E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.48047/ijprt/16.02.569

Research Article

INCIDENCE AND PREDICTORS OF INTRAOPERATIVE HYPERTENSION DURING LAPAROSCOPIC CHOLECYSTECTOMY FOR ACUTE CHOLECYSTITIS: A RETROSPECTIVE COHORT STUDY

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Received date: 10-09-2026, date of acceptance: 15-09-2026,
Date of Publication: 16-09-2026

Abstract

Background: Intraoperative hypertension is a frequently encountered hemodynamic disturbance during laparoscopic cholecystectomy and is associated with increased perioperative cardiovascular risk, particularly in patients with acute cholecystitis. Surgical stress, pneumoperitoneum-induced physiological alterations, inadequate anesthetic depth, sympathetic stimulation, and pre-existing comorbidities contribute to significant intraoperative blood pressure fluctuations. Identification of patients at increased risk of intraoperative hypertension may facilitate timely preventive interventions, optimize anesthetic management, and improve perioperative outcomes.

Objective: To determine the incidence of intraoperative hypertension and identify independent predictors associated with its occurrence among patients undergoing laparoscopic cholecystectomy for acute cholecystitis.

Material and Methods: This retrospective cohort study was conducted in the Department of General Surgery and Department of Anaesthesiology of a tertiary care teaching hospital. Medical records of 240 adult patients who underwent laparoscopic cholecystectomy for acute cholecystitis between January 2023 and December 2025 were reviewed. Demographic characteristics, comorbidities, preoperative clinical parameters, anesthetic variables, intraoperative hemodynamic data, pneumoperitoneum pressure, operative duration, and postoperative outcomes were

extracted from electronic medical records. Intraoperative hypertension was defined as a sustained systolic blood pressure ≥160 mmHg or a ≥20% increase above baseline for at least five minutes requiring pharmacological intervention. Univariate and multivariable logistic regression analyses were performed to identify independent predictors of intraoperative hypertension.

Results: Among the 240 patients included in the study, intraoperative hypertension occurred in 56 patients (23.3%). Patients who developed intraoperative hypertension were significantly older and had a higher prevalence of pre-existing hypertension, diabetes mellitus, obesity, and American Society of Anesthesiologists (ASA) physical status III. Increased pneumoperitoneum pressure, prolonged operative duration, higher baseline systolic blood pressure, and severe gallbladder inflammation were significantly associated with intraoperative hypertensive episodes. Multivariable logistic regression identified pre-existing hypertension, elevated baseline systolic blood pressure, pneumoperitoneum pressure ≥14 mmHg, operative duration exceeding 90 minutes, and ASA physical status III as independent predictors of intraoperative hypertension. Patients experiencing intraoperative hypertension demonstrated higher postoperative intensive care utilization and longer hospital stay compared with normotensive patients.

Conclusion: Nearly one-fourth of patients undergoing laparoscopic cholecystectomy for acute cholecystitis experienced intraoperative hypertension. Pre-existing hypertension, elevated baseline blood pressure, higher pneumoperitoneum pressure, prolonged operative duration, and increased perioperative risk status independently predicted intraoperative hypertensive episodes. Early identification of high-risk patients and optimization of anesthetic and hemodynamic management may reduce perioperative cardiovascular complications and improve surgical outcomes.

Keywords: Acute cholecystitis; Laparoscopic cholecystectomy; Intraoperative hypertension; Pneumoperitoneum; Hemodynamic instability; Perioperative complications; Predictors; Retrospective cohort study.

INTRODUCTION

Acute cholecystitis is one of the most common causes of emergency surgical admission and remains the leading indication for urgent laparoscopic cholecystectomy. The condition most commonly results from obstruction of the cystic duct by gallstones, leading to gallbladder distension, inflammation, edema, bacterial proliferation, and, if untreated, progression to gangrene, perforation, empyema, or generalized peritonitis [1]. Early laparoscopic cholecystectomy is currently regarded as the standard treatment because it reduces recurrent biliary events, shortens hospital stay, and improves overall clinical outcomes [2].

Although laparoscopic cholecystectomy is considered a safe and minimally invasive procedure, the establishment of carbon dioxide pneumoperitoneum produces important physiological changes that may

influence cardiovascular function [3]. Increased intra-abdominal pressure during pneumoperitoneum elevates systemic vascular resistance, decreases venous return, alters cardiac output, and stimulates sympathetic nervous system activity [4]. In addition, reverse Trendelenburg positioning and carbon dioxide absorption may further accentuate hemodynamic fluctuations during surgery. These physiological responses are particularly relevant in patients with acute cholecystitis, where inflammatory stress and surgical manipulation may exaggerate cardiovascular responses [5].

Intraoperative hypertension is a common perioperative hemodynamic disturbance characterized by persistent elevation of arterial blood pressure during surgery. Although transient increases in blood pressure may occur during laryngoscopy, intubation, pneumoperitoneum, or surgical stimulation, sustained hypertension may increase myocardial oxygen demand, precipitate myocardial ischemia, provoke cardiac arrhythmias, increase intraoperative bleeding, and predispose patients to postoperative cardiovascular and cerebrovascular complications. Maintaining stable intraoperative blood pressure is therefore an important objective of anesthetic management during laparoscopic surgery [6,7].

The development of intraoperative hypertension is multifactorial. Patient-related factors such as advanced age, pre-existing hypertension, diabetes mellitus, obesity, and higher American Society of Anesthesiologists (ASA) physical status have been associated with exaggerated hemodynamic responses during surgery [8]. Operative factors including prolonged surgical duration, increased pneumoperitoneum pressure, difficult dissection, and severe inflammatory changes may further contribute to sympathetic activation and blood pressure elevation. Identification of these risk factors before surgery may facilitate individualized perioperative planning and early preventive intervention [9].

Previous studies have evaluated intraoperative hemodynamic changes during laparoscopic procedures; however, most have included heterogeneous surgical populations or elective laparoscopic cholecystectomy. Evidence specifically examining intraoperative hypertension in patients undergoing laparoscopic cholecystectomy for acute cholecystitis remains limited. Since acute inflammation may independently influence cardiovascular responses during anesthesia and surgical manipulation, evaluation of this subgroup is clinically important for improving perioperative risk stratification and patient safety.

Identification of independent predictors of intraoperative hypertension has important clinical implications. Recognition of patients at increased risk allows optimization of preoperative blood pressure control, appropriate selection of anesthetic techniques, adjustment of pneumoperitoneum pressure, closer intraoperative hemodynamic monitoring, and timely administration of antihypertensive therapy. Such measures may reduce perioperative cardiovascular complications and improve postoperative recovery [10].

The present retrospective cohort study was undertaken to determine the incidence of intraoperative hypertension among patients undergoing laparoscopic cholecystectomy for acute cholecystitis and to identify the demographic, clinical, anesthetic, and operative factors independently associated with its occurrence. The findings are expected to contribute to improved perioperative risk assessment and evidence-based strategies for optimizing hemodynamic management in patients undergoing laparoscopic cholecystectomy.

MATERIAL AND METHODS

Study Design and Setting

This retrospective cohort study was conducted in the Departments of General Surgery and Anaesthesiology of a tertiary care teaching hospital. Medical records of patients who underwent laparoscopic cholecystectomy for acute calculous cholecystitis between January 2023 and December 2025 were retrospectively reviewed to determine the incidence and predictors of intraoperative hypertension.

The study protocol was approved by the Institutional Ethics Committee prior to data collection. As this was a retrospective record-based study, the requirement for individual informed consent was waived by the Ethics Committee. Patient confidentiality was maintained throughout the study by anonymizing all extracted data.

Study Population

Adult patients diagnosed with acute calculous cholecystitis who underwent laparoscopic cholecystectomy during the study period constituted the study population.

Sample Size

A total of 240 eligible patients were included in the final analysis.

Sample Size Calculation

The sample size was estimated using the standard prevalence formula:

$$n = \frac{Z^2 PQ}{d^2}$$

Where:

- n = required sample size
- Z = standard normal deviate at 95% confidence interval (1.96)
- P = anticipated prevalence of intraoperative hypertension from previous studies
- $Q = 100 - P$
- d = allowable error

All eligible patients satisfying the study criteria during the study period were included to enhance statistical precision and study power.

Inclusion Criteria

- Patients aged 18 years or older.
- Diagnosis of acute calculous cholecystitis based on clinical, laboratory, and ultrasonographic findings.
- Patients who underwent laparoscopic cholecystectomy.
- Availability of complete perioperative anesthesia and operative records.

Exclusion Criteria

- Patients converted to open cholecystectomy before establishment of pneumoperitoneum.
- Concomitant major abdominal procedures.
- Severe chronic liver disease or decompensated cirrhosis.
- Incomplete anesthesia records or missing intraoperative blood pressure data.
- Patients with secondary causes of hypertension, including pheochromocytoma.

Data Collection

Clinical information was extracted from electronic medical records, anesthesia charts, operative notes, laboratory reports, radiological investigations, and postoperative records using a standardized data collection form.

The following variables were collected:

- Demographic characteristics including age, sex, and body mass index.
- Clinical characteristics including history of hypertension, diabetes mellitus, coronary artery disease, smoking status, ASA physical status, and baseline blood pressure.
- Laboratory parameters including hemoglobin, total leukocyte count, serum creatinine, liver function tests, and C-reactive protein.
- Ultrasonographic findings including gallbladder wall thickness, gallstones, pericholecystic fluid, gallbladder distension, and common bile duct diameter.
- Operative variables including operative duration, pneumoperitoneum pressure, estimated blood loss, difficulty of dissection, bile spillage, gallbladder perforation, drain placement, and conversion to open surgery.
- Intraoperative anesthetic records including blood pressure measurements, antihypertensive medication administration, and other hemodynamic events.

Definition of Intraoperative Hypertension

Intraoperative hypertension was defined as:

- Sustained systolic blood pressure ≥160 mmHg for at least five consecutive minutes,

or

- An increase in systolic blood pressure of ≥20% above the pre-induction baseline requiring pharmacological antihypertensive treatment.

Patients were categorized into:

- Intraoperative hypertension group.
- Normotension group.

Outcome Measures

Primary Outcome

- Incidence of intraoperative hypertension during laparoscopic cholecystectomy.

Secondary Outcomes

- Independent predictors of intraoperative hypertension.
- Requirement for intraoperative antihypertensive therapy.
- Intraoperative cardiovascular events.
- Postoperative intensive care unit admission.
- Postoperative complications.
- Duration of postoperative hospital stay.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0.

Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. Comparisons between patients with and without intraoperative hypertension were performed using the independent Student's *t*-test or Mann-Whitney *U* test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables, as appropriate.

Variables demonstrating a p-value <0.10 on univariate analysis were entered into a multivariable logistic regression model to identify independent predictors of intraoperative hypertension. Adjusted odds ratios (AORs) with 95% confidence intervals (95% CI) were calculated. Model discrimination was assessed using receiver operating characteristic (ROC) curve analysis, while calibration was evaluated using the Hosmer-Lemeshow goodness-of-fit test. A two-tailed p-value <0.05 was considered statistically significant.

The analyzed data were used to determine the incidence of intraoperative hypertension and identify demographic, clinical, anesthetic, and operative factors independently associated with its occurrence during laparoscopic cholecystectomy for acute cholecystitis.

RESULTS

A total of 240 patients who underwent laparoscopic cholecystectomy for acute calculous cholecystitis were included in the final analysis. Based on predefined hemodynamic criteria, 56 patients (23.3%) developed intraoperative hypertension, while 184 patients (76.7%) maintained stable intraoperative blood pressure throughout the procedure. The majority of patients belonged to the middle-aged population, with a slight female predominance reflecting the epidemiology of gallstone disease. Patients who experienced intraoperative hypertension were significantly older and demonstrated a higher prevalence of pre-existing hypertension, diabetes mellitus, obesity, and higher American Society of Anesthesiologists (ASA) physical status. Baseline systolic blood pressure was significantly greater among patients who subsequently developed hypertensive episodes during surgery. Operative characteristics revealed that higher pneumoperitoneum pressures, prolonged operative duration, and technically difficult dissections were associated with increased

incidence of intraoperative hypertension. Laparoscopic cholecystectomy was completed successfully in the majority of patients, although postoperative intensive care utilization and duration of hospitalization were significantly greater among patients with intraoperative hypertension. Multivariable logistic regression identified pre-existing hypertension, elevated baseline systolic blood pressure, pneumoperitoneum pressure ≥14 mmHg, operative duration >90 minutes, and ASA physical status III as independent predictors of intraoperative hypertension. Overall, the study demonstrates that intraoperative hypertension is a relatively common event during laparoscopic cholecystectomy for acute cholecystitis and is influenced by both patient-related and operative factors

Table 1: Baseline Demographic Characteristics of the Study Population

Table 1 summarizes the demographic characteristics of the study participants.

Variable	Hypertension (n=56)	Normotension (n=184)	p-value
Age (years), Mean ± SD	58.4 ± 10.8	47.9 ± 12.6	<0.001
Female, n (%)	34 (60.7)	116 (63.0)	0.764
Male, n (%)	22 (39.3)	68 (37.0)	
BMI (kg/m²), Mean ± SD	29.1 ± 3.8	26.8 ± 3.4	<0.001

Table 1 demonstrates that patients who developed intraoperative hypertension were significantly older than those who remained normotensive (58.4 ± 10.8 vs. 47.9 ± 12.6 years, p<0.001). Although female patients constituted the majority in both groups, gender distribution was comparable and did not demonstrate statistical significance. Body mass index was significantly higher among patients who developed intraoperative hypertension, suggesting that obesity may contribute to exaggerated intraoperative hemodynamic responses.

Table 2: Pre-existing Clinical Characteristics

Table 2 compares baseline comorbidities between the two study groups.

Variable	Hypertension n (%)	Normotension n (%)	p-value
Known Hypertension	36 (64.3)	42 (22.8)	<0.001
Diabetes Mellitus	22 (39.3)	38 (20.7)	0.007
Coronary Artery Disease	12 (21.4)	14 (7.6)	0.005
Chronic Kidney Disease	6 (10.7)	8 (4.3)	0.083
Smoking	14 (25.0)	38 (20.7)	0.505

Table 2 shows that pre-existing hypertension was significantly more prevalent among patients who developed intraoperative hypertension (64.3% vs. 22.8%, p<0.001). Diabetes mellitus and coronary artery disease were also significantly more common in the hypertension

group. Although chronic kidney disease occurred more frequently among hypertensive patients, the difference was not statistically significant.

Table 3: ASA Physical Status and Baseline Hemodynamic Parameters

Table 3 compares preoperative anesthetic risk assessment.

Variable	Hypertension	Normotension	p-value
ASA I	4 (7.1%)	42 (22.8%)	
ASA II	24 (42.9%)	108 (58.7%)	
ASA III	28 (50.0%)	34 (18.5%)	<0.001
Baseline SBP (mmHg)	148.6 ± 11.4	132.8 ± 10.6	<0.001
Baseline DBP (mmHg)	88.4 ± 8.6	81.3 ± 7.8	<0.001

Table 3 demonstrates that half of the patients who developed intraoperative hypertension belonged to ASA physical status III compared with only 18.5% of normotensive patients. Baseline systolic and diastolic blood pressures were significantly higher among patients who subsequently developed hypertensive episodes, indicating that preoperative hemodynamic status strongly influences intraoperative blood pressure behavior.

Table 4: Laboratory Parameters

Table 4 compares important laboratory findings.

Parameter	Hypertension	Normotension	p-value
Hemoglobin (g/dL)	12.8 ± 1.4	12.9 ± 1.3	0.674
TLC (×10³/mm³)	13.6 ± 3.4	12.9 ± 3.2	0.162
CRP (mg/L)	48.8 ± 18.6	41.7 ± 17.2	0.018
Serum Creatinine (mg/dL)	1.04 ± 0.26	0.96 ± 0.22	0.031

Table 4 shows that inflammatory markers, particularly C-reactive protein, were significantly higher among patients who developed intraoperative hypertension, suggesting a possible association between severe inflammatory response and perioperative sympathetic activation.

Table 5: Operative Characteristics

Table 5 compares operative variables between study groups.

Variable	Hypertension	Normotension	p-value
Operative Duration (minutes)	96.4 ± 18.2	74.8 ± 15.7	<0.001

Estimated Blood Loss (mL)	72 ± 28	54 ± 21	<0.001
Difficult Dissection	26 (46.4%)	42 (22.8%)	0.001
Gallbladder Perforation	10 (17.9%)	18 (9.8%)	0.109

Table 5 demonstrates that operative duration was significantly longer among patients who developed intraoperative hypertension. Difficult dissection and increased blood loss were also significantly associated with hypertensive episodes, indicating that technically challenging procedures contribute to greater intraoperative sympathetic stimulation.

Table 6: Pneumoperitoneum Characteristics

Table 6 compares pneumoperitoneum-related variables.

Variable	Hypertension	Normotension	p-value
Pressure ≥14 mmHg	38 (67.9%)	54 (29.3%)	<0.001
Pressure <14 mmHg	18 (32.1%)	130 (70.7%)	

Table 6 shows that pneumoperitoneum pressures of 14 mmHg or greater were significantly associated with intraoperative hypertension. More than two-thirds of hypertensive patients underwent surgery with higher pneumoperitoneum pressures compared with less than one-third of normotensive patients.

Table 7: Intraoperative Hemodynamic Events

Table 7 summarizes intraoperative cardiovascular events.

Event	Hypertension n (%)	Normotension n (%)	p-value
Tachycardia	24 (42.9)	28 (15.2)	<0.001
Vasodilator Requirement	40 (71.4)	8 (4.3)	<0.001
Arrhythmia	6 (10.7)	4 (2.2)	0.009

Table 7 demonstrates that patients with intraoperative hypertension experienced significantly more tachycardia, required vasodilator therapy more frequently, and developed arrhythmias more often than normotensive patients.

Table 8: Postoperative Outcomes

Table 8 compares postoperative outcomes.

Outcome	Hypertension	Normotension	p-value
ICU Admission	10 (17.9%)	8 (4.3%)	0.001
Hospital Stay (days)	5.8 ± 1.7	4.2 ± 1.3	<0.001
Postoperative Complications	12 (21.4%)	18 (9.8%)	0.024

Table 8 shows that patients who developed intraoperative hypertension required postoperative intensive care admission significantly more frequently and experienced longer hospital stay. Overall postoperative complications were also significantly higher in this group.

Table 9: Univariate Logistic Regression Analysis

Table 9 shows predictors identified on univariate analysis.

Variable	Odds Ratio	95% CI	p-value
Age >55 years	2.84	1.53–5.26	0.001
Hypertension	6.11	3.11–12.02	<0.001
Diabetes Mellitus	2.48	1.25–4.91	0.009
BMI ≥28 kg/m²	2.73	1.43–5.21	0.002
Pneumoperitoneum ≥14 mmHg	5.07	2.59–9.91	<0.001

Table 9 demonstrates that increasing age, pre-existing hypertension, diabetes mellitus, obesity, and higher pneumoperitoneum pressure were significant predictors of intraoperative hypertension on univariate analysis.

Table 10: Multivariable Logistic Regression Analysis

Table 10 identifies independent predictors of intraoperative hypertension.

Variable	Adjusted OR	95% CI	p-value
Pre-existing Hypertension	4.82	2.18–10.67	<0.001
Baseline SBP ≥140 mmHg	3.56	1.62–7.82	0.002
Pneumoperitoneum ≥14 mmHg	3.94	1.88–8.27	<0.001
Operative Duration >90 min	2.61	1.24–5.47	0.011
ASA III	2.87	1.34–6.15	0.007

Table 10 demonstrates that pre-existing hypertension, elevated baseline systolic blood pressure, higher pneumoperitoneum pressure, prolonged operative duration, and ASA physical status III remained independent predictors of intraoperative hypertension after adjustment for confounding variables.

Table 11: Predictive Performance of Multivariable Model

Table 11 evaluates the performance of the predictive model.

Parameter	Value
Area Under ROC Curve	0.882
Hosmer-Lemeshow p-value	0.641
Model Accuracy	86.3%

Table 11 demonstrates excellent discrimination and calibration of the multivariable logistic regression model. The area under the ROC curve of 0.882 indicates strong predictive ability for identifying patients at risk of intraoperative hypertension.

Table 12: Incidence of Intraoperative Hypertension

Table 12 summarizes the primary study outcome.

Outcome	Number	Percentage (%)
Intraoperative Hypertension	56	23.3
Normotension	184	76.7

Table 12 demonstrates that intraoperative hypertension occurred in 56 of the 240 patients, yielding an overall incidence of 23.3%. Nearly one in four patients undergoing laparoscopic cholecystectomy for acute cholecystitis experienced clinically significant intraoperative hypertension requiring pharmacological intervention, emphasizing the importance of vigilant perioperative monitoring and early identification of high-risk individuals.

Tables Summary

Table 1 demonstrates that patients who developed intraoperative hypertension were significantly older and had higher body mass index compared with normotensive patients, while sex distribution remained comparable between the groups. **Table 2** shows that pre-existing hypertension, diabetes mellitus, and coronary artery disease were significantly more prevalent among patients who experienced hypertensive episodes during surgery, indicating the important influence of baseline cardiovascular comorbidities on intraoperative hemodynamic stability. **Table 3** further demonstrates that ASA physical status III and elevated baseline systolic and diastolic blood pressures were strongly associated with the occurrence of intraoperative hypertension.**Table 4** reveals significantly higher inflammatory marker levels among hypertensive patients, suggesting that more severe inflammatory responses may contribute to exaggerated sympathetic activation during surgery. **Table 5** demonstrates that prolonged operative duration, technically difficult dissection, and increased blood loss were associated with significantly higher rates of intraoperative hypertension. **Table 6** identifies higher pneumoperitoneum pressure as an important operative factor contributing to hypertensive episodes.**Table 7** shows that intraoperative hypertension was associated with increased tachycardia, greater vasodilator requirements, and higher incidence of cardiac arrhythmias, reflecting substantial intraoperative cardiovascular instability. **Table 8** demonstrates that these patients

also experienced increased postoperative intensive care utilization, longer hospital stay, and higher postoperative complication rates, emphasizing the clinical consequences of intraoperative hypertension.**Table 9** identifies several significant predictors of intraoperative hypertension on univariate analysis, including older age, pre-existing hypertension, diabetes mellitus, obesity, and elevated pneumoperitoneum pressure. **Table 10** confirms that pre-existing hypertension, elevated baseline systolic blood pressure, pneumoperitoneum pressure ≥14 mmHg, operative duration exceeding 90 minutes, and ASA physical status III remained independent predictors following multivariable adjustment. **Table 11** demonstrates excellent predictive performance of the regression model, indicating reliable identification of high-risk patients. **Table 12** establishes that intraoperative hypertension occurred in nearly one-fourth of patients undergoing laparoscopic cholecystectomy for acute cholecystitis. Collectively, these findings highlight the multifactorial nature of intraoperative hypertension and underscore the importance of comprehensive preoperative risk assessment, individualized anesthetic management, optimization of pneumoperitoneum pressure, and vigilant intraoperative monitoring to improve perioperative outcomes.

DISCUSSION

The present retrospective cohort study evaluated the incidence and predictors of intraoperative hypertension in patients undergoing laparoscopic cholecystectomy for acute cholecystitis. Intraoperative hypertension occurred in 23.3% of patients, indicating that significant perioperative blood pressure elevation remains a common anesthetic challenge during laparoscopic surgery for acute gallbladder inflammation [11]. The study further demonstrated that pre-existing hypertension, elevated baseline systolic blood pressure, higher pneumoperitoneum pressure, prolonged operative duration, and ASA physical status III were independent predictors of intraoperative hypertension. Patients who developed hypertensive episodes also experienced greater perioperative morbidity, including increased postoperative intensive care utilization and longer hospital stay [12].

Patient-related factors played a major role in the development of intraoperative hypertension. Individuals with pre-existing hypertension and elevated baseline systolic blood pressure were significantly more likely to develop hypertensive episodes during surgery [13]. Chronic hypertension is associated with impaired vascular compliance, altered baroreceptor sensitivity, and increased sympathetic activity, predisposing patients to exaggerated hemodynamic responses during anesthesia and surgical stimulation [14]. Similarly, patients with higher ASA physical status demonstrated a greater incidence of intraoperative hypertension, reflecting the influence of multiple systemic comorbidities on perioperative cardiovascular stability. These findings emphasize the importance of careful preoperative cardiovascular assessment and optimization before laparoscopic cholecystectomy [15].

Advanced age and obesity were also associated with an increased occurrence of intraoperative hypertension on univariate analysis. Aging is accompanied by progressive arterial stiffness and reduced

cardiovascular reserve, while obesity contributes to sympathetic overactivity and impaired vascular function. Although these variables did not remain independent predictors after multivariable adjustment, they identify patient populations requiring closer intraoperative monitoring and individualized anesthetic management [16].

Among operative factors, pneumoperitoneum pressure and operative duration demonstrated a significant association with intraoperative hypertension. Carbon dioxide pneumoperitoneum increases intra-abdominal pressure, resulting in elevated systemic vascular resistance and activation of neurohumoral pathways that contribute to blood pressure elevation [17]. Likewise, prolonged operative duration exposes patients to sustained surgical stimulation and longer periods of pneumoperitoneum, increasing the likelihood of hemodynamic instability. These findings support the use of the lowest effective pneumoperitoneum pressure and efficient surgical techniques whenever feasible to minimize adverse cardiovascular responses [18].

An important observation of the present study was the relationship between intraoperative hypertension and postoperative outcomes. Patients who experienced hypertensive episodes required intraoperative antihypertensive therapy more frequently and had higher rates of postoperative intensive care admission, prolonged hospitalization, and postoperative complications. These findings suggest that intraoperative hypertension should not be regarded as an isolated physiological event but rather as a marker of increased perioperative risk. Early recognition and prompt management of blood pressure elevations may therefore contribute to improved postoperative recovery [19].

The multivariable logistic regression model identified readily available clinical and operative variables that independently predicted intraoperative hypertension. These predictors can be incorporated into routine preoperative assessment to identify patients at increased risk before surgery. Such risk stratification may facilitate optimization of blood pressure control, selection of appropriate anesthetic techniques, closer intraoperative monitoring, and timely pharmacological intervention, thereby improving perioperative hemodynamic stability [20].

The present study has certain limitations. Its retrospective design limits the establishment of causal relationships and introduces the possibility of selection bias. Being a single-center study, the findings may not be generalizable to all healthcare settings. Variations in anesthetic management and surgeon experience could not be completely standardized, and long-term cardiovascular outcomes were not evaluated. Nevertheless, the relatively large study population and comprehensive assessment of demographic, clinical, anesthetic, and operative variables strengthen the validity of the findings.

In conclusion, intraoperative hypertension is a relatively common occurrence during laparoscopic cholecystectomy for acute cholecystitis. Pre-existing hypertension, elevated baseline systolic blood pressure, higher pneumoperitoneum pressure, prolonged operative duration, and higher ASA physical status independently increase the risk of hypertensive episodes during surgery. Recognition of these predictors allows early perioperative risk

stratification and implementation of targeted anesthetic and surgical strategies that may improve hemodynamic stability and postoperative outcomes.

CONCLUSION

The present retrospective cohort study demonstrated that intraoperative hypertension is a relatively frequent hemodynamic event during laparoscopic cholecystectomy for acute cholecystitis, with an incidence of 23.3%. Patients with pre-existing hypertension, elevated baseline systolic blood pressure, higher ASA physical status, increased pneumoperitoneum pressure, and prolonged operative duration were at significantly greater risk of developing intraoperative hypertensive episodes. These factors independently contributed to perioperative hemodynamic instability and were associated with less favorable postoperative outcomes, including increased intensive care utilization and longer hospital stay.

The findings underscore the importance of comprehensive preoperative risk assessment and optimization of modifiable cardiovascular risk factors before surgery. Intraoperative strategies such as meticulous anesthetic management, maintenance of adequate anesthetic depth, use of the lowest effective pneumoperitoneum pressure, and continuous hemodynamic monitoring may reduce the occurrence of hypertensive episodes and improve perioperative cardiovascular stability.

Early identification of patients at increased risk enables individualized perioperative management and timely therapeutic intervention, thereby minimizing perioperative complications and enhancing postoperative recovery. Further prospective multicenter studies with larger patient populations are warranted to validate these findings and develop standardized risk prediction models for improving perioperative outcomes in patients undergoing laparoscopic cholecystectomy for acute cholecystitis.

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