemodynamic parameters were continuously monitored intraoperatively using electrocardiogram (ECG), pulse oximetry, and invasive arterial blood pressure via radial artery cannulation. Hemodynamic instability was defined as a mean arterial pressure (MAP) less than 65 mmHg sustained for more than 10 minutes during surgery. Blood glucose levels were monitored using capillary glucometers preoperatively, every hour during surgery, and for 24 hours postoperatively. A glucose level exceeding 180 mg/dL at any perioperative time point was categorized as hyperglycemia and considered indicative of poor glycemic control.

Postoperative Observation and Complication Assessment: Patients were followed for 30 days post-surgery to monitor the occurrence of complications. The primary complications observed included surgical site infections (classified as superficial or deep based on CDC guidelines), delayed wound healing, acute kidney injury (AKI as per KDIGO criteria), unplanned ICU admissions, prolonged hospital stay (defined as more than 10 days), and 30-day all-cause mortality. All complications were recorded using predefined diagnostic criteria to ensure consistency across both centers.

Ethical Considerations: The study was approved by the Institutional Review Boards (IRBs) of both Prime Teaching Hospital, Peshawar, and Combined Military Hospital, Rawalpindi. All patients provided written informed consent before participation. Patient confidentiality was strictly maintained, and data were used exclusively for research purposes.

Statistical Analysis: Data analysis was performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation (SD) and compared using independent samples t-test. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test. To determine independent predictors of postoperative complications, multivariate logistic regression analysis was applied. A p-value of less than 0.05 was considered statistically significant throughout the analysis.

RESULTS

This study analyzed a total of 100 patients who underwent major abdominal surgery at Prime Teaching Hospital, Peshawar, and Combined Military Hospital (CMH), Rawalpindi, between June 2022 and May 2023. The patients were evaluated for perioperative hemodynamic changes and glycemic fluctuations, and their association with postoperative outcomes was systematically examined.

Demographic and Baseline Clinical Characteristics: The mean age of the study participants was 52.6 ± 11.4 years, with the age range spanning from 21 to 74 years. A male predominance was observed, with 61% of the patients being male (n=61) and 39% being female (n=39). A considerable proportion of the study population had underlying comorbid conditions, particularly diabetes mellitus (34%) and hypertension (28%). Most patients were categorized as ASA class II (68%), indicating mild systemic disease, while the remaining 32% were ASA class III, reflecting more severe systemic involvement. The distribution of surgical procedures included colectomy in 40% of patients, gastrectomy in 30%, hepatic resections in 20%, and pancreatectomies in 10%. These surgeries represent some of the most physiologically taxing abdominal procedures. The baseline characteristics showed no statistically significant differences between patients who developed postoperative complications and those who did not, indicating a relatively homogeneous population in terms of age, gender, and comorbidities as shown in table 1.

Table 1: Baseline Demographic and Clinical Characteristics (N = 100)

Variable	Value
Mean Age (years)	52.6 ± 11.4
Gender (Male/Female)	61 (61%) / 39 (39%)
Diabetic Patients	34 (34%)
Hypertensive Patients	28 (28%)
ASA II	68 (68%)
ASA III	32 (32%)
Type of Surgery	Colectomy (40%) Gastrectomy (30%) Hepatectomy (20%) Pancreatectomy (10%)

Perioperative Hemodynamic Instability and Hyperglycemia: Among the 100 patients, intraoperative hemodynamic instability was documented in 31 individuals (31%). This was defined by a sustained mean arterial pressure (MAP) drop below 65 mmHg lasting more than 10 minutes, as per established clinical thresholds. These episodes of hypotension were primarily attributed to blood loss, anesthetic depth, or underlying cardiovascular dysfunction.

In terms of glycemic control, 44 patients (44%) experienced hyperglycemia during the perioperative period, defined as capillary blood glucose levels exceeding 180 mg/dL at any point intraoperatively or within 24 hours postoperatively. This hyperglycemia was more common in patients with pre-existing diabetes but also occurred in several non-diabetic patients, likely

due to stress-induced insulin resistance and the catabolic effects of surgery as shown in table 2.

Table 2: Frequency of Hemodynamic Instability and Hyperglycemia (N = 100)

Parameter	Frequency (n)	Percentage (%)
Hemodynamic Instability (MAP <65)	31	31%
Perioperative Hyperglycemia (>180)	44	44%

Association Between Instability and Postoperative Complications: Postoperative complications occurred in 42 patients (42%). Among patients who experienced intraoperative hypotension (n=31), 25 individuals (80.6%) developed one or more postoperative complications, which was significantly higher than the 24.6% complication rate observed in patients who remained hemodynamically stable ($p < 0.001$). These complications primarily included acute kidney injury, ICU admission, and prolonged recovery time, suggesting that inadequate tissue perfusion during surgery directly contributed to organ dysfunction and poor healing. Similarly, perioperative hyperglycemia was strongly correlated with adverse postoperative outcomes. Among the 44 hyperglycemic patients, 30 (68.2%) developed postoperative complications compared to only 12 (21.4%) among those with well-controlled blood glucose ($p < 0.001$). Hyperglycemic patients were more prone to surgical site infections, wound dehiscence, and extended hospital stays, emphasizing the immunosuppressive and pro-inflammatory effects of elevated glucose levels in the perioperative setting as shown in table 3.

Table 3: Relationship Between Instability and Postoperative Complications

Group	Complications Present	Complications Absent	p-value
Hemodynamically Unstable (n=31)	25 (80.6%)	6 (19.4%)	<0.001
Hemodynamically Stable (n=69)	17 (24.6%)	52 (75.4%)	
Hyperglycemic Patients (n=44)	30 (68.2%)	14 (31.8%)	<0.001
Normoglycemic Patients (n=56)	12 (21.4%)	44 (78.6%)	

Postoperative Complications Profile: The spectrum of complications was varied but most commonly involved infectious and wound healing issues. Surgical site infections (SSIs) were observed in 24 patients (24%), and delayed wound healing in 18 patients (18%). ICU admission was required in 16 patients (16%) due to cardiorespiratory instability, renal failure, or prolonged recovery from anesthesia. Acute kidney injury occurred in 12 patients (12%) and was significantly associated with both intraoperative hypotension and pre-existing diabetes. A total of 21 patients (21%) had a hospital stay longer than 10 days, which was considered prolonged. Two patients (2%) succumbed to sepsis and multiorgan failure within 30 days of surgery. The distribution of complications further highlights the dual influence of both poor hemodynamic and glycemic control on systemic outcomes. Patients who experienced both instability and hyperglycemia were the most severely affected and accounted for a disproportionately large share of complications as shown in table 4.

Table 4: Frequency and Types of Postoperative Complications (N = 100)

Complication Type	Frequency (n)	Percentage (%)
Surgical Site Infection	24	24%
Delayed Wound Healing	18	18%
ICU Admission	16	16%
Acute Kidney Injury	12	12%
Prolonged Hospital Stay	21	21%
30-Day Mortality	2	2%

The results of this study indicate that both perioperative hypotension and hyperglycemia are not only frequent occurrences during major abdominal surgeries but are also strong, independent predictors of postoperative complications. Hemodynamic instability was particularly associated with systemic complications such as AKI and ICU transfer, while hyperglycemia contributed significantly to wound-related complications and infections. These findings underscore the importance of vigilant intraoperative monitoring and proactive intervention strategies to maintain both stable blood pressure and tight glycemic control in the surgical setting. In resource-limited settings, where advanced monitoring may not always be available, emphasis on early detection and correction of even mild derangements may significantly reduce postoperative morbidity and mortality.

DISCUSSION

This study provides compelling evidence that perioperative hemodynamic instability and glycemic dysregulation are significant and independent predictors of postoperative complications in patients undergoing major abdominal surgeries[12]. The findings are consistent with the growing body of literature that identifies both intraoperative hypotension and perioperative hyperglycemia as critical modifiable risk factors that directly impact patient recovery, complication rates, and healthcare utilization[13].

The incidence of intraoperative hypotension observed in this study (31%) aligns with previously reported rates in high-risk abdominal surgeries. It is well-established that sustained drops in mean arterial pressure (MAP) below 65 mmHg impair perfusion to vital organs such as the kidneys, brain, and myocardium[14]. In our cohort, patients who experienced hypotension were significantly more likely to develop complications, particularly acute kidney injury (AKI), prolonged ICU stays, and delayed recovery. This is consistent with earlier work by Walsh et al. and Sun et al., who demonstrated a direct association between intraoperative hypotension and postoperative renal and cardiac dysfunction. The pathophysiological basis for this relationship lies in ischemia-reperfusion injury, endothelial dysfunction, and impaired oxygen delivery, which together compromise organ recovery and resilience following surgical trauma[15, 16].

Perioperative hyperglycemia was documented in 44% of patients, many of whom were either known diabetics or developed stress-induced insulin resistance. These findings are of particular concern as hyperglycemia has been shown to impair neutrophil chemotaxis and phagocytic function, thereby compromising innate immunity[17]. In this study, patients with glucose levels exceeding 180 mg/dL had a significantly higher incidence of surgical site infections (SSI), wound dehiscence, and prolonged hospitalization. This aligns with the findings of Umpierrez et al. and van den Berghe et al., who reported that even transient elevations in glucose levels during surgery are associated with poor wound healing and increased infection rates[18].

Of notable importance is the synergistic effect observed when both hypotension and hyperglycemia co-occurred in the same patient. Such individuals accounted for the majority of severe complications, highlighting the compounded risk posed by dual physiological stressors. This emphasizes the necessity of adopting a bundled intraoperative strategy that simultaneously targets cardiovascular stability and metabolic control[19].

Moreover, these findings have important implications for surgical and anesthetic practices in resource-limited settings such as Pakistan, where access to advanced intraoperative monitoring, critical care, and endocrine support may be restricted[20]. Basic but consistent interventions such as the use of arterial lines for MAP monitoring, hourly glucose checks, targeted insulin infusion protocols, and early fluid resuscitation can make a substantial difference in patient outcomes. The study thus advocates for the integration of simple, evidence-based monitoring protocols into routine perioperative care, especially for patients undergoing high-risk abdominal procedures[21].

Our study also adds to the literature by providing region-specific data from two major tertiary centers in Pakistan[22]. While international guidelines advocate for tight hemodynamic and glycemic control, there has been a paucity of locally contextualized

data to support the same in South Asian populations. Given differences in nutritional status, comorbidity profiles, and hospital resources, these findings are highly relevant and support the urgent need for perioperative care optimization in our region[23].

Despite its strengths, this study has a few limitations. It was observational in nature and conducted in only two centers, which may limit generalizability[24]. We also did not evaluate intraoperative fluid management and anesthetic depth factors that could influence hemodynamic outcomes. Additionally, long-term outcomes beyond 30 days were not assessed. Nevertheless, the strength of associations, the statistical significance, and the biological plausibility of mechanisms strongly support the relevance of our findings[25].

CONCLUSION

This study demonstrates that both intraoperative hemodynamic instability and perioperative hyperglycemia are powerful, independent predictors of postoperative complications in patients undergoing major abdominal surgery. The presence of either factor significantly increases the risk of surgical site infections, delayed wound healing, ICU admission, and prolonged hospital stay. When both factors coexist, the risk multiplies, underscoring the need for integrated and proactive intraoperative management. The findings call for heightened vigilance in perioperative care, particularly the routine monitoring of mean arterial pressure and blood glucose levels, with timely corrective interventions. Adopting targeted intraoperative strategies to maintain MAP above 65 mmHg and glucose levels below 180 mg/dL may significantly reduce morbidity and improve surgical outcomes. Given the burden of surgical complications in resource-constrained settings, these simple but effective measures can have profound implications for patient safety, recovery, and healthcare resource utilization. Further multicenter and interventional studies are warranted to validate these findings and translate them into standardized perioperative care protocols across surgical centers in Pakistan and other low-to-middle-income countries.

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