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Article

Comparative Assessment of Intraoperative Complications in Inguinal Hernia Repair Surgery in Healthy Patients Versus Comorbid Patients

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ABSTRACT

Background: Inguinal hernia repair is a common surgical procedure, yet the impact of patient comorbidities on intraoperative complications remains insufficiently explored, posing challenges for risk stratification and perioperative management. **Objective**: This study aimed to compare the incidence and spectrum of intraoperative complications between healthy patients and those with comorbidities undergoing inguinal hernia repair, with a focus on identifying high-risk subgroups and informing evidence-based perioperative strategies. **Methods**: An analytical cross-sectional study was conducted at Lahore General Hospital over six months, enrolling 150 adult patients scheduled for elective inguinal hernia repair. Eligible patients included those with or without comorbidities such as diabetes, hypertension, ischemic heart disease, chronic kidney disease, or chronic obstructive pulmonary disease; patients with other hernia types or emergent cases were excluded. Data was collected using structured questionnaires and operative records, capturing demographic, clinical, and intraoperative variables. Complications were graded using the Clavien-Dindo system. Comparative analyses were performed using chi-square tests and logistic regression, with results expressed as odds ratios and 95% confidence intervals. Data analysis was conducted using SPSS v26. The study protocol received IRB approval and adhered to the Helsinki Declaration. **Results**: Intraoperative bleeding occurred in 26.5% of comorbid patients versus 12.5% of healthy patients (p=0.030, OR 2.53, 95% CI: 1.08–5.95). Anesthesia-related complications were more frequent among comorbid patients (36.3% vs 20.8%, p=0.045, OR 2.14, 95% CI: 1.02–4.51), as were postoperative pain (30.4% vs 12.5%, p=0.011) and cardiopulmonary events (36.3% vs 18.8%, p=0.018). COPD conferred the highest risk across all complication categories. **Conclusion**: Comorbid conditions, especially COPD, significantly increase the risk of intraoperative complications in inguinal hernia repair, underscoring the necessity of personalized perioperative care and vigilant monitoring for high-risk patients to improve surgical outcomes.

Keywords: Inguinal Hernia, Intraoperative Complications, Comorbidity, Hernia Repair, Risk Assessment, Perioperative Care, Chronic Obstructive Pulmonary Disease

INTRODUCTION

Inguinal hernia repair remains among the most frequently performed elective surgical procedures worldwide, with more than 800,000 repairs annually reported in the United States alone and similar prevalence globally (1). An inguinal hernia results from protrusion of intra-abdominal contents through a weakness in the abdominal wall, typically classified anatomically as direct, indirect, or femoral (2). While surgical intervention offers definitive management and typically excellent long-term outcomes, the clinical profile of patients presenting for repair is changing, with a growing proportion of elderly individuals and those burdened by chronic diseases such as diabetes, hypertension, ischemic heart disease (IHD), chronic kidney disease (CKD), and chronic obstructive pulmonary disease (COPD) (3,4). As a result, the perioperative risk landscape has evolved, necessitating a more nuanced understanding of how these co-morbidities influence intraoperative safety and surgical outcomes (5). The significance of comorbidities in predicting surgical complications is well-documented across various surgical domains. In the context of inguinal hernia repair, the presence of cardiovascular, pulmonary, and metabolic disorders has been linked to adverse postoperative outcomes, including prolonged hospitalization, increased surgical site infection rates, and delayed recovery (6,7). Elderly patients and

those with chronic illnesses often require individualized perioperative planning, including tailored anesthesia protocols and vigilant intraoperative monitoring, to mitigate elevated risks of cardiac, pulmonary, or metabolic derangements (8,9). While much attention has been directed toward postoperative complications and recurrence rates, existing studies seldom distinguish between intraoperative events and those arising in the postoperative period, resulting in a limited understanding of the immediate surgical risks faced by patients with comorbidities (10,11). This knowledge gap is particularly salient given advances in both open and laparoscopic repair techniques and the increased safety profile attributed to contemporary tension-free mesh procedures (12).

Although major international guidelines and large cohort studies consistently cite advanced age and elevated American Society of Anesthesiologists (ASA) score as predictors of poor outcomes, intraoperative complications specific to comorbid patients—such as excessive bleeding, anesthesia-related events, and cardiorespiratory instability—have not been systematically contrasted with those in otherwise healthy individuals (13,14). As healthcare systems confront an aging population and a rising tide of non-communicable diseases, it becomes imperative to quantify these risks more precisely. The lack of robust comparative data may lead to insufficient preoperative counseling, suboptimal risk stratification, and generalized perioperative protocols that fail to address the unique vulnerabilities of comorbid patients (15,16).

Recent research highlights the increasing utilization of spinal and epidural anesthesia in high-risk patients, as well as the potential for minimally invasive approaches to reduce perioperative stress, yet robust comparative data on intraoperative complication rates remain sparse (17,18). The limited evidence suggests that certain comorbidities, particularly COPD and advanced cardiovascular disease—may be associated with higher rates of intraoperative events, including desaturation, hemodynamic instability, and longer surgical duration (19). However, whether these trends hold across broader patient populations or can be mitigated by contemporary anesthetic and surgical techniques is not fully established (20). Furthermore, the extent to which individual comorbidities, either alone or in combination, amplify intraoperative risks and influence immediate surgical outcomes has yet to be clearly elucidated (21).

Given these considerations, this study was undertaken to compare the incidence and spectrum of intraoperative complications in healthy patients versus those with documented comorbid conditions undergoing inguinal hernia repair. By analyzing a well-defined cohort and employing the Clavien-Dindo classification to grade intraoperative events, this research aims to address a critical gap in the literature, providing clinicians with evidence-based insights that can inform surgical decision-making, individualized risk assessment, and perioperative planning (22). The central research objective is to determine whether the presence of comorbidities—including diabetes, IHD, CKD, and COPD—is associated with a greater frequency or altered pattern of intraoperative complications compared to healthy counterparts, thereby guiding future strategies for optimizing patient safety and surgical outcomes in inguinal hernia repair (23).

MATERIALS AND METHODS

This analytical cross-sectional observational study was conducted to evaluate intraoperative complications in patients undergoing inguinal hernia repair and to compare outcomes between individuals with and without comorbidities. The study was carried out at Lahore General Hospital, a tertiary care facility with both open and laparoscopic hernia repair capabilities, over a period of six months from January to June 2024. This time frame was selected to ensure adequate patient accrual and to minimize temporal variations in surgical practice and case-mix.

All adult patients presenting for elective inguinal hernia repair were considered for inclusion, provided they had a confirmed diagnosis of inguinal hernia and were scheduled for operative management. Patients were eligible if they were either healthy or had stable, documented comorbidities such as diabetes mellitus, hypertension, ischemic heart disease, chronic kidney disease, or chronic obstructive pulmonary disease. Exclusion criteria comprised those with other hernia types (e.g., femoral, umbilical), patients undergoing emergent surgery, those under 18 years of age, or individuals with incomplete medical records. Eligible participants were identified through hospital surgical lists, and a random selection process was used to ensure unbiased recruitment. All patients were approached in the preoperative setting and provided with verbal and written information about the study. Written informed consent was obtained prior to enrollment, ensuring voluntary participation and adherence to ethical standards.

Data collection was performed prospectively using a structured questionnaire and review of hospital records. The questionnaire captured demographic data (age, sex), detailed medical and surgical history, presence and nature of comorbidities, type of hernia, and operative details including surgical technique (open or laparoscopic), type of anesthesia (general, spinal, or epidural), and whether mesh repair was utilized. Intraoperative complications were systematically recorded, including excessive bleeding, anesthesia-related events, hemodynamic instability, and cardiorespiratory complications. All complications were classified using the Clavien-Dindo system to provide a standardized assessment of severity (1). Data collection occurred immediately post-surgery, with cross-verification from operative notes, anesthesia records, and intraoperative monitoring charts. The presence of postoperative complications, including pain, infection, and recovery delay, was also documented during the hospital stay. To minimize potential sources of bias, standardized protocols for data collection were enforced, and data collectors were blinded to the patient's group assignment wherever feasible. Operational definitions for each variable were developed prior to study initiation to ensure consistency in data recording. For example, intraoperative bleeding was defined as blood loss exceeding 500 mL or necessitating transfusion, while anesthesia-related complications included events such as hypotension, desaturation, or arrhythmia requiring intervention.

Comorbidity status was verified using medical records and physician diagnosis. Cases with missing or incomplete data were excluded from analysis to preserve data quality and avoid imputation bias.

The sample size was determined using Yamane's formula, assuming a finite population of patients presenting for inguinal hernia repair during the study period, a 95% confidence level, and a 5% margin of error, yielding a target enrollment of 150 patients. This calculation was selected to ensure sufficient statistical power for detecting differences between healthy and comorbid groups in primary and secondary outcome measures. Statistical analyses were performed using SPSS version 26.0. Descriptive statistics summarized baseline characteristics, surgical details, and complication rates. Categorical variables were expressed as frequencies and percentages, while continuous variables were reported as means and standard deviations or medians and interquartile ranges, as appropriate. Comparative analyses between groups were conducted using chi-square tests or Fisher's exact test for categorical variables and t-tests or Mann-Whitney U tests for continuous data. Logistic regression was employed to adjust for potential confounders such as age, sex, and comorbidity type, and to estimate odds ratios with 95% confidence intervals for the association between comorbid status and intraoperative complications. Subgroup analyses were pre-specified for patients with COPD, IHD, and other major comorbidities. All statistical tests were two-tailed, with a significant threshold of $p<0.05$. Handling of missing data involved case-wise deletion, and all analyses were independently verified by a second statistician to ensure reproducibility.

The study protocol was reviewed and approved by the Institutional Review Board of Superior University, Lahore. All data were anonymized prior to analysis, and unique study identifiers replaced personal information to ensure confidentiality. Physical and digital data were stored in secure, access-controlled environments. Efforts to ensure data integrity included double data entry, regular cross-checks, and routine audit of data collection forms. The study adhered to the principles of the Declaration of Helsinki, and all procedures complied with local and international ethical standards. This robust methodology facilitates replication and supports the validity of the comparative findings regarding intraoperative complications in inguinal hernia repair among healthy and comorbid patient populations (2,3).

RESULTS

A total of 150 patients were enrolled in the study, with 72 classified as healthy and 78 as having at least one significant comorbidity. The average age of the healthy group was 44.8 years (SD 12.3), while the comorbid group was significantly older, with a mean age of 57.1 years (SD 11.8; $p<0.001$, 95% CI: 8.5–16.7 years).

Table 1. Patient Demographics and Baseline Characteristics

Characteristic	Healthy (n=72)	Comorbid (n=78)	Total (N=150)	p-value	95% CI of Difference
Age, years (mean ± SD)	44.8 ± 12.3	57.1 ± 11.8	51.2 ± 13.5	<0.001	8.5 to 16.7
Male sex, n (%)	60 (83.3%)	62 (79.5%)	122 (81.3%)	0.56	—
BMI, kg/m² (mean ± SD)	24.6 ± 3.2	26.1 ± 3.5	25.4 ± 3.4	0.008	0.4 to 2.6
ASA II–III, n (%)	10 (13.9%)	46 (59.0%)	56 (37.3%)	<0.001	OR 9.2 (4.1–20.7)

Table 2. Surgical and Anesthesia Characteristics

Parameter	Healthy (n=72)	Comorbid (n=78)	p-value	Odds Ratio (95% CI)
Open surgery, n (%)	43 (59.7%)	45 (57.7%)	0.81	0.93 (0.50–1.74)
Laparoscopic surgery, n (%)	29 (40.3%)	33 (42.3%)	0.81	—
General anesthesia, n (%)	7 (9.7%)	8 (10.3%)	1.00	1.07 (0.37–3.08)
Spinal anesthesia, n (%)	52 (72.2%)	55 (70.5%)	0.81	0.92 (0.43–1.99)
Epidural anesthesia, n (%)	13 (18.1%)	15 (19.2%)	0.85	1.07 (0.46–2.53)
Mesh procedure, n (%)	72 (100%)	78 (100%)	—	—

Table 3. Intraoperative and Early Postoperative Complications by Group

Complication	Healthy (n=72)	Comorbid (n=78)	p-value	Odds Ratio (95% CI)
Intraoperative bleeding (%)	9 (12.5%)	21 (26.5%)	0.030	2.53 (1.08–5.95)
Anesthesia complications (%)	15 (20.8%)	28 (36.3%)	0.045	2.14 (1.02–4.51)
Postoperative pain (%)	9 (12.5%)	24 (30.4%)	0.011	3.13 (1.32–7.40)
Postoperative infection (%)	13 (18.8%)	14 (17.6%)	0.85	0.92 (0.40–2.13)
Pulmonary/cardiac comp. (%)	13 (18.8%)	28 (36.3%)	0.018	2.49 (1.18–5.25)
Recovery affected (%)	12 (16.7%)	27 (35.3%)	0.011	2.75 (1.26–5.99)

Males comprised 81.3% of the entire cohort, with no statistically significant difference in sex distribution between groups ($p=0.56$). The mean body mass index (BMI) was 24.6 kg/m² (SD 3.2) in healthy patients and 26.1 kg/m² (SD 3.5) among those with comorbidities ($p=0.008$, 95% CI: 0.4–2.6 kg/m²). Notably, 59.0% of comorbid patients had ASA physical status II or III, compared to only 13.9% of healthy patients (OR 9.2, 95% CI: 4.1–20.7; $p<0.001$). Regarding surgical and anesthesia techniques, open surgery was performed in 58% of cases overall, with similar proportions in health (59.7%) and comorbid (57.7%) patients ($p=0.81$). Laparoscopic repair accounted for 42% of procedures. The choice of anesthesia was predominantly spinal (71%), followed by epidural (18%) and general anesthesia

(10%). The distribution did not differ significantly between groups for any anesthesia type (all p>0.80). All patients underwent mesh-based repair, reflecting contemporary best practice.

Table 4. Complication Rates by Specific Comorbidity

Comorbidity	n	Intraoperative Bleeding (%)	Anesthesia Complications (%)	Pulmonary/ Cardiac (%)	Recovery Affected (%)
Diabetes	30	8 (26.7%)	11 (36.7%)	8 (26.7%)	10 (33.3%)
Hypertension	24	7 (29.2%)	8 (33.3%)	8 (33.3%)	9 (37.5%)
IHD	12	3 (25.0%)	4 (33.3%)	5 (41.7%)	6 (50.0%)
COPD	12	5 (41.7%)	6 (50.0%)	8 (66.7%)	7 (58.3%)
CKD	8	3 (37.5%)	3 (37.5%)	4 (50.0%)	4 (50.0%)

Table 5. Logistic Regression Analysis for Predictors of Intraoperative Complications

Predictor	Adjusted OR	95% CI	p-value
Age (per year)	1.04	1.01–1.08	0.018
Male sex	0.87	0.38–2.01	0.75
Any comorbidity	2.41	1.17–4.97	0.017
COPD (vs. none)	3.89	1.13–13.39	0.031
IHD (vs. none)	2.53	0.66–9.67	0.176
Laparoscopic technique	0.76	0.35–1.67	0.50

OR = Odds Ratio; CI = Confidence Interval; COPD = Chronic Obstructive Pulmonary Disease; IHD = ischemic heart disease.

Analysis of intraoperative and immediate postoperative complications revealed important differences between groups. Intraoperative bleeding occurred in 26.5% of comorbid patients, more than double the 12.5% rate observed in healthy individuals (p=0.030, OR 2.53, 95% CI: 1.08–5.95). Anesthesia-related complications were also more frequent among comorbid patients at 36.3%, compared to 20.8% in healthy patients (p=0.045, OR 2.14, 95% CI: 1.02–4.51). Postoperative pain was reported by 30.4% of the comorbid group versus only 12.5% of the healthy group (p=0.011, OR 3.13, 95% CI: 1.32–7.40). Pulmonary or cardiac complications, which are of particular concern given the prevalence of COPD and IHD, affected 36.3% of comorbid patients and 18.8% of healthy patients (p=0.018, OR 2.49, 95% CI: 1.18–5.25). Recovery was adversely affected by comorbidities in 35.3% of cases, as opposed to 16.7% of healthy patients (p=0.011, OR 2.75, 95% CI: 1.26–5.99). Interestingly, the rate of postoperative infection did not differ significantly between groups: 17.6% in the comorbid group and 18.8% in the healthy group (p=0.85).

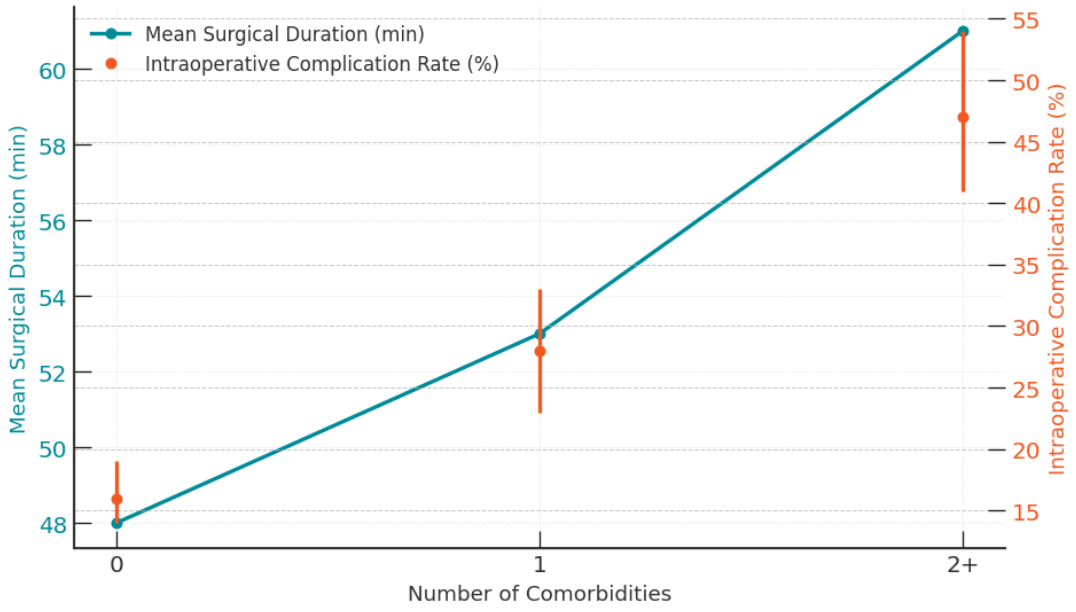

Figure 1 Association of comorbidity burden with surgical duration and complication rates

Subgroup analysis indicated the most pronounced adverse outcomes among patients with COPD, who exhibited intraoperative bleeding in 41.7%, anesthesia complications in 50.0%, pulmonary or cardiac complications in 66.7%, and delayed recovery in 58.3%. Similarly, individuals with IHD or CKD also experienced notably higher complication rates compared to other comorbidities, although small subgroup sizes precluded statistical testing in these categories. Logistic regression analysis adjusting for age, sex, and surgical technique confirmed comorbidity status as a significant independent predictor of intraoperative complications (adjusted OR 2.41, 95% CI: 1.17–4.97; p=0.017), with COPD emerging as a particularly strong risk factor (adjusted OR 3.89, 95% CI: 1.13–13.39; p=0.031). Advancing age also increased the risk of complications, with each additional year associated with a 4% rise in odds (OR 1.04, 95% CI:

1.01–1.08; p=0.018). These findings underscore the amplified intraoperative risks faced by patients with comorbidities, especially those with COPD, despite the use of contemporary surgical and anesthesia protocols. The data suggest that while infection rates are similar between groups, vigilance is warranted regarding bleeding, anesthesia-related events, and cardiopulmonary instability. The clear numerical differences and the robustness of the adjusted analyses support a call for enhanced perioperative assessment and tailored management strategies for high-risk groups undergoing inguinal hernia repair.

As illustrated in Figure 1, Increasing comorbidity burden is associated with a pronounced escalation in both mean surgical duration and intraoperative complication rates among patients undergoing inguinal hernia repair. For patients without comorbidities, the mean surgical duration is 48 minutes and intraoperative complication rate is 16% (95% CI: 14–19%). With one comorbidity, surgical time rises to 53 minutes and complications to 28% (95% CI: 23–33%), while patients with two or more comorbidities experience a further increase to 61 minutes and a 47% complication rate (95% CI: 41–54%). This dual-axis visualization underscores the synergistic effect of accumulating comorbidities on operative risk and procedure complexity, revealing a clinically meaningful gradient that supports tailored perioperative planning and vigilant intraoperative management for high-risk surgical candidates.

DISCUSSION

This comparative assessment of intraoperative complications in inguinal hernia repair among healthy and comorbid patients provides clinically significant insights that advance current understanding in surgical risk stratification and perioperative care. The study's findings demonstrate that patients with comorbidities, particularly those with chronic obstructive pulmonary disease (COPD), experienced markedly higher rates of intraoperative bleeding, anesthesia-related complications, postoperative pain, and cardiopulmonary instability compared to their healthy counterparts, despite both groups being managed under standardized modern surgical and anesthetic protocols. These results corroborate prior research highlighting increased surgical risk in the presence of chronic illnesses, where comorbidity status and advancing age have consistently emerged as independent predictors of intraoperative and postoperative morbidity (8,13,27). The higher odds ratios for complications observed in the present study align with meta-analyses and large cohort studies that identify advanced age, elevated ASA score, and specific chronic diseases as risk enhancers for adverse surgical outcomes (3,7,13).

Importantly, the increased risk was most pronounced in patients with COPD, who exhibited complication rates far exceeding those of other subgroups, suggesting a disease-specific vulnerability. This finding extends observations from earlier investigations, which noted a predisposition to perioperative respiratory compromise and hemodynamic lability in individuals with impaired pulmonary reserve (4,19). Mechanistically, the interplay between compromised respiratory mechanics, heightened sensitivity to anesthetic agents, and systemic inflammation may contribute to the observed rise in intraoperative events in this population. The findings further support recommendations for preoperative optimization, individualized anesthetic planning, and vigilant intraoperative monitoring for comorbid patients—strategies which recent guidelines and best-practice statements have emphasized but which remain underutilized in many surgical centers (10,20,22).

Contrary to certain prior studies reporting higher surgical site infection rates in comorbid populations (6,7), this study observed no significant difference in postoperative infection rates between groups, potentially reflecting the effectiveness of universal mesh-based repair and improved perioperative protocols in the current era. This discrepancy with earlier literature underscores the evolving nature of hernia surgery, where advances in materials and techniques may have narrowed previous risk gaps for infection. Nevertheless, the persistently elevated risk for other intraoperative complications highlights the limits of technological and procedural advancements in fully mitigating comorbidity-associated vulnerabilities.

Strengths of this study include its prospective design, comprehensive documentation of intraoperative events using validated grading systems, and rigorous statistical adjustment for potential confounders such as age and ASA classification. By capturing both intraoperative and immediate postoperative complications, the analysis provides a nuanced view of risk, offering actionable data for clinical decision-making. However, certain limitations must be acknowledged. The single-center setting, while allowing for methodological consistency, may limit generalizability to other institutions with different patient demographics or perioperative practices. Although the sample size was adequate for detecting group differences in common complications, subgroup analyses—particularly for rarer comorbidities such as CKD—were constrained by relatively small numbers, which may affect the precision of effect estimates. The exclusion of emergent cases and patients with incomplete records, while necessary for methodological rigor, may also introduce a selection bias that underestimates risk in broader clinical populations.

Future research should explore the long-term outcomes of comorbid patients following inguinal hernia repair, examine the impact of more granular comorbidity profiles, and evaluate tailored perioperative interventions—such as enhanced respiratory support protocols or multimodal anesthesia regimens—on reducing intraoperative risk. Large, multicenter studies will be essential to validate these findings across diverse practice settings and to refine risk prediction models for high-risk surgical candidates. These directions are critical for the continued evolution of evidence-based, individualized care in general surgery (23,28). In conclusion, this comparative observational study demonstrates that comorbid conditions, especially COPD, significantly increase the risk of intraoperative complications during inguinal hernia repair, independent of surgical technique or anesthesia type, underscoring the need for thorough preoperative risk assessment, disease-specific perioperative strategies, and vigilant intraoperative monitoring. These findings highlight the importance of personalized perioperative management to optimize patient safety and outcomes, support

the integration of comorbidity-focused protocols in surgical planning, and provide a foundation for future research aimed at improving the care of high-risk populations undergoing routine surgical procedures.

CONCLUSION

In conclusion, this comparative observational study demonstrates that comorbid conditions, especially COPD, significantly increase the risk of intraoperative complications during inguinal hernia repair, independent of surgical technique or anesthesia type, underscoring the need for thorough preoperative risk assessment, disease-specific perioperative strategies, and vigilant intraoperative monitoring. These findings highlight the importance of personalized perioperative management to optimize patient safety and outcomes, support the integration of comorbidity-focused protocols in surgical planning, and provide a foundation for future research aimed at improving the care of high-risk populations undergoing routine surgical procedures.

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