Surgical Complications in Patients With Morbid Obesity Undergoing Laparoscopic Cholecystectomy: A Retrospective Cohort Study

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AIM: Few studies have compared surgical outcomes across different grades of obesity. We assessed the effect of severe obesity (SO) on operative time, intraoperative blood loss >100 mL and length of hospital stay (LOS) after laparoscopic cholecystectomy (LC).
METHODS: This retrospective cohort study included 1126 patients aged 14 years or older who underwent LC at Dr. Soliman Fakeeh Hospital between January 2019 and December 2021. Patients were grouped according to the presence or absence of SO, defined as a body mass index (BMI) ≥40 kg/m^2 or ≥35 kg/m^2 in patients with obesity-related comorbidities. Demographic, clinical, operative, and postoperative data were compared between groups. Categorical variables were analyzed using Pearson's chi-square or Fisher's exact tests, while continuous variables were analyzed using either the independent Student's *t*-test or Mann–Whitney U test according to data distribution. Additional multivariable linear and logistic regression analyses were performed to identify whether SO was independently associated with operative time, intraoperative blood loss >100 mL, and LOS.
RESULTS: Severe obesity was identified in 16.1% (181/1126) of patients. Patients with SO had significantly longer symptom duration and operative times than those without SO (4.00 (2.00–24.00) vs. 4.00 (2.00–12.00), $p = 0.007$; and 53.5 (39.75–75.5) vs. 48.0 (36.0–65.0) min, $p = 0.004$, respectively). The SO− group had significantly higher rates of endoscopic retrograde cholangiopancreatography (ERCP) and biliary stenting, whereas the difference in obstructive jaundice was not statistically significant. Intraoperative blood loss >100 mL occurred more frequently in the SO+ group (3.3% vs. 0.5%, $p = 0.004$). LOS was also significantly longer among SO+ (2.0 (2.0–3.0) vs. 2.0 (2.0–3.0), $p = 0.003$). In multivariable linear regression analysis, SO remained independently associated with longer operative time (B = 7.48 minutes, 95% CI 2.54–12.42, $p = 0.003$). Multivariable logistic regression analysis also demonstrated that SO was independently associated with increased odds of intraoperative blood loss >100 mL (odds ratio [OR] = 30.79, 95% CI 5.07–187.03, $p < 0.001$). However, SO was not independently associated with prolonged LOS after adjustment for clinically relevant covariates (B = 0.127, 95% confidence interval [CI] –0.046 to 0.300, $p = 0.149$).
CONCLUSIONS: Patients with SO undergoing LC experienced longer operative times and higher rates of intraoperative blood loss >100 mL; however, severe obesity was not independently associated with prolonged hospital stay. Multivariable analyses demonstrated that SO remained independently associated with operative time and bleeding risk after adjustment for clinically relevant covariates. These findings suggest that SO is associated with longer operative time and an increased likelihood of intraoperative bleeding during LC, although its association with postoperative outcomes appears limited. Larger prospective studies are needed to further clarify the independent effects of SO on surgical outcomes.

Keywords: severe obesity; laparoscopic cholecystectomy; gallbladder disease; operative time; intraoperative bleeding; multivariable regression analysis; surgical outcomes

Introduction

The World Health Organization defines obesity as a body mass index (BMI) of ≥30 kg/m^2. Severe obesity (SO) is defined as a BMI of ≥40 kg/m^2 or ≥35 kg/m^2 in those with obesity-related comorbidities [1]. The increasing prevalence of obesity is a major global health issue, overtaking undernutrition and infectious diseases. The obesity epidemic places a substantial financial burden on public healthcare owing to the severe risks and multiple associated comorbidities. Obesity also significantly reduces both the quality and duration of life, and SO is a major contributor to premature mortality among middle-aged adults. The prevalence of obesity-related health issues, including atherosclerosis, coronary artery disease, hypertension, insulin resistance, sleep apnoea, osteoarthritis, gastroesophageal reflux, gallbladder disease, depression and various types of malignancies, is increasing [2].

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Cholelithiasis, more commonly known as gallstones, and its complications are among these associated conditions, with increasing risk corresponding to increasing body weight [3]. Laparoscopic cholecystectomy (LC) is the gold standard treatment for patients with symptomatic cholelithiasis. LC has been reported as safe for patients with obesity [4]. However, difficulty accessing abdominal insufflation and increased intra-abdominal pressure during surgery in morbidly obese patients can potentially affect cardiopulmonary function. Furthermore, excess adipose tissue can prolong operative time and cause difficulty in identifying the appropriate dissection plane. While some research has found that the incidence of wound infections and the need for open surgical procedures increase with increasing BMI, other studies have reported comparable complication rates between patients with and without obesity [5]. Similarly, some studies have found obesity to be associated with surgical morbidity in procedures such as gastrectomy [6], colectomy [7], hepatectomy [8,9] and LC [10,11]. However, other studies have found no such associations between obesity and morbidity or mortality during gastrectomy [12], hepatectomy [13] and LC [14].

To date, limited evidence has specifically evaluated the impact of severe obesity on perioperative outcomes following LC. This cohort study aimed to assess whether severe obesity independently influences operative time, intraoperative blood loss >100 mL, and LOS after LC.

Methods

Study Design and Setting

Using the institutional electronic medical records of Dr. Soliman Fakeeh Hospital, a private tertiary care centre in Jeddah, Saudi Arabia. We gathered data from a total of 1173 consecutive patients aged 14 years or older with gallbladder disease who underwent LC between January 2019 and December 2021.

Patient Selection

Inclusion Criteria

Patients aged 14 years or older who underwent laparoscopic cholecystectomy for gallbladder disease between January 2019 and December 2021 at our institution were eligible for inclusion.

Exclusion Criteria

Patients younger than 14 years, patients with a BMI ≤18.4 kg/m^2, and patients with incomplete medical records or missing perioperative data that could affect the accuracy of the analysis were excluded.

After applying these criteria, 47 patients were excluded, leaving 1126 patients in our final analysis.

Grouping and Definition of Severe Obesity

Patients were classified into two groups based on the presence or absence of SO. The SO+ group included patients with a BMI of ≥40 kg/m^2 or ≥35 kg/m^2 in those with obesity-related comorbidities [1], while the SO− group included all remaining patients. For patients with a BMI of 35–39.9 kg/m^2, obesity-related comorbidities were defined as diabetes mellitus (DM), hypertension (HTN), coronary artery disease (CAD), or chronic kidney disease (CKD), as documented in the medical records. Patients with at least one of these conditions were classified into the SO+ group. A total of 181 (16.1%) patients were classified as SO+, and 945 (83.9%) as SO−. Of the 181 patients in the SO+ group, 91 had a BMI of ≥35 kg/m^2 with obesity-related comorbidities, 66 had a BMI of ≥40 kg/m^2 with comorbidities and 24 had a BMI of ≥40 kg/m^2 without comorbidities.

Data Collection

Each patient's diagnosis of gallbladder disease was confirmed based on clinical examination, laboratory tests and ultrasonography. Endoscopic retrograde cholangiopancreatography (ERCP) was performed when biliary system obstruction occurred. Trained surgical residents recorded all relevant data digitally pre- and postoperatively. Our hospital healthcare information system was used to record any complications or adverse events that occurred during the first 30 days after surgery. Postoperative complications were identified from the hospital healthcare information system and medical records documenting events occurring within 30 days after surgery. Surgical site infection (SSI), bile leak, and common bile duct (CBD) injury were identified based on the relevant postoperative clinical documentation in the medical records. The anaesthesia team and circulating nurses recorded intraoperative data on the system during and after the procedure, including the start and end times, estimated blood loss and conversion to open surgery. Blood loss was estimated either by measuring the volume of blood collected following suctioning or by counting the number of wet gauze pads used. Each surgical gauze pad is 10.25 × 10.25 cm and absorbs approximately 10–15 mL of blood [15]. A blood loss of >100 mL was used as a pragmatic threshold to identify cases with relatively increased bleeding. Clinically significant outcomes, such as the need for haemostatic intervention or blood transfusion, may provide additional clinical context. However, none of the patients in our cohort required blood transfusion or major haemostatic intervention [16].

For this study, the measured outcomes were conversion to open surgery, the incidence of complications, the LOS and the readmission rate. The American Society of Anesthesiologists (ASA) physical status classification system was used as a measure of each patient's preoperative clinical condition. ASA scores range from I (a normal healthy patient) to V (a moribund patient not expected to survive without

surgery). For our analysis, patients were divided into two ASA groups: ASA I–III and ASA IV–V [17].

Definitions and Outcomes

'Comorbidity' was defined as any distinct additional pathological clinical entity that occurs during the clinical course of the index disease and can affect prognosis, therapeutic plans or outcomes [18].

'Symptom duration' was defined as the time interval (in weeks) between the onset of gallbladder-related symptoms (e.g., biliary colic, cholecystitis), as reported by the patient, and the date of surgery.

The primary outcomes were operative time, intraoperative blood loss >100 mL and conversion to open surgery. Acute cholecystitis included in the regression models was defined based on the postoperative histopathological examination of the resected gallbladder.

The secondary outcomes were postoperative complications (including surgical site infection [SSI] and bile leak), LOS and 30-day readmission rate.

Surgery Techniques

At our centre, LC is our primary approach to the management of gallbladder disease. The decision to convert from laparoscopic to open surgery is made by the operating surgeon based on intraoperative difficulties and the status of the patient. All surgeons at our centre perform LC using the traditional four-port method, ensuring the critical view of safety before structural division. The gallbladder is extracted using a plastic endopouch specimen retriever to minimise contamination. We do not routinely use surgical drains unless the gallbladder perforates or intraoperative bleeding occurs.

Statistical Analysis

Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as means and standard deviations for normally distributed data or medians and interquartile ranges for non-normally distributed data. Normality was assessed using the Shapiro–Wilk test. Comparisons between groups were performed using Pearson's chi-square test or Fisher's exact test for categorical variables, and either the independent Student's *t*-test or Mann–Whitney U test for continuous variables, as appropriate. All statistical tests were two-sided, and a *p*-value < 0.05 was considered statistically significant.

Additional multivariable linear regression analyses were performed for operative time and postoperative length of stay, whereas multivariable binary logistic regression analysis was used for intraoperative blood loss >100 mL.

Variables included in the multivariable regression models were selected based on clinical relevance, previously published literature, and their potential to confound the relationship between severe obesity and operative outcomes. These variables included age, gender, comorbidities, symptom duration, preoperative stent insertion, emergency surgery status, gallbladder wall thickness and acute cholecystitis.

All statistical analyses were performed using SPSS, v.25 (IBM Corp., Armonk, NY, USA) software.

This study was performed in accordance with the ethical standards of the Declaration of Helsinki and its later amendments. The study was approved by the Institutional Review Board of Dr. Soliman Fakeeh Hospital (DSFH) (approval no. 228/IRB/2021).

Results

Patient Characteristics and BMI Distribution

Of the 1126 patients included in our analysis, 19.4% (219/1126) had a BMI (18.5–24.9) in the healthy range, 32.2% (363/1126) were in the overweight range (25–29.9), 26.3% (296/1126) were in the obesity class I range (30–34.9), 14% (158/1126) were in the obesity class II range (35–39.9) and 8% (90/1126) were in the obesity class III range (BMI ≥40), per the World Health Organization (WHO) classification system [1]. Severe obesity was present in 16.1% (181/1126) of the patients.

Comparison Between SO+ and SO− Groups

The median BMI was significantly higher in the SO+ group than in the SO− group (39.95 [37.10–43.53] vs. 28.50 [25.30–31.90] kg/m^2, $p < 0.001$). Patients in the SO+ group were significantly older (47.00 [35.00–57.00] vs. 38.00 [32.00–50.00] years, $p < 0.001$) and more likely to be female (75.7% vs. 67.8%, $p = 0.036$). They also had higher incidences of diabetes (35.4% vs. 14.1%, $p < 0.001$) and other comorbidities (86.7% vs. 43.2%, $p < 0.001$).

Clinical Presentation

The SO+ group had a significantly longer duration of symptoms before surgery (4.00 [2.00–24.00] vs. 4.00 [2.00–12.00] weeks, $p = 0.007$), a significantly higher median white blood cell count (8.33 [6.58–10.21] vs. 7.26 [5.70–9.18], $p < 0.001$).

Patients without severe obesity were more likely to undergo preoperative ERCP (9.5% vs. 4.4%, $p = 0.026$) and biliary stent placement (8.9% vs. 3.9%, $p = 0.023$). Although statistically significant differences were observed in bilirubin, aspartate aminotransferase (AST), and alanine aminotransferase (ALT) levels, the absolute differences between groups were small and were not considered clinically meaningful.

There were no significant between-group differences in ASA classification, smoking status, biliary pancreatitis, haemoglobin, albumin, gallbladder wall thickness, pericholecystic fluid, stone size, emergency presentation, or the combined variable of CBD stones and obstructive jaundice (all $p > 0.05$) (Table 1).

Table 1. The demographics and clinical characteristics of laparoscopic cholecystectomy patients with and without severe obesity.

Variables	SO+ group (n = 181)	SO− group (n = 945)	Test statistics	*p*-value [a]
Age at surgery, years	47.00 (35.00–57.00)	38.00 (32.00–50.00)	U = 66,842.5	<0.001
BMI	39.95 (37.10–43.53)	28.50 (25.30–31.90)	U = 3049.5	<0.001
Sex, n (%)			χ^2 = 4.395	0.036
Male	44 (24.3)	304 (32.2)		
Female	137 (75.7)	641 (67.8)		
ASA score, n (%)			Fisher's exact test	1.000
I–III	181 (100.0)	941 (99.6)		
IV + V	0 (0.0)	4 (0.4)		
Diabetes, n (%)			χ^2 = 47.678	<0.001
Yes	64 (35.4)	133 (14.1)		
No	117 (64.6)	812 (85.9)		
Comorbidities, n (%)			χ^2 = 115.326	<0.001
Yes	157 (86.7)	408 (43.2)		
No	24 (13.3)	537 (56.8)		
Smoking, n (%)			χ^2 = 1.711	0.191
Yes	35 (19.3)	225 (23.8)		
No	146 (80.7)	720 (76.2)		
Symptom duration (weeks)	4.00 (2.00–24.00)	4.00 (2.00–12.00)	U = 74,899.0	0.007
Biliary pancreatitis, n (%)			χ^2 = 0.062	0.804
Yes	8 (4.4)	38 (4.0)		
No	173 (95.6)	907 (96.0)		
CBD stones and/or obstructive jaundice, n (%)			χ^2 = 3.12	0.077
Yes	5 (2.8)	57 (6.0)		
No	176 (97.2)	888 (94.0)		
WBC ($\times 10^9$/L)	8.33 (6.58–10.21)	7.26 (5.70–9.18)	U = 70,015.0	<0.001
HB (g/dL)	12.70 (11.20–13.80)	12.90 (11.70–14.20)	U = 77,597	0.062
Albumin (g/dL)	3.40 (3.40–3.40)	3.40 (3.40–3.40)	U = 84,307.0	0.491
Total bilirubin (mg/dL)	0.68 (0.33–0.90)	0.75 (0.39–0.90)	U = 77,606.5	0.045
Alkaline phosphatase (U/L)	110.00 (78.50–110.00)	110.00 (74.65–110.00)	U = 83,505.5	0.688
AST (U/L)	50.00 (21.00–50.00)	50.00 (26.45–50.00)	U = 75,313.0	0.007
ALT (U/L)	38.75 (18.93–50.00)	50.00 (20.00–50.00)	U = 77,585.5	0.043
INR	0.90 (0.90–0.97)	0.91 (0.90–1.00)	U = 74,708.5	0.005
Pericholecystic fluid (US)			χ^2 = 1.082	0.298
Yes	9 (5.0)	67 (7.1)		
No	172 (95.0)	878 (92.9)		
GB wall thickness (mm)	3.00 (2.00–4.00)	2.00 (2.00–4.00)	U = 81,850.5	0.383
Stone size (mm)	7.00 (5.00–15.00)	7.00 (5.00–11.00)	U = 79,133.5	0.106
ERCP			χ^2 = 4.980	0.026
Yes	8 (4.4)	90 (9.5)		
No	173 (95.6)	855 (90.5)		
Stent insertion			χ^2 = 5.156	0.023
Yes	7 (3.9)	84 (8.9)		
No	174 (96.1)	861 (91.1)		

[a] Continuous variables are presented as mean ± SD for normally distributed data and as median (IQR) for non-normally distributed data. Categorical variables are presented as frequencies and percentages. Categorical variables were compared using Pearson's chi-square test or Fisher's exact test, as appropriate. Normally distributed continuous variables were compared using the independent-samples Student's *t*-test, whereas non-normally distributed continuous variables were analyzed using the Mann–Whitney U test. ASA, American Society of Anesthesiologists physical status classification; ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; CBD, common bile duct; ERCP, endoscopic retrograde cholangiopancreatography; GB, gallbladder; HB, haemoglobin; IQR, interquartile range; SD, standard deviation; SO, severe obesity; US, ultrasound; WBC, white blood cell count; INR, International Normalized Ratio.

Table 2. Operative outcomes and recovery in laparoscopic cholecystectomy patients with and without severe obesity.

Variables	SO+ group(n = 181)	SO− group(n = 945)	Test statistics	*p*-value [a]
Surgery, n (%)			$\chi^2 = 1.179$	0.278
Elective	172 (95.0)	877 (92.8)		
Urgent/ ER	9 (5.0)	68 (7.2)		
Operative approach, n (%)			Fisher's exact test	1.000
Laparoscopy	179 (98.9)	935 (98.9)		
Converted	2 (1.1)	10 (1.1)		
Operative time (min)	53.5 (39.75–75.5)	48.0 (36.0–65.0)	U = 73,896.0	0.004
Gallbladder perforation, n (%)			Fisher's exact test	0.604
Yes	3 (1.7)	24 (2.5)		
No	178 (98.3)	921 (97.5)		
Intraoperative blood loss >100 mL, n (%)			Fisher's exact test	0.004
Yes	6 (3.3)	5 (0.5)		
No	175 (96.7)	940 (99.5)		
Drain, n (%)			$\chi^2 = 0.611$	0.435
Yes	25 (13.8)	111 (11.7)		
No	156 (86.2)	834 (88.3)		
Surgical site infection, n (%)			Fisher's exact test	0.164
Yes	3 (1.7)	6 (0.6)		
No	178 (98.3)	939 (99.4)		
Biliary leak, n (%)			Fisher's exact test	1.000
Yes	2 (1.1)	11 (1.2)		
No	179 (98.9)	934 (98.8)		
CBD injury, n (%)			Fisher's exact test	1.000
Yes	0 (0.0)	1 (0.1)		
No	181 (100.0)	944 (99.9)		
30-day morbidity			Fisher's exact test	0.594
Yes	5 (2.8)	21 (2.2)		
No	176 (97.2)	924 (97.8)		
Histopathology, n (%)			$\chi^2 = 4.583$	0.032
Chronic cholecystitis	176 (97.2)	879 (93.0)		
Acute cholecystitis	5 (2.8)	66 (7.0)		
LOS (days)	2.0 (2.0–3.0)	2.0 (2.0–3.0)	U = 75,853.0	0.003
30-day readmission, n (%)			Fisher's exact test	0.745
Yes	3 (1.7)	14 (1.5)		
No	178 (98.3)	931 (98.5)		

[a] Continuous variables are presented as mean ± standard deviation (SD) for normally distributed data and as median (interquartile range [IQR]) for non-normally distributed data. Categorical variables are presented as frequencies and percentages. Categorical variables were compared using Pearson's chi-square test or Fisher's exact test, as appropriate. Normally distributed continuous variables were compared using the independent-samples Student's *t*-test, whereas non-normally distributed continuous variables were analyzed using the Mann–Whitney U test. CBD, common bile duct; ER, emergency room.

Operative Outcomes

Primary Operative Outcomes

Patients in the SO+ group had a higher incidence of intraoperative blood loss >100 mL (3.3% vs. 0.5%, $p = 0.004$) and longer operative times (53.5 [39.75–75.5] vs. 48.0 [36.0–65.0] min, $p = 0.004$). The LOS was also longer in the SO+ group (2.0 [2.0–3.0] vs. 2.0 [2.0–3.0] days, $p = 0.003$). The rate of conversion to open surgery was similarly low in both groups, with an overall rate of 1.1% (12/1126).

Secondary Operative Outcomes

We found no significant differences between the SO+ and SO− groups in surgical complications, the need for drainage, or the readmission rate. Nor were any differences found in the incidences of gallbladder perforation, SSI, bile leak or common bile duct (CBD) injury.

A histopathological finding of chronic cholecystitis was significantly more frequent in the SO+ group than in the SO− group (97.2% vs. 93%, $p = 0.032$).

Surgical drainage was required in 12% (136/1126) of the total cohort, with no significant difference between groups (Table 2).

Table 3. Multivariable linear regression analysis of factors independently associated with operative time.

Variables	B coefficient	95% CI	*p*-value
Age (years)	0.05	−0.08 to 0.19	0.454
Gender (female)	−6.44	−10.16 to −2.72	<0.001
Comorbidities (yes)	0.42	−3.31 to 4.15	0.824
Symptom duration (weeks)	0.09	0.06 to 0.13	<0.001
Preoperative stent insertion	12.50	6.16 to 18.83	<0.001
Emergency surgery	9.66	2.69 to 16.62	0.007
Severe obesity	7.48	2.54 to 12.42	0.003
GB wall thickness (mm)	2.03	0.98 to 3.08	<0.001
Histopathologically confirmed acute cholecystitis	11.49	4.29 to 18.69	0.002

Multivariable linear regression analysis was performed using the Enter method to identify factors independently associated with operative time after adjustment for age, gender, comorbidities, symptom duration, preoperative biliary stent insertion, emergency surgery status, severe obesity, gallbladder wall thickness, and acute cholecystitis. B, unstandardized regression coefficient; CI, confidence interval; GB, gallbladder. Model statistics: $R^2 = 0.095$, adjusted $R^2 = 0.088$, $F = 13.06$, $p < 0.001$.

Regression Analysis

Further multivariable regression analyses were conducted to evaluate factors associated with operative difficulty, intraoperative blood loss >100 mL and LOS.

Operative Time

A multivariable linear regression model was constructed to identify factors independently associated with operative time after adjustment for age, sex, comorbidities, symptom duration, preoperative biliary stent insertion, emergency surgery, severe obesity, gallbladder wall thickness, and acute cholecystitis (Table 3). The overall model was statistically significant ($F = 13.06$, $p < 0.001$), explaining 9.5% of the variability in operative time ($R^2 = 0.095$; adjusted $R^2 = 0.088$).

After adjustment for the included covariates, severe obesity remained independently associated with longer operative time, increasing the expected operative duration by 7.48 minutes (95% confidence interval [CI] 2.54–12.42, $p = 0.003$).

Longer symptom duration was independently associated with prolonged operative time, with each additional week of symptoms increasing operative time by 0.09 minutes (95% CI 0.06–0.13, $p < 0.001$). Patients who required preoperative biliary stent insertion had operative times that were 12.50 minutes longer than those without stent placement (95% CI 6.16–18.83, $p < 0.001$). Similarly, emergency surgery was associated with an average increase of 9.66 minutes in operative time (95% CI 2.69–16.62, $p = 0.007$).

Gallbladder wall thickness was also independently associated with longer operative time, with each 1-mm increase corresponding to an average increase of 2.03 minutes (95% CI 0.98–3.08, $p < 0.001$).

Histopathologically confirmed acute cholecystitis was also independently associated with longer operative time (B = 11.49, 95% CI 4.29–18.69, $p = 0.002$).

Age and the presence of comorbidities were not independently associated with operative time after adjustment for the other covariates (both $p > 0.05$). Female sex was independently associated with a shorter operative time than male sex (B = −6.44, 95% CI −10.16 to −2.72, $p < 0.001$).

Intraoperative Blood Loss >100 mL

A multivariable logistic regression model was constructed to identify factors independently associated with intraoperative bleeding exceeding 100 mL (Table 4). The overall model was statistically significant ($\chi^2 = 56.59$, $p < 0.001$) and demonstrated good calibration according to the Hosmer–Lemeshow goodness-of-fit test ($p = 0.926$).

After adjustment for age, sex, comorbidities, symptom duration, preoperative biliary stent insertion, emergency surgery, gallbladder wall thickness, and acute cholecystitis, severe obesity remained independently associated with substantially increased odds of intraoperative blood loss >100 mL (adjusted odds ratio [OR] 30.79, 95% CI 5.07–187.03, $p < 0.001$). The wide confidence intervals likely reflect the relatively small number of bleeding events.

Histopathologically confirmed acute cholecystitis was also independently associated with intraoperative blood loss >100 mL (adjusted OR 60.27, 95% CI 8.06–450.51, $p < 0.001$). Female sex was independently associated with lower odds of bleeding than male sex (adjusted OR 0.08, 95% CI 0.01–0.45, $p = 0.004$). None of the remaining variables were independently associated with intraoperative blood loss >100 mL.

Length of Hospital Stay (LOS)

A multivariable linear regression model was constructed to identify factors independently associated with LOS (Table 5). The model was statistically significant ($F = 18.33$, $p < 0.001$), explaining 12.9% of the variability in hospital stay ($R^2 = 0.129$; adjusted $R^2 = 0.122$).

Table 4. Multivariable logistic regression analysis of factors independently associated with intraoperative blood loss >100 mL.

Variables	Odds ratio (OR)	95% CI	*p*-value
Age	0.95	0.90 to 1.01	0.076
Gender (female)	0.08	0.01 to 0.45	0.004
Comorbidities (yes)	1.25	0.24 to 6.64	0.794
Symptom duration (weeks)	0.77	0.55 to 1.07	0.121
Preoperative stent insertion	3.36	0.49 to 22.91	0.217
Emergency surgery	0.13	0.01 to 1.56	0.107
Severe obesity	30.79	5.07 to 187.03	<0.001
GB wall thickness (mm)	1.28	0.90 to 1.81	0.174
Histopathologically confirmed acute cholecystitis	60.27	8.06 to 450.51	<0.001

Multivariable binary logistic regression analysis was performed to identify factors independently associated with intraoperative blood loss >100 mL after adjustment for age, gender, comorbidities, symptom duration, preoperative biliary stent insertion, emergency surgery status, severe obesity, gallbladder wall thickness, and acute cholecystitis. OR, odds ratio; CI, confidence interval.

Table 5. Multivariable linear regression analysis of factors independently associated with LOS.

Variables	B coefficient	95% CI	*p*-value
Age (years)	0.005	0.000 to 0.009	0.053
Gender (female)	−0.034	−0.164 to 0.096	0.609
Comorbidities (yes)	0.119	–0.011 to 0.250	0.073
Symptom duration (weeks)	0.001	–0.001 to 0.002	0.393
Preoperative stent insertion	0.461	0.240 to 0.683	<0.001
Emergency surgery	0.904	0.661 to 1.148	<0.001
Severe obesity	0.127	−0.046 to 0.300	0.149
GB wall thickness (mm)	0.056	0.020 to 0.093	0.003
Histopathology (Acute cholecystitis)	0.591	0.339 to 0.843	<0.001

Multivariable linear regression analysis was performed using the Enter method to identify factors independently associated with LOS after adjustment for age, gender, comorbidities, symptom duration, preoperative biliary stent insertion, emergency surgery status, severe obesity, gallbladder wall thickness, and acute cholecystitis. B, unstandardized regression coefficient; CI, confidence interval; GB, gallbladder.

After adjustment for age, sex, comorbidities, symptom duration, preoperative biliary stent insertion, emergency surgery, severe obesity, gallbladder wall thickness, and acute cholecystitis, severe obesity was not independently associated with postoperative length of stay (B = 0.127 days, 95% CI −0.046 to 0.300, $p = 0.149$).

Emergency surgery (B = 0.904 days, 95% CI 0.661–1.148, $p < 0.001$), preoperative biliary stent insertion (B = 0.461 days, 95% CI 0.240–0.683, $p < 0.001$), increased gallbladder wall thickness (B = 0.056 days per mm, 95% CI 0.020–0.093, $p = 0.003$), and histopathologically confirmed acute cholecystitis (B = 0.591 days, 95% CI 0.339–0.843, $p < 0.001$) were independently associated with longer hospital stay.

Age, gender, comorbidities, and symptom duration were not independently associated with LOS.

Discussion

Our SO+ and SO− groups exhibited comparable rates of conversion to open surgery, SSI, biliary leak and biliary system injury. Although the SO+ group exhibited significantly higher rates of intraoperative bleeding and longer operative duration, severe obesity was not independently associated with longer hospital stay after adjustment for clinically relevant covariates, and no patient required blood transfusion. The two groups showed similar postoperative outcomes, 30-day morbidity and readmission rates.

We noticed that patients with SO had longer symptom durations and more commonly presented with chronic cholecystitis. This finding is unique to the present study, as the existing literature does not address this phenomenon. Several factors may contribute to this treatment delay, including patients with SO exhibiting numerous obesity-related symptoms masking biliary symptoms, social stigma, the additional effort imposed by the increased physical load when visiting the hospital and psychological factors such as de-

pression. It could also be due to greater engagement of this patient group in non-surgical management strategies [19]. A further possibility is poorer care provision by healthcare facilities [19]. This could explain the late presentation and chronic histopathological findings associated with cholecystitis in our SO patients.

We found that only a small percentage of the patients in the SO+ group had CBD stones, underwent ERCP or received stenting. This could either be due to selective conservative management or a relatively low incidence rate.

Although severe obesity has previously been described as a risk factor for conversion to open surgery [10,20], we did not observe a significant association between SO and conversion in our cohort, in keeping with findings from another published study [21]. Despite the SO+ group having a median BMI of 39.95 kg/m^2 (IQR, 37.10–43.53), the overall conversion rate remained low at 1.1% (2/181). This was considerably lower than the 11.7% conversion rate reported by Paajanen et al. [10].

Several studies have investigated the impact of obesity on operative time. In high-volume, low-complexity general surgery (cholecystectomy, hernia repair), obesity increased operative time by about 4–23 minutes, especially at BMI ≥35–40 kg/m^2 [22]. In our cohort, after adjustment for clinically relevant confounders, severe obesity remained independently associated with an approximately 7.5-minute increase in operative time. From a practical standpoint, this finding may help surgeons better anticipate technically challenging cases, improve operative planning, and provide more realistic preoperative counselling for patients with severe obesity. It also suggests that surgical experience and careful perioperative management may help overcome some of the technical difficulties associated with severe obesity.

In a 563-patient series, obese vs non-obese had no difference in bleeding volume or complications; only operative time was longer [14]. However, differences in obesity definitions and study populations may limit direct comparisons with our severe-obesity cohort. On the other hand, in a registry from Finland comprising 22,000 cholecystectomies, the haemorrhage rate was 1.3% after LC, with some patients requiring substantial transfusions [23]. In this cohort, multivariable logistic regression demonstrated that SO+ remained independently associated with substantially increased odds of intraoperative blood loss >100 mL. However, the confidence intervals were wide, reflecting the small number of bleeding events. Although statistically significant, these findings should therefore be interpreted cautiously and validated in larger prospective cohorts. None of the patients required blood transfusion or resuscitation, and this did not translate into higher rates of conversion or postoperative complications.

Although patients with SO+ had a longer LOS in the univariable analysis, severe obesity was no longer independently associated with LOS after adjustment for clinically relevant confounders. This suggests that the modest difference observed initially may have been explained by operative complexity and disease-related factors rather than severe obesity itself.

Several factors may influence LOS, including conversion to open surgery and institutional discharge policies for patients with severe obesity [24].

This study has several limitations. First, as a single-centre retrospective study without randomisation, it carries a risk of selection bias, and the generalisability of its findings may be limited. Second, there were clear baseline differences between the groups that may have influenced operative outcomes and introduced the possibility of residual confounding. The small number of intraoperative bleeding events (n = 11) relative to the nine predictors included in the multivariable logistic regression model raises a substantial risk of overfitting and unstable estimates; therefore, the adjusted odds ratio for severe obesity should be interpreted with caution. Finally, some variables, such as symptom duration, were patient-reported information and may therefore be subject to recall bias.

Conclusions

In this cohort, severe obesity was independently associated with longer operative time and a higher likelihood of intraoperative bleeding during LC. However, after adjustment for clinically relevant confounding factors, severe obesity was not independently associated with a longer postoperative hospital stay. Overall, postoperative recovery, complication rates, and 30-day readmission were comparable between patients with and without severe obesity.

These findings suggest that, although laparoscopic cholecystectomy may be technically more demanding in patients with severe obesity, comparable short-term outcomes may be achievable in this patient population. Recognizing the increased technical complexity associated with severe obesity may help surgeons optimize preoperative planning, resource allocation, and patient counselling.

Given the retrospective nature of this study and the baseline differences between the study groups, these findings should be interpreted with appropriate caution. Larger prospective multicentre studies are warranted to further clarify the independent effect of severe obesity on perioperative and long-term outcomes following LC.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

AMA is the sole contributor to this manuscript. The author confirms sole responsibility for the conception and design of the study; the acquisition, analysis, and interpretation of data; the preparation of the manuscript; and for being accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The Institutional Review Board of Dr. Soliman Fakeeh Hospital (DSFH) approved the study protocol (approval number: 228/IRB/2021). Written informed consent was obtained from all participants. For minor patients, informed consent was also obtained from their guardians. This study was performed in accordance with the ethical standards of the Declaration of Helsinki and its later amendments.

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Conflict of Interest

The author declares no conflict of interest.

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