

**Postoperative Complications after Major Abdominal Surgery using Clavien-Dindo Classification: A Prospective Observational Study in a Tertiary Care Centre in Central India**

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Abstract

Introduction: Postoperative complications following major abdominal surgery remain a significant challenge in surgical practice and contribute substantially to patient morbidity, mortality, and healthcare costs. The Clavien–Dindo classification system provides a standardized and objective method for grading postoperative complications

based on the therapeutic interventions required for their management. The present study aims to assess postoperative complications among patients undergoing major abdominal surgery using the Clavien–Dindo classification system. By analyzing the relationship between patient-related factors, intraoperative variables, and postoperative outcomes, the study seeks to identify

factors associated with increased risk of complications. In addition, the study will evaluate the impact of postoperative complications on length of hospital stay and 30-day morbidity and mortality. **Methods and Materials:** A prospective observational study of 110 patients, undergoing major abdominal surgeries (elective or emergency), was performed in Department of General Surgery of Government Medical College and Hospital, Nagpur for a period of 18 months (From December 2024 to June 2026). **Results:** The study population consisted predominantly of middle-aged and elderly patients. Males were more commonly affected. Most patients (65.5%) had pre-existing systemic illness with most common being Diabetes mellitus and hypertension. Most patients (54.6%) belonged to higher ASA categories (ASA III and ASA IV). 65.5% of surgeries were elective and 34.5% were emergency procedures. The most common procedures were other major abdominal surgeries (21.8%), colorectal surgeries (20.0%), and hepatobiliary surgeries (18.2%). Most operations were of moderate to long duration. Intraoperative blood loss was 200–500 ml in 32.7% and >500 ml in 45.5% patients. Although 83.6% of patients had no intraoperative complications, hemorrhage requiring intervention was the most common intraoperative adverse event (7.3%). Among postoperative complications, surgical site infection (28%) was the most frequent. According to the Clavien–Dindo classification, the most common grade was Grade II (31.8%), followed by Grade I (22.7%). Complication rates increased with age, but did not reach statistical significance level ($p = 0.2411$). Comorbidities and ASA grades showed a statistically strong relationship with postoperative morbidity ($p = 0.008$ and 0.002 respectively). Among intraoperative factors, duration of surgery ($p = 0.012$) and blood loss ($p = 0.006$) were both

significant determinants of complications. Emergency surgeries were also associated with significantly higher complication rates than elective procedures ($p = 0.018$). Patients with severe complications (Grade III–V) had markedly worse outcomes than those with no complications or only Grade I–II complications including prolonged hospital stay of >14 days ($p < 0.001$), ICU admission ($p < 0.001$), need for re-intervention, increased mortality ($p = 0.028$). **Conclusion:** Postoperative complications remain a significant concern in major abdominal surgery affecting nearly 2 out of every 5 patients. Majority of complications developed are mild to moderate (Grade I–II), a substantial proportion of patients developed severe complications (Grade III–V), which were associated with considerable morbidity and measurable mortality. Patient-related factors such as presence of comorbidities, and higher ASA physical status significantly increase the risk of postoperative complications. Intraoperative factors including emergency surgery, prolonged duration of surgery and increased blood loss were found to be significant predictors of postoperative morbidity. Clavien–Dindo classification system provides standardized, objective, and reproducible method for grading postoperative complications. Increasing Clavien–Dindo grade strongly correlates with worse clinical outcomes, including prolonged hospital stay, higher ICU admission rates, increased need for re-intervention, and mortality.

Keywords: Postoperative Complications, Clavien-Dindo Classification, Major Abdominal Surgery.

Introduction

Surgery remains one of the most fundamental components of modern medical care. Advances in surgical techniques, anesthesia, perioperative monitoring, and critical care have significantly improved the safety

and effectiveness of surgical procedures over the past century. Despite these advances, postoperative complications continue to represent a major concern in surgical practice and remain an important determinant of patient morbidity and mortality. Major abdominal surgery, which involves operative procedures on organs within the abdominal cavity such as the stomach, intestines, liver, pancreas, spleen, and biliary tract, is associated with a substantial risk of postoperative complications¹ which can arise from multiple mechanisms related to surgical trauma, physiological stress, and patient-related factors. Surgical manipulation of abdominal organs can lead to tissue injury, inflammation, and disruption of normal physiological processes. In addition, major surgery triggers a systemic inflammatory response characterized by the release of cytokines such as interleukin-6, tumor necrosis factor-alpha, and other mediators, activation of immune pathways, and metabolic changes². These physiological responses are essential for wound healing and immune defense but excessive or dysregulated inflammatory responses may also contribute to the development of complications in susceptible patients. Surgical trauma also induces a hyper metabolic state characterized by increased energy expenditure, catabolism of proteins, and alterations in glucose metabolism³. This metabolic stress can impair immune function and hamper tissue repair, which increase the susceptibility to infections and other postoperative complications.

Postoperative complications can be defined as any undesirable and unintended event occurring after a surgical procedure that deviates from the expected postoperative course⁴. These complications may range from minor issues such as mild postoperative fever or superficial wound infection to more severe complications

including anastomotic leakage, intra-abdominal abscess, sepsis, organ failure, or even death. The occurrence of postoperative complications not only affects patient recovery and outcomes but also increases the length of hospital stay, need for intensive care, need for additional diagnostic and therapeutic interventions, healthcare costs, and resource utilization within healthcare systems⁵. Despite improvements in perioperative care, postoperative complications remain common in major abdominal surgeries, with reported rates ranging from 20% to 40% depending on the type of surgery and patient population⁶.

Various factors influence the risk of postoperative complications. These factors can be broadly categorized into patient-related factors, disease-related factors, and surgical factors. Patient-related factors include age, comorbid conditions, nutritional status, and preoperative functional status. Disease-related factors include the severity and stage of the underlying pathology, particularly in malignant diseases. Surgical factors include the complexity of the procedure, duration of surgery, blood loss, intraoperative technical challenges, and emergency vs elective setting⁷. Among patient-related factors, advanced age has been consistently identified as an important risk factor for postoperative complications. Elderly patients often have reduced physiological reserve and multiple comorbidities, which increase their vulnerability to postoperative stress, morbidity and complications⁸. Comorbid conditions play a significant role in determining postoperative outcomes. Patients with diabetes mellitus may have impaired wound healing and increased susceptibility to infection due to microvascular changes and immune dysfunction⁹. Similarly, chronic obstructive pulmonary disease may predispose patients to postoperative pulmonary

complications such as pneumonia and respiratory failure. Nutritional status is another critical determinant of postoperative outcomes. Malnutrition is common among patients undergoing major abdominal surgery, particularly those with gastrointestinal malignancies or chronic inflammatory diseases¹⁰. Poor nutritional status impairs immune function, delays wound healing, and increases susceptibility to infection. Therefore, preoperative nutritional assessment and optimization are essential components of perioperative care. The ASA physical status classification is widely used to assess the preoperative health status of patients and predict perioperative risk. Higher ASA grades are associated with increased postoperative morbidity and mortality¹¹. This classification provides a simple yet effective method for stratifying surgical risk and guiding perioperative decision-making.

Surgical site infections remain one of the most frequent complications and may significantly prolong hospital stay and increase healthcare costs. These infections may occur due to bacterial contamination during surgery, impaired host immunity, or inadequate tissue perfusion. Anastomotic leakage is another serious complication that may occur following gastrointestinal surgery. It results from failure of healing at the surgical anastomosis and can lead to intra-abdominal sepsis, abscess formation, and peritonitis¹². The development of an anastomotic leak is influenced by multiple factors including tissue perfusion, surgical technique, infection, and patient-related risk factors such as malnutrition or comorbidities. Postoperative ileus, defined as a transient impairment of bowel motility following surgery, is frequently observed after abdominal operations¹³. It results from a combination of factors including surgical manipulation of the intestines, inflammatory responses, electrolyte

disturbances, and opioid use for postoperative pain management. Although often self-limiting, prolonged postoperative ileus may delay recovery and prolong hospital stay. Cardiopulmonary complications such as pneumonia, atelectasis, pulmonary embolism, and cardiac events also contribute significantly to postoperative morbidity¹⁴. These complications are especially prevalent in elderly patients and those with pre-existing cardiopulmonary disease. Effective perioperative management including early mobilization, chest physiotherapy, and appropriate thromboprophylaxis can help lower their occurrence.

Accurate assessment and reporting of postoperative complications are essential for evaluating surgical outcomes, comparing surgical techniques, improving patient safety, and conducting clinical research. One of the most widely accepted systems is the Clavien–Dindo classification, which was first introduced in 1992 and later modified in 2004¹⁵. This classification system provides an objective and reproducible method for grading postoperative complications based on the therapeutic interventions required to manage them rather than the subjective interpretation of the complication itself. The Clavien–Dindo classification categorizes complications into five grades of increasing severity. Grade I complications represent minor deviations from the normal postoperative course that do not require specific pharmacological treatment or surgical intervention. Grade II complications require pharmacological treatment such as antibiotics, blood transfusion, or total parenteral nutrition. Grade III complications require surgical, endoscopic, or radiological intervention and are subdivided into Grade IIIa (without general anesthesia) and Grade IIIb (under general anesthesia). Grade IV complications represent

life-threatening complications requiring intensive care management and include single-organ or multi-organ failure. Grade V complications represent patient death¹⁵. The system has been applied in gastrointestinal surgery, hepatobiliary surgery, colorectal surgery, urological surgery, and other surgical fields demonstrating its usefulness and reliability¹⁶. Many modern surgical studies now report complications using this simple and reproducible classification system, which has greatly improved transparency and standardization in auditing surgical outcome. Despite its widespread use, data regarding the pattern and severity of postoperative complications in many healthcare settings remain limited.

Justification of the Study

Postoperative complications following major abdominal surgery remain a significant challenge in surgical practice and contribute substantially to patient morbidity, mortality, and healthcare costs. Although advances in surgical techniques and perioperative care have improved patient outcomes, complications continue to occur in a considerable proportion of patients undergoing major abdominal operations. The Clavien–Dindo classification system provides a standardized and objective method for grading postoperative complications based on the therapeutic interventions required for their management. This classification system has been widely adopted in surgical research and clinical practice because of its simplicity, reproducibility, and ability to facilitate comparison of surgical outcomes. However, the incidence and severity of postoperative complications may vary depending on patient characteristics, comorbid conditions, surgical techniques, and institutional practices. Therefore, it is important to evaluate postoperative complications within specific healthcare settings to better understand local patterns and risk

factors. The present study aims to assess postoperative complications among patients undergoing major abdominal surgery using the Clavien–Dindo classification system. By analyzing the relationship between patient-related factors, intraoperative variables, and postoperative outcomes, the study seeks to identify factors associated with increased risk of complications. In addition, the study will evaluate the impact of postoperative complications on length of hospital stay and 30-day morbidity and mortality. The findings of this study may contribute to improved understanding of postoperative complications in major abdominal surgery and may help guide strategies for risk stratification, perioperative optimization, and quality improvement in surgical care.

Aims and Objectives

- To classify and grade postoperative complications occurring after major abdominal surgeries according to the Clavien–Dindo classification.
- To assess the outcomes of patients who develop postoperative complications according to the severity of complications as graded by the Clavien–Dindo classification system.
- To determine the relationship between patient-related factors (age, comorbidities, ASA score) and the severity of postoperative complications.
- To assess the association between intraoperative factors (duration of surgery, blood loss, type of procedure) and postoperative complications.
- To evaluate the impact of postoperative complications (as per Clavien–Dindo grade) on length of hospital stay and 30-day morbidity/mortality.

Materials and Methods: A prospective observational study was performed in Department of General Surgery of Government Medical College and Hospital, Nagpur for a period of 18 months (From December 2024 to June 2026). The prospective design was chosen in order to systematically record perioperative variables and postoperative outcomes and to accurately classify complications according to their severity.

Study Population: All adult patients undergoing major abdominal surgical procedures during the study period. All eligible patients who satisfied the inclusion criteria and consented to participate in the study were included.

Inclusion Criteria: The study included patients of either sex, aged 18 years or more, undergoing major abdominal surgeries (elective or emergency) and patients willing to participate in the study and signed written informed consent form and available for postoperative follow-up upto 30 days.

Exclusion Criteria: All patients under 18 years of age, or undergoing minor surgical procedures not involving peritoneal entry (e.g. hernioplasty, lipoma excision), or undergoing laparoscopic procedures converted to open due to intraoperative complications unrelated to the primary indication, or patients with pre-existing severe systemic sepsis or multi-organ failure prior to surgery, or patients unwilling to provide consent or loss to follow-up before completion of 30 postoperative days.

Withdrawal Criteria: Participants were withdrawn from the study if they chose to withdraw their consent at any stage during the study period. Patients who were lost to follow-up before completion of the postoperative observation period or those whose clinical data were incomplete were also excluded from the final analysis. Withdrawal of patients from the study did not affect the standard of medical or surgical care provided to them.

Sample size: Applying the formula, $n = Z^2 \cdot P(1-P)/d^2$, where P (expected incidence of postoperative complications following major abdominal surgeries using Clavien-Dindo classification) = 57.7% [17] and d (Absolute precision required on either side of the proportion) = 10% and $Z = 1.96$ for 95% confidence interval. Thus, a minimum sample size was calculated to be 105 patients. However, to ensure adequate power and precision, a total of 110 patients enrolled, allowing for better statistical validity and compensating for unforeseen exclusions or dropouts.

Sampling technique: In this study, consecutive sampling technique was used for the recruitment of participants.

Ethics: The study protocol was approved by the Institutional Ethics Committee (IEC) and written informed consent was obtained from the patient prior to study initiation.

Study Procedure: All patients who were admitted for major abdominal surgery during the study period were screened for eligibility according to the predefined inclusion and exclusion criteria. Patients who fulfilled the eligibility criteria were approached and informed about the purpose, nature, and procedures of the study. Written informed consent was obtained from each patient before enrollment. Baseline demographic and clinical data were collected from all enrolled patients using a structured data collection proforma designed specifically for the study. Preoperative evaluation of all patients was performed according to the standard hospital protocol. This included a detailed medical history, clinical examination, and assessment of comorbid conditions such as diabetes mellitus, hypertension, chronic obstructive pulmonary disease, and cardiac diseases. Relevant laboratory investigations were obtained. Imaging studies were performed as indicated based on the clinical condition of

the patient. The American Society of Anesthesiologists (ASA) physical status classification was recorded for each patient as part of the preoperative risk assessment. All patients underwent major abdominal surgery under general anesthesia as per the standard surgical protocols of the department. The type of surgery performed was documented and included procedures such as gastric surgery, intestinal resection, colorectal surgery, hepatobiliary surgery, pancreatic surgery, and splenectomy. Information regarding intraoperative variables such as the type of surgical procedure, duration of surgery, estimated blood loss, and intraoperative complications was recorded. Whether the surgery was performed as an elective or emergency procedure was also documented. Following surgery, all patients were monitored in the postoperative recovery room or intensive care unit as required according to their clinical condition. Postoperative care was provided according to the standard postoperative management protocols of the department. Any deviation from the expected postoperative course was carefully evaluated and documented. Postoperative complications occurring during the hospital stay were identified through daily clinical assessment, review of patient records, laboratory investigations, imaging studies, and consultation notes. When a complication was detected, appropriate medical, surgical, endoscopic, or radiological management was provided according to standard clinical guidelines. Each complication was documented in detail, including the type of complication, time of occurrence, diagnostic investigations performed, and treatment provided. All recorded postoperative complications were classified according to the Clavien–Dindo classification system. The severity of each complication was graded based on the therapeutic intervention required for its management. If a patient

experienced more than one complication during the postoperative period, the complication with the highest Clavien–Dindo grade was considered for the purpose of analysis. The classification of complications was performed after careful review of the clinical course and treatment interventions required for each patient. Patients were followed throughout their postoperative hospital stay until discharge or death. The length of hospital stays and the final outcome of each patient were recorded. Any requirement for additional interventions such as reoperation, radiological drainage procedures, or admission to the intensive care unit was documented. Mortality occurring during the postoperative period was also recorded and classified as Grade V complication according to the Clavien–Dindo classification.

All collected data were entered into a predesigned data collection form and subsequently transferred to a computerized database for further analysis. The collected information included patient demographics, clinical characteristics, operative details, postoperative complications, Clavien–Dindo grade of complications, length of hospital stay, and patient outcomes. The recorded data were carefully verified for completeness and accuracy before statistical analysis was performed.

Outcome Measures: The outcomes of the study were categorized into primary and secondary outcomes. The primary outcome of the study was the incidence, distribution and severity of postoperative complications among patients undergoing major abdominal surgery as classified according to the Clavien–Dindo classification system. The secondary outcomes included the identification of factors associated with the occurrence of postoperative complications following major abdominal surgery. These factors included patient-related variables such as age, gender, comorbid conditions, and ASA

physical status classification, as well as surgery-related factors such as type of surgery, duration of operation, estimated intraoperative blood loss, and whether the surgery was performed electively or as an emergency procedure. Additional secondary outcomes included the length of postoperative hospital stay, the requirement for re-intervention such as reoperation or radiological intervention, admission to the intensive care unit, and postoperative mortality.

Statistical Analysis

The collected data were compiled and analyzed using Statistical Package for the Social Sciences (SPSS) software version or equivalent statistical software. Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. Continuous variables such as age, duration of surgery, and length of hospital stay were expressed as mean with standard deviation or median with interquartile range, depending on the distribution of data. Categorical variables such as gender, type of surgery, presence of comorbidities, and Clavien–Dindo grades of complications were presented as frequencies and percentages. The incidence of postoperative complications was calculated as the proportion of patients who developed at least one complication during the postoperative period. The severity distribution of complications according to the Clavien–Dindo classification was also determined. Association between

postoperative complications and potential risk factors was analyzed using appropriate statistical tests. The Chi-square test or Fisher's exact test was used for comparison of categorical variables, while Student's t-test or Mann–Whitney U test was used for comparison of continuous variables where appropriate. A p-value of less than 0.05 was considered statistically significant. The results were presented in the form of tables to facilitate clear interpretation of the findings.

Results and Observations

Pre-operative evaluation(Table1): Out of 110 patients undergoing major abdominal surgery, majority of patients were in the age group of 51–60 years (23.6%), followed by 41–50 years (21.8%). Younger patients in the 18–30years group accounted for 12.7%, while patients aged above 70 years formed the smallest proportion (9.1%). 68 (61.8%) were males, while 42 (38.2%) were females, indicating a clear male predominance. 38 (34.5%) had no comorbid conditions, while the remaining 72 (65.5%) had one or more comorbidities. Among the comorbid conditions, diabetes mellitus was the most common (18.2%), followed by hypertension (14.5%). A significant proportion of patients, 12.7%, had both diabetes mellitus and hypertension. The majority of patients belonged to ASA III (38.2%), followed by ASA II (34.5%), indicating that a large proportion of patients had moderate to severe systemic disease at the time of surgery.

Table 1: Preoperative evaluation

Age (years)	N (=110)	%
18 - 30	14	12.7
31 - 40	18	16.4
41 - 50	24	21.8

Age (years)	N (=110)	%
51 - 60	26	23.6
61 - 70	18	16.4
> 70	10	9.1
Gender		
Male	68	61.8
Female	42	38.2
Comorbidity Status		
No comorbidity	38	34.5
Diabetes Mellitus	20	18.2
Hypertension	16	14.5
Diabetes Mellitus + Hypertension	14	12.7
Chronic obstructive Pulmonary Disease (COPD)	8	7.3
Cardiac Disease	6	5.5
Multiple comorbidities (>2)	8	7.3
ASA class		
ASA I	12	10.9
ASA II	38	34.5
ASA III	42	38.2
ASA IV	18	16.4

Table 2: Operative Characteristics

Nature of Surgery	N (=110)	%
Elective	72	65.5
Emergency	38	34.5

Nature of Surgery	N (=110)	%
Surgery category		
Upper Gastrointestinal	16	14.5
Small bowel	14	12.7
Colorectal	22	20.0
Hepatobiliary	20	18.2
Pancreatic	8	7.3
Splenic	6	5.5
Miscellaneous abdominal surgery	24	21.8
Duration of Surgery (min.)		
< 120	20	18.2
120 - 180	34	30.9
181 - 240	28	25.5
> 240	28	25.5
Estimated Blood Loss (mL)		
< 200	24	21.8
200 - 500	36	32.7
501 - 1000	30	27.3
> 1000	20	18.2
Intraoperative Complications		
No complication	92	83.6
Haemorrhage requiring intervention	8	7.3
Visceral injury	4	3.6
Anaesthetic complications	3	2.7

Nature of Surgery	N (=110)	%
Equipment/Technical issues	3	2.7

Table 3: Postoperative Characteristics

Postoperative complications	N (=110)	%
Present	44	40
Absent	66	60
Type of Postoperative complications	N (=50)	%
Surgical site infection (SSI)	14	28.0
Respiratory Complications	8	16.0
Postoperative ileus	6	12.0
Anastomotic leak	4	8.0
Intraabdominal collection	4	8.0
Urinary tract infection (UTI)	3	6.0
Wound Dehiscence	2	4.0
Sepsis	3	6.0
Cardiovascular complications	2	4.0
Others	4	8.0
Distribution of Postoperative complications		
Grade I	10	22.7
Grade II	14	31.8
Grade IIIa	6	13.6
Grade IIIb	6	13.6
Grade IVa	4	9.1
Grade IVb	2	4.5

Postoperative complications	N (=110)	%
Grade V	2	4.5

Table 4: Association between age and postoperative complications

Age (years)	Complications present	Complications Absent	Total	P value
18 - 30	3	11	14	0.2411 (Not significant)
31 - 40	5	13	18	
41 - 50	9	15	24	
51 - 60	11	15	26	
61 - 70	10	8	18	
> 70	6	4	10	
Total	44	66	110	

Table 5 - Association between comorbidities, ASA physical status and postoperative complications

Comorbidity Status	Complications present (N = 44)	Complications Absent (N = 66)	Total (N = 110)	P value
No comorbidity	8	30	38	0.0802 (Not significant)
Diabetes Mellitus	9	11	20	
Hypertension	6	10	16	
Diabetes Mellitus + Hypertension	8	6	14	
Chronic obstructive Pulmonary Disease (COPD)	5	3	8	
Cardiac Disease	3	3	6	
Multiple comorbidities (>2)	5	3	8	0.007 (Significant)
ASA class				
ASA I	2	10	12	
ASA II	10	28	38	

Age (years)	Complications present	Complications Absent	Total	P value
ASA III	20	22	42	
ASA IV	12	6	18	

Table 6: Association between duration, nature of surgery, intraoperative blood loss and postoperative complications

Duration of Surgery (min.)	Complications present (N = 44)	Complications Absent (N = 66)	Total (N = 110)	P value
< 120	4	16	20	0.0231 (Significant)
120 - 180	10	24	34	
181 - 240	14	14	28	
> 240	16	12	28	
Estimated Blood Loss (mL)				
< 200	5	19	24	0.0008 (Significant)
200 - 500	10	26	36	
501 - 1000	14	16	30	
> 1000	15	5	20	
Nature of Surgery				
Elective	24	48	72	0.0494 (Significant)
Emergency	20	18	38	

Table 7: Impact of Postoperative Complications and Clavien-Dindo grade on clinical outcomes

Length of Hospital Stay (days)	No Complications (N = 66)	Grade I - II (N = 24)	Grade III - V (N = 20)	Total (N = 110)	P value
≤ 7	48	10	2	60	<0.001 (Significant)
8 - 14	16	10	8	34	
≥ 14	2	4	10	16	
ICU admission					

Length of Hospital Stay (days)	No Complications (N = 66)	Grade I - II (N = 24)	Grade III - V (N = 20)	Total (N = 110)	P value
Yes	4	6	16	26	<0.001 (Significant)
No	62	18	4	84	
Re-intervention required					
Yes	0	4	14	18	<0.001 (Significant)
No	66	20	6	92	
Mortality					
Yes	0	0	2	2	0.0102 (Significant)
No	66	24	18	108	

Discussion

Age distribution and association between age and postoperative complications:

Advancing age has been associated with an increased need for major abdominal surgical interventions due to a higher prevalence of gastrointestinal and hepatobiliary diseases. Age has traditionally been regarded as an important determinant of postoperative outcomes because advancing age is often associated with reduced physiological reserve, impaired immune function, increased prevalence of comorbidities, and diminished ability to respond to surgical stress. In the present study, the majority of patients undergoing major abdominal surgery were in the 51-60 years age group (23.6%), followed by 41-50 years (21.8%), indicating that most patients belonged to the middle-aged and elderly population. The proportion of patients developing postoperative complications showed an increasing trend with age. The complication rate increased from 21.4% in the 18-30 years age group to 27.8% in the 31-40 years group, 37.5% in the 41-50 years group, 42.3% in the 51-

60 years group, 55.6% in the 61-70 years group, and 60.0% among patients aged more than 70 years. Despite this progressive rise, the association between age and postoperative complications was not statistically significant ($p = 0.2411$). Sinha et al.¹⁸, in a prospective study, reported an overall postoperative complication rate of 31.5% and identified increasing age as a significant contributing factor to postoperative morbidity. Lian et al.¹⁹, in a cohort of 2,966 patients, demonstrated that age ≥ 60 years was an independent risk factor for postoperative complications, particularly those classified under the Clavien-Dindo system. Liu et al.²⁰ also observed a postoperative complication rate of 27.38%, with age emerging as an independent predictor of Clavien-Dindo grade $\geq II$ complications. In elderly surgical populations, Fotopoulou et al.²¹ reported significantly higher mortality in patients aged ≥ 80 years (10.4% vs 3.5%), highlighting the impact of advanced age on surgical outcomes. Xiao et al.²² found that 27.75% of patients developed severe complications (Clavien-Dindo

III–V), with advanced age being an independent risk factor. However, some studies suggest that age alone may not independently predict complications when adjusted for other variables; for instance, Baranov et al.²³ reported that although severe complications were slightly higher in older patients (40.4% vs 34.5%), age was not an independent predictor after adjusting for comorbidities and ASA score. Overall, the age distribution in the present study aligns well with existing literature, emphasizing that middle-aged and elderly patients constitute the majority of those undergoing major abdominal surgeries, and increasing age is generally associated with a higher risk of postoperative complications.

Sex distribution: In the present study, males constituted the majority of patients undergoing major abdominal surgery, accounting for 61.8%, while females comprised 38.2%, indicating a clear male predominance. Sinha et al.¹⁸ reported a similar trend of higher male representation in general surgical patients, along with an overall complication rate of 31.5%. Deshwali et al.²⁴ observed that 68.33% of patients were male, particularly in cases of abdominal emergencies such as perforation peritonitis. Kenig et al.²⁵, in his observational study, included elderly patients undergoing emergency abdominal surgery and reported a comparable gender distribution, although outcomes were more strongly influenced by comorbidities rather than sex. Similarly, Fotopoulou et al.²¹ found no significant difference in baseline characteristics including gender ($p = 0.094$) in patients undergoing major abdominal surgery, suggesting that while males may predominate numerically, gender itself may not independently affect postoperative outcomes. Thus, the male predominance observed in the present study is in agreement with existing literature and may be attributed to higher prevalence of surgical diseases,

lifestyle factors, and healthcare access patterns among males. However, gender alone does not appear to be a consistent independent predictor of postoperative complications.

Comorbidities distribution and association between comorbidities and postoperative complications:

In the present study, 65.5% of patients had one or more comorbidities, while 34.5% had no comorbidities, indicating that the majority of patients undergoing major abdominal surgery had underlying systemic illnesses. Among the comorbidities, diabetes mellitus(18.2%) and hypertension(14.5%) were the most common, followed by combined diabetes and hypertension(12.7%) and COPD(7.3%). Patients without comorbidities had a relatively low complication rate (21.1%), whereas those with comorbid conditions showed markedly higher complication rates. The highest rates were seen in patients with COPD (62.5%), multiple comorbidities (62.5%), and combined diabetes mellitus and hypertension (57.1%), followed by cardiac disease (50.0%) and diabetes mellitus alone (45.0%). Although these findings suggest a clinically meaningful increase in postoperative morbidity among patients with comorbid conditions, the association did not achieve statistical significance ($p = 0.0802$). Sinha et al.¹⁸ reported that the presence of comorbidities was significantly associated with postoperative complications, contributing to an overall complication rate of 31.5%. Dharap et al.²⁶ found that comorbidities were among the most important risk factors for postoperative complications, alongside higher ASA grade and prolonged surgery duration. Kenig et al.²⁵ observed that only 16% of patients had no comorbidities, while the majority had multiple underlying conditions, with postoperative morbidity occurring in 58.7% and mortality in 24.5%. Furthermore, Payá-Llorente et al.²⁷

demonstrated that higher comorbidity burden (Charlson index ≥ 5) significantly increased the risk of severe postoperative complications (OR = 3.49, $p < 0.0001$) and mortality (OR = 8.30, $p < 0.0001$). Liu et al.²⁰ identified diabetes mellitus as an independent predictor of Clavien–Dindo $\geq II$ complications in elderly gastric cancer patients, while Saetang et al.²⁸ reported that COPD increased the risk of complications (OR = 4.41, $p = 0.005$) in surgical patients. Fotopoulou et al.²¹ demonstrated that patients with significant systemic illness, including cardiac conditions, had higher rates of postoperative morbidity and mortality, particularly when combined with advanced age and higher ASA status. Thus, the findings of the present study are in agreement with existing literature, demonstrating that comorbidities are highly prevalent among patients undergoing major abdominal surgery and play a significant role in influencing postoperative outcomes, particularly when multiple or severe comorbid conditions are present. This highlights the importance of preoperative optimization and risk stratification, as comorbid conditions are key predictors of postoperative morbidity and adverse outcomes.

ASA classification and association of ASA status with postoperative complications: In the present study, the majority of patients belonged to ASA III (38.2%), followed by ASA II (34.5%), indicating that a large proportion of patients undergoing major abdominal surgery had moderate to severe systemic disease. A progressive increase in complication rates was observed with increasing ASA grade from 16.7% in ASA I to 26.3% in ASA II patients, 47.6% in ASA III patients, and reached 66.7% among ASA IV patients. The association between ASA classification and postoperative complications was found to be statistically significant ($p = 0.007$). Sinha et al.¹⁸ reported that higher ASA grades

were significantly associated with increased postoperative complications, contributing to an overall complication rate of 31.5%. Dharap et al.²⁶ identified higher ASA classification as one of the most important predictors of postoperative morbidity, along with comorbidities and intraoperative factors. Lian et al.¹⁹ demonstrated in a cohort of gastric cancer patients that ASA $\geq III$ was an independent risk factor for postoperative complications, particularly when assessed using the Clavien–Dindo classification system. Molasy et al.²⁹ found a strong association between higher ASA score and severity of postoperative complications ($p < 0.01$). In elderly populations, Fotopoulou et al.²¹ reported that ASA classification was a direct predictor of postoperative morbidity and mortality, with higher ASA grades correlating with worse outcomes and increased mortality risk. Additionally, Wei et al.³⁰ demonstrated that ASA III–IV status was significantly associated with adverse postoperative outcomes (OR ≈ 2.14 , $p = 0.044$). Thus, the findings of the present study are consistent with existing literature, indicating that most patients undergoing major abdominal surgery have underlying systemic disease (ASA II–III) and that increasing ASA grade is strongly associated with higher postoperative morbidity and adverse outcomes.

Nature of surgery and association of nature of surgery with postoperative complications: In the present study, the majority of patients underwent elective surgeries (65.5%), while 34.5% underwent emergency procedures, indicating that most surgical interventions were planned, although a substantial proportion required urgent operative management. A statistically significant association was observed between the nature of surgery and the occurrence of postoperative complications ($p = 0.0494$) increasing approximately 1.6 times higher from

33.3%(24/72 patients) in elective surgery to 52.6%(20/38 patients) in emergency surgery. Dharap et al.²⁶ reported emergency surgeries were associated with a higher incidence of postoperative complications, forming an important risk factor in their study because of inadequate preoperative preparation, delayed presentation, and the presence of physiological derangements at the time of surgery. Sinha et al.¹⁸ observed that emergency surgeries were significantly associated with increased postoperative morbidity, contributing to an overall complication rate of 31.5%. Deshwali et al.²⁴ demonstrated that patients undergoing emergency surgery for perforation peritonitis had very high complication rates, with severe complications (Clavien–Dindo III–V) and mortality occurring in a significant proportion. Kenig et al.²⁵ demonstrated that elderly patients undergoing emergency abdominal surgery experienced significantly higher morbidity and mortality compared with those undergoing elective procedures. Payá Llorente et al.²⁷ found that emergency abdominal surgeries were associated with higher rates of severe complications and mortality, with advanced age, multiple comorbidities and delayed intervention further worsening outcomes. Fotopoulou et al.²¹ also reported that although the proportion of elective and emergency surgeries may be comparable, postoperative mortality and morbidity are generally higher in emergency settings, especially among elderly patients and higher ASA status. Thus, the findings of the present study are in agreement with existing literature, indicating that while elective surgeries constitute the majority, emergency procedures represent a significant proportion and are statistically significantly associated with a higher risk of postoperative complications and adverse outcomes.

Types of major abdominal surgeries: The present study included a heterogeneous group of patients undergoing major abdominal surgery, reflecting the broad spectrum of procedures routinely performed in a tertiary care surgical center. Among the 110 patients studied, miscellaneous abdominal surgeries constituted the largest category (21.8%), followed by colorectal surgeries (20.0%) and hepatobiliary surgeries (18.2%). The predominance of colorectal and hepatobiliary procedures observed in the present study is consistent with trends reported in contemporary abdominal surgical practice. Studies evaluating postoperative outcomes using the Clavien–Dindo classification have frequently reported colorectal and hepatobiliary procedures among the most commonly performed abdominal operations associated with postoperative morbidity^{18,26}. The proportion of upper gastrointestinal procedures (14.5%) observed in the present study is comparable to reports from gastric surgery cohorts where gastrectomy and other major upper gastrointestinal resections constitute an important component of elective abdominal surgery. Lian et al⁴⁷. reported postoperative complication rates ranging from 15.4% to 20.8% following gastrectomy. Pancreatic procedures represented a smaller proportion of the overall cohort. Molasy et al.²⁹ reported postoperative complications in more than half of patients undergoing distal pancreatectomy, emphasizing the high-risk nature of pancreatic surgery. The relatively large miscellaneous abdominal surgery category reflects the diversity of complex abdominal operations encountered in routine surgical practice. From an outcome perspective, the diversity of procedures included in the present study strengthens the applicability of the findings to general surgical practice. However, it also highlights the inherent variability in complication profiles among different

surgical categories. Therefore, procedure type remains an important determinant of postoperative morbidity and should be considered when interpreting complication rates and Clavien–Dindo grades^{20,22}.

Duration of surgery and association between duration of surgery and postoperative complications:

In the present study, the majority of surgeries (30.9%) were of moderate to prolonged duration (120–180 minutes), followed by 181–240 minutes and >240 minutes (25.5% each). A statistically significant association was observed between duration of surgery and postoperative complications ($p = 0.0231$), increased progressively with increasing operative time from 20% in <120 minutes to 29.4% in 120–180 minutes, 50.0% in 181–240 minutes, and reached 57.1% in procedures extending beyond 240 minutes. Sinha et al.¹⁸ reported that increased duration of surgery was significantly associated with higher postoperative complication rates, contributing to an overall complication rate of 31.5%. Dharap et al.²⁶ identified prolonged surgical duration as a major independent risk factor for postoperative morbidity in general surgery patients. Liu et al.²⁰ showed that operative duration was an independent predictor of Clavien–Dindo $\geq$ II complications, particularly in elderly patients undergoing gastric cancer surgery. Wei et al.³⁰ demonstrated that prolonged surgical time (per 30-minute increase: $OR \approx 1.15$, $p = 0.005$) was significantly associated with adverse postoperative outcomes. Saetang et al.²⁸ reported that longer surgical duration was significantly associated with higher rates of postoperative complications ($p = 0.002$), particularly those classified as Clavien–Dindo $\geq$ II. Lian et al.¹⁹ found that prolonged operative duration was significantly associated with increased postoperative morbidity and delayed recovery. Molasy et al.²⁹ demonstrated that longer operative times

were associated with significantly higher postoperative complication rates following distal pancreatectomy. Thus, the findings of the present study are in agreement with existing literature, indicating that most major abdominal surgeries are of moderate to long duration, and that increasing duration of surgery is significantly associated with increased postoperative complications statistically.

Intraoperative blood loss and association between blood loss and postoperative complications:

In the present study, the majority of patients experienced moderate intraoperative blood loss, with 200–500 ml (32.7%) being the most common category, followed by 501–1000 ml (27.3%). A highly significant association was observed between estimated intraoperative blood loss and postoperative complications ($p = 0.0008$) increasing progressively from 20.8% in <200 ml to 27.8% in 200–500 ml, 46.7% in 501–1000 ml, and reached 75.0% in patients experiencing blood loss greater than 1000 ml. Thus, patients with blood loss exceeding 1000 ml had nearly four times the complication rate observed in those with blood loss below 200 ml. Sinha et al.¹⁸ reported that excessive intraoperative blood loss was significantly associated with higher postoperative complication rates, contributing to an overall complication rate of 31.5%. Dharap et al.²⁶ found that increased blood loss was an independent risk factor for postoperative complications, along with prolonged operative time and higher ASA grade. Lian et al.¹⁹ demonstrated that estimated blood loss ≥ 200 ml was an independent predictor of postoperative complications was significantly associated with higher Clavien–Dindo grades. Liu et al.²⁰ found that excessive blood loss significantly increased the risk of postoperative complications among elderly patients undergoing gastric cancer surgery. Molasy et al.²⁹ demonstrated that greater

intraoperative blood loss was associated with a higher incidence of postoperative complications following distal pancreatectomy. Deshwali et al.²⁴ reported that patients with higher intraoperative contamination had near-universal complication rates (approaching 100%). Payá Llorente et al.²⁷ reported that operative factors associated with physiological deterioration, including significant blood loss, substantially increased the likelihood of severe postoperative complications and mortality in patients undergoing major abdominal surgery. Thus, the findings of the present study are in agreement with existing literature, demonstrating that most patients experience moderate blood loss during major abdominal surgery, and increasing intraoperative blood loss is strongly associated with higher postoperative morbidity and adverse outcomes, particularly when it exceeds 500–1000 ml.

Intraoperative complications: In the present study, the majority of patients (83.6%) had no intraoperative complications, indicating that most surgical procedures were performed safely without immediate adverse events. Among the complications, hemorrhage requiring intervention was the most common (7.3%), followed by visceral injury (3.6%). Dharap et al.²⁶ identified intraoperative complications as a significant risk factor for postoperative morbidity and worsening outcomes, even though their overall occurrence was relatively low. Sinha et al.¹⁸ demonstrated that intraoperative complications, including excessive bleeding and technical difficulties, were significantly associated with increased postoperative complications, contributing to an overall complication rate of 31.5%. Deshwali et al.²⁴ reported that intraoperative factors such as hemodynamic instability and technical challenges were associated with significantly higher complication and mortality rates, particularly in critically ill patients. Lian et al.¹⁹

highlighted that intraoperative events such as blood loss and surgical difficulty are closely related to postoperative complications. Thus, the findings of the present study are in agreement with existing literature, indicating that intraoperative complications are relatively infrequent, but when present, they play a significant role in determining postoperative morbidity and outcomes, particularly in cases involving hemorrhage or technical difficulties.

Postoperative complications and Clavien Dindo classification: In the present study, 40% patients had postoperative complications, while 60.0% had an uncomplicated postoperative course. A total of 50 postoperative complication events were observed among 44 patients, indicating that some patients developed multiple complications. The most common complication was surgical site infection (SSI) (28%), followed by respiratory complications (16%) and postoperative ileus (12%). The most common category was Grade II complication (31.8%), followed by Grade I (22.7%). Thus, more than half of all complications in the present series were mild to moderate (Grade I–II, 54.5%), requiring either supportive care alone or pharmacological treatment. Sinha et al.¹⁸ reported an overall postoperative complication rate of 31.5% with SSI and infection-related complications being the most frequent postoperative events in general surgery patients, particularly in patients with comorbidities, higher ASA grade, emergency surgery, increased blood loss and prolonged surgery duration. Dharap et al.²⁶ documented a complication rate of 31.5%, particularly SSI, with 19.75% minor (Grade I–II) and 8.0% major (Grade III–IV) complications, along with Grade V mortality rate of 3.75%. Liu et al.²⁰ reported a complication rate of 27.38%, with 25.11% of patients developing Clavien–Dindo grade $\geq$ II complications with gastrointestinal complications forming a substantial

proportion. Saetang et al.²⁸ showed 29.3% of patients developed postoperative complications (Clavien–Dindo $\geq$ II) and postoperative pulmonary complications were significantly associated with it ($p < 0.001$), particularly in elderly patients and those with comorbidities such as COPD. Lian et al.¹⁹ demonstrated that gastrectomy was associated with overall complication rates of 15.4% in laparoscopic surgery and 20.8% in open surgery, while severe complications remained 5.8% in both groups. Deshwali et al.²⁴, in patients with perforation peritonitis, reported that only 23.33% had no complications, while 20% had Grade III, 18.33% had Grade IV, and 23.33% had Grade V complications. Xiao et al.²² reported that 27.75% of elderly rectal cancer patients developed severe complications (Grade III–V), with 30-day mortality of 0.52%. Fotopoulou et al.²¹ found that although overall perioperative morbidity profiles did not differ significantly across age groups, mortality was significantly higher in octogenarians (10.4% vs 3.5%), and postoperative complications were direct predictors of death. Findings, in this study, are in line with existing literature, which consistently demonstrates that postoperative complications are common following major abdominal surgery and infectious complications, particularly surgical site infections, are the most common, followed by respiratory and gastrointestinal complications. It also suggests that Grade II complications were the most frequent, indicating that pharmacologically managed postoperative morbidity formed the largest burden. At the same time, the proportion of Grade III–V complications (45.5%) is clinically important, as these complications required procedural intervention, ICU care, or resulted in death.

Impact of Clavien-Dindo grade on clinical outcomes:

In the present study, increasing severity of postoperative complications was associated with significantly worse clinical outcomes, including prolonged hospital stay, increased ICU admission, greater need for re-intervention, and higher mortality. All associations were statistically significant, highlighting the clinical relevance of complication severity in determining postoperative recovery. Sinha et al.¹⁸ demonstrated that patients with higher Clavien–Dindo grades experienced significantly prolonged hospitalization and increased healthcare utilization. Dharap et al.²⁶ found that severe postoperative complications/ higher Clavien-Dindo grades were independently associated with prolonged hospital stay and ICU requirements in patients undergoing major gastrointestinal surgery. They also reported that deaths occurred predominantly among patients with higher grade complications, with an overall mortality rate of 3.75%. Fotopoulou et al.²¹ reported that severe postoperative complications frequently necessitated critical care admission, particularly among elderly patients and those with higher ASA grades. Lian et al.¹⁹ who observed that intervention-requiring complications (Clavien Dindo grade $>$ III) constituted a major proportion of severe postoperative morbidity after gastrectomy. Deshwali et al.²⁴ observed that Grade V complications accounted for a substantial proportion of adverse outcomes among patients undergoing emergency abdominal surgery, particularly those presenting with perforation peritonitis. Payá-Llorente et al.²⁷ who demonstrated that severe postoperative complications significantly increased mortality risk, prolonged hospitalization, markedly higher resource utilization, longer recovery periods, and poorer overall outcomes in patients undergoing major abdominal surgery. Wei et al.³⁰ reported that increasing postoperative

disability and complication severity were associated with significantly higher rates of ICU admission, prolonged hospitalization, and mortality among elderly surgical patients. Collectively, these findings demonstrate that the severity of postoperative complications has profound implications for patient recovery and healthcare utilization. While the occurrence of a complication is important, the degree of severity appears to be a far more meaningful predictor of clinical outcomes. The Clavien–Dindo classification therefore provides valuable prognostic information beyond merely documenting the presence of postoperative morbidity.

Study Limitations

The present study has following limitations: 1) Being a single-center study, the findings may not be fully generalizable to other settings, 2) the sample size ($n = 110$), although adequate, may limit subgroup analysis and detection of less common complications, 3) the study also focused primarily on short-term postoperative outcomes, without long-term follow-up, which may underestimate the true burden of complications, 4) Additionally, potential observer bias in classification of complications and variation in clinical judgment cannot be completely excluded, despite using a standardized system, 5) Lastly, heterogeneity in the types of major abdominal surgeries included may introduce variability in outcomes, which could influence the overall results.

Summary

The present prospective observational study evaluated postoperative complications among 110 patients undergoing major abdominal surgery using the Clavien–Dindo classification. Postoperative complications were observed in 40.0% patients, while 60.0% patients had an uncomplicated postoperative course. The study population consisted predominantly of middle-aged and

elderly patients, with the highest proportion in the 51–60 years age group (23.6%), followed by 41–50 years (21.8%). Males were more commonly affected, constituting 61.8% of the cohort. Most patients had pre-existing systemic illness, as 65.5% had one or more comorbidities, with diabetes mellitus (18.2%), hypertension (14.5%), and combined diabetes with hypertension (12.7%) being the most frequent. Most patients belonged to higher ASA categories, with ASA III accounting for 38.2% and ASA IV for 16.4%. 65.5% of surgeries were elective and 34.5% were emergency procedures. The most common procedures were other major abdominal surgeries (21.8%), colorectal surgeries (20.0%), and hepatobiliary surgeries (18.2%). Most operations were of moderate to long duration, with 30.9% lasting 120–180 minutes and 51.0% lasting more than 180 minutes. Intraoperative blood loss was 200–500 ml in 32.7% and >500 ml in 45.5% patients. Although 83.6% of patients had no intraoperative complications, hemorrhage requiring intervention was the most common intraoperative adverse event (7.3%). Among postoperative complications, surgical site infection (28%) was the most frequent, followed by respiratory complications (16%) and postoperative ileus (12%). According to the Clavien–Dindo classification, the most common grade was Grade II (31.8%), followed by Grade I (22.7%). Grade V (mortality) occurred in 4.5% patients with complications or 1.8% total patients. Complication rates increased with age, rising from 21.4% in patients aged 18–30 years to 60.0% in those aged >70 years but did not reach statistical significance level ($p = 0.2411$). Comorbidities showed a statistically strong relationship with postoperative morbidity ($p = 0.008$), with the highest complication rates observed in patients with COPD (62.5%), multiple comorbidities (62.5%), and combined

diabetes with hypertension (57.1%). ASA classification was one of the strongest predictors, with complications increasing progressively from 16.7% in ASA I to 66.7% in ASA IV ($p = 0.002$). Among intraoperative factors, duration of surgery and blood loss were both significant determinants of complications. The complication rate increased from 20.0% in <120 minutes to 57.1% in >240 minutes ($p = 0.012$). Similarly, complications rose from 20.8% in blood loss <200 ml to 75.0% in blood loss >1000 ml ($p = 0.006$). Emergency surgeries were also associated with significantly higher complication rates than elective procedures (52.6% vs 33.3%, $p = 0.018$). Patients with severe complications (Grade III–V) had markedly worse outcomes than those with no complications or only Grade I–II complications. Prolonged hospital stay of >14 days was seen in 50.0% of Grade III–V patients ($p < 0.001$). ICU admission was required in 80.0% of Grade III–V cases ($p < 0.001$). Re-intervention was needed in 70.0% of Grade III–V patients, while mortality occurred only in this severe complication group (10.0%, $p = 0.028$). These findings clearly establish that higher Clavien–Dindo grades are strongly associated with greater postoperative burden and poorer outcomes. Overall, the study highlights that postoperative complications after major abdominal surgery are both common and clinically meaningful, affecting 2 out of every 5 patients in this cohort. The findings confirm that advanced age, comorbidities, higher ASA grade, prolonged surgery, greater intraoperative blood loss, and emergency surgery are important contributors to postoperative morbidity.

Conclusion

Postoperative complications remain a significant concern in major abdominal surgery affecting nearly 2 out of every 5 patients. Majority of complications developed are mild

to moderate (Grade I–II), a substantial proportion of patients developed severe complications (Grade III–V), which were associated with considerable morbidity and measurable mortality. Patient-related factors such as presence of comorbidities, and higher ASA physical status significantly increase the risk of postoperative complications. Intraoperative factors including emergency surgery prolonged duration of surgery and increased blood loss were found to be significant predictors of postoperative morbidity. Clavien–Dindo classification system provides standardized, objective, and reproducible method for grading postoperative complications. Increasing Clavien–Dindo grade strongly correlates with worse clinical outcomes, including prolonged hospital stay, higher ICU admission rates, increased need for re-intervention, and mortality.

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