Original Research

VARIOUS SURGICAL MODIFICATIONS VERSUS TRADITIONAL TECHNIQUE OF LAPROSCOPIC CHOLECYSTECTOMY IN MANAGEMENT OF DIFFICULT GALLBLADDER AND THEIR SURGICAL OUTCOME: A PROSPECTIVE INTERVENTIONAL COMPARATIVE STUDY

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ABSTRACT

Background: Difficult gallbladder cases remain technically demanding due to inflammation, adhesions, and distorted anatomy, often requiring deviation from the standard laparoscopic approach. We conducted this study, to compare surgical outcomes between traditional and modified laparoscopic cholecystectomy techniques in difficult gallbladder cases.

Methods: This prospective interventional comparative study was conducted on 40 patients, randomly aaaigned to traditional (n=8) and modified technique groups (n=32). Modified techniques included fundus-first, intraluminal, combined antegrade–retrograde dissection, and stump stenting. We followed patients for intraoperative and postoperative outcomes.

Results: In the present study, we found that patients who had modified laparoscopic cholecystectomy were much older (50.69 ± 12.84 years) than traditional group (38.25 ± 12.43 years); p=0.018, with a relatively higher number of males. In modified group, the incidence of acute cholecystitis (71.88 vs. 50.00), frozen anatomy (62.50 vs. 50.00) and complex conditions were significantly higher but the operative times was comparable (63.31 vs 66.88 min; p=0.265). We found that drain utilization and stone spillage were significantly higher in modified cases (100% vs. 87.50%; p<0.0001) and (34.38% vs. 12.50%; p<0.0001) respectively, while port-site infection was lower (9.38% vs. 25.00%; p<0.0001). Hospital stay and recovery were similar. Furthermore, predictive analysis revealed that age >50 years (RR 3.50; OR 5.44) and stone spillage (RR 2.75; OR 3.67) were moderately associated with difficult cases, while other variables showed weak or minimal associations.

Conclusion: Evidently, modified laparoscopic techniques are safe and effective in difficult gallbladder cases, offering comparable operative and recovery outcomes while facilitating safer dissection in complex anatomical situations.

Keywords: Difficult Gallbladder Laparoscopic Cholecystectomy, Surgical Modifications, Stone Spillage, Operative Difficulty.

INTRODUCTION

Laparoscopic cholecystectomy has, over the past few decades, quietly shifted from being a new minimally invasive procedure to the accepted standard of care for symptomatic gallstone disease.

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What once replaced open surgery on the promise of smaller incisions and quicker recovery is now, almost universally, the first-line operative approach in both elective and emergency settings.[1] Yet, this apparent routine nature can be misleading. Not all gallbladders are "routine." A subset, often labelled as difficult gallbladders continues to test the limits of laparoscopic safety. The difficulty usually sources from a familiar cluster of factors like: dense adhesions, acute inflammation, fibrosis, distorted Calot's triangle, or conditions like empyema and mucocele.[2] In such settings, achieving the critical view of safety becomes challenging, and the risk of bile duct or vascular injury rises considerably. This is precisely where conventional antegrade dissection begins to show its limitations. Surgeons are then

forced into a decision either persist with the standard technique at the cost of safety, or adapt.

Over time, that second option has evolved into what are now broadly called "bailout" or modified techniques. Among these, the fundus-first (retrograde) approach has gained particular attention. Instead of beginning dissection at Calot's triangle, the surgeon starts from the fundus and works downward, effectively postponing the most dangerous part of the operation until better exposure is achieved.[3] Studies have shown that this approach can reduce operative difficulty and even lower conversion rates to open surgery in selected difficult cases.[4-6] More recent prospective comparisons have gone further, suggesting that fundus-first techniques may significantly reduce operative time and intraoperative complications compared to the standard approach in difficult cholecystectomy.[5,6]

Another important adaptation is laparoscopic subtotal cholecystectomy, which has emerged as a safe alternative when complete removal of the gallbladder is deemed hazardous. Rather than risking injury in a hostile Calot's triangle, the procedure deliberately leaves a portion of the gallbladder behind. Systematic reviews have supported its role as a reliable strategy to avoid bile duct injury in difficult acute cholecystitis.[7] Similarly, hybrid techniques combining antegrade and retrograde dissection, or intraluminal approaches have been described to navigate particularly complex anatomical scenarios.[8,9]

While these techniques are available, there is still no consensus on which modification technique is optimal for a given intraoperative scenario. Surgeon experience, intraoperative evaluation, and institutional bias still play a major role in the decision-making. Some surgeons advocate early use of modifications to prevent complications, whereas others advocate delaying their use until needed as a "last-resort" modification. This observation raises a question in surgery: be proactive or reactive? However, it is becoming apparent that difficult laparoscopic cholecystectomy is not a uniform entity. Variations in anatomy and pathology may need variations in technique. Literature, while advocates for individual techniques, often assess it independently and not as part of a comprehensive assessment. In this context, a comparative assessment of these surgical techniques and the standard antegrade technique is important. Not only to determine whether modification is successful - but to establish relative outcomes of different strategies in clinical practice, with particular reference to the safety of the operation, complications, and recovery. Therefore present study has been conducted to compare surgical outcomes and assess safety between various modifications and traditional technique of laparoscopic management of difficult gallbladder

METHODS

This study was designed as a prospective interventional comparative study spanned from 1st May 2024 to 30th April 2025. A total of 40 patients with difficult gallbladder were included, all of whom were admitted to the Postgraduate Department of General Surgery at Government Medical College, Jammu. Patients were enrolled based on predefined inclusion and exclusion criteria. The inclusion criteria comprised patients with difficult gallbladders and frozen Calot's triangle, as determined by radiological or intraoperative findings, patients of either sex with gallbladder disease, those aged above 18 years, and individuals who were willing to provide informed consent. Patients with advanced gallbladder malignancy and those with comorbid conditions rendering them unfit for surgery under general anaesthesia were excluded from the study.

After selection, patients were randomly assigned into two groups. Group A consisted of patients who underwent the traditional technique of laparoscopic cholecystectomy, specifically LSC-I (antegrade dissection). Group B included patients managed with modified laparoscopic techniques. These modifications comprised LSC-II (fundus-first retrograde dissection), LSC-III (intraluminal guided retrograde dissection), LSC-IV (transection of the gallbladder followed by combined antegrade and retrograde dissection), and LSC-V (stump stenting technique).

All patients were followed throughout their hospital stay and subsequently during follow-up either in the outpatient department or through telephonic communication. Data were collected systematically during this period. Postoperative complications were assessed using standard methods, including detailed history and physical examination during hospitalization and at follow-up intervals of one and two weeks. Patients who did not attend outpatient follow-up were contacted telephonically to obtain the necessary information.

RESULTS

Table 1: Demographic profile of patients in traditional versus modified laparoscopic cholecystectomy groups

Variable	Category	Lap. Traditional (n = 8)	Lap. Modifications (n = 32)	
Age (years)	≤20	1 (12.50%)	0 (0.0%)	0.018
	21–30	2 (25.00%)	1 (3.13%)	

	31–40	1 (12.50%)	6 (18.75%)	
	41–50	3 (37.50%)	11 (34.38%)	
	>50	1 (12.50%)	14 (43.75%)	
Mean Age ± SD		**38.25 ± 12.43**	**50.69 ± 12.84**	
Sex Distribution	Male	2 (25.00%)	14 (43.75%)	0.011
	Female	6 (75.00%)	18 (56.25%)	

We evaluated the age distribution and found that it differed significantly between the two groups (p=0.018), the laparoscopic modification group had a higher proportion of older patients, particularly those above 50 years (43.75%), whereas the traditional group was more concentrated in the 41–50 year range (37.50%). Younger age categories were relatively less represented in the modification group. As evident the mean age was higher in the modification group compared to the traditional group (50.69 ± 12.84 years vs. 38.25 ± 12.43 years). With respect to sex distribution, females predominated in both groups, though more markedly in the traditional group (75.00%), while the modification group had a relatively higher proportion of males (43.75%) and the difference was significant with a p-value of 0.011. We evaluated the diagnostic profile and found acute calculous cholecystitis was the most common diagnosis in both, but more frequent in the modified group (71.88% vs. 50.00%, p=0.050). However; chronic calculous cholecystitis was higher in the traditional group (25.00% vs. 12.50%, p=0.042). More complex conditions were evident only in the modified group, including empyema (3.13%), duodenal diverticulum (3.13%), mucocele (6.25%) and one case of xanthogranulomatous cholecystitis (3.13%). Meanwhile, Mirizzi syndrome (12.50%) and portal cavernoma (12.50%) were observed exclusively in the traditional group. The distribution of associated intraoperative variables showed a few differences between the groups with aberrant anatomy more frequent in the traditional group (25.00% vs. 3.13%), with a significant association (p<0.0001). Similarly, cirrhosis or portal hypertension was higher in the traditional group (37.50% vs. 12.50%, p<0.0001). Although slightly higher in the modification group, frozen anatomy was commonest in both groups (62.50% vs. 50.00%; p-value=0.242), contracted gallbladder was evident only in the modification group (21.88%), while a distended gallbladder was more frequent in the traditional group (100.00% vs. 78.13%; p-value 0.101). Impacted stones were somewhat more common in the modification group (21.88% vs. 12.50%, p=0.113). Mirizzi syndrome appeared only in the traditional group (12.50%), whereas empyema was noted only in the modification group (3.13%). Mucocele was present in both groups but slightly higher in the traditional group (12.50% vs. 6.25%), without statistical significance (p=0.152). The comparative analysis of operative duration revealed no statistically significant difference between the surgical approaches (p=0.265). The traditional technique group demonstrated a mean operative time of 66.88 ± 9.20 minutes, while the modified techniques group averaged 63.31 ± 7.69 minutes.

Table 2: Comparison of intraoperative and postoperative surgical outcomes between traditional and modified laparoscopic cholecystectomy groups

Variable	Category	Lap. Traditional (n = 8)	Lap. Modifications (n = 32)	p-value
Surgical drain tube	Yes	7 (87.50%)	32 (100.0%)	<0.0001
	No	1 (12.50%)	0 (0.00%)	
Bleeding from trocar site	Yes	1 (12.50%)	2 (6.25%)	0.131
	No	7 (87.50%)	30 (93.75%)	
Liver bed bleeding	Yes	4 (50.00%)	18 (56.25%)	0.383
	No	4 (50.00%)	14 (43.75%)	
Spillage of stone	Yes	1 (12.50%)	11 (34.38%)	<0.0001
	No	7 (87.50%)	21 (65.62%)	
Port site infection	Yes	2 (25.00%)	3 (9.38%)	<0.0001
	No	6 (75.00%)	29 (90.62%)	

We compared the surgical outcomes between the two groups and found that a few distinct differences. Use of a surgical drain was clearly higher in the modified group (100%) compared to the traditional group (87.5%), and this difference was statistically significant (p<0.0001). Bleeding from the trocar site was uncommon in both groups, occurring (12.5% vs 6.25%), with no significant difference (p=0.131). Similarly, liver bed bleeding was observed in 50.0% of traditional cases and 56.25% of modified cases, again without statistical significance (p=0.383). In contrast, spillage of stones was more frequent in the

modified group (34.38%) compared to the traditional group (12.5%), and this difference was statistically significant (p<0.0001). Port site infection, however, was lower in the modified group (9.38%) compared to the traditional group (25.0%), also showing statistical significance (p<0.0001).

Table 3: Comparison of postoperative recovery parameters between traditional and modified laparoscopic cholecystectomy groups

Variable	Category	Lap. Traditional (n = 8)	Lap. Modifications (n = 32)	p-value
Postoperative hospital stay	2 days	1 (12.50%)	0 (0.00%)	<0.0001
	3 days	4 (50.00%)	17 (53.13%)	
	4 days	2 (25.00%)	15 (46.87%)	
	5 days	1 (12.50%)	0 (0.00%)	
Mean ± SD		**3.38 ± 0.92**	**3.47 ± 0.51**	
Time to return to normal activity	4 days	4 (50.00%)	11 (34.38%)	<0.0001
	5 days	3 (37.50%)	17 (53.13%)	
	6 days	0 (0.00%)	4 (12.50%)	
	7 days	1 (12.50%)	0 (0.00%)	
	Mean ± SD	4.75 ± 1.04	4.78 ± 0.66	

We assessed the postoperative recovery parameters and found that these were largely comparable between the two groups, with only subtle differences in distribution. Most patients in both groups had a hospital stay of 3–4 days, accounting for 75% in the traditional group and 100% in the modified group. A small proportion in the traditional group stayed for 2 days (12.5%) or 5 days (12.5%), whereas no such extremes were observed in the modified group. The mean hospital stay was similar, 3.38±0.92 days in the traditional group and 3.47±0.51 days in the modified group, despite a statistically significant p-value (<0.0001). With respect to time to return to normal activity; in the traditional group, most patients resumed activity by 4–5 days (87.5%), while in the modified group, the majority did so by 5 days (53.13%), with some extending to 6 days (12.5%). A small proportion in the traditional group required up to 7 days (12.5%). The mean duration was nearly identical between the groups (4.75±1.04 vs 4.78±0.66 days), suggesting minimal clinical difference despite statistical significance.

Table 4: Comparative analysis of surgical outcomes and postoperative recovery across different laparoscopic surgical classifications (LSC I–V)

Variable	Category	LSC I	LSC II	LSC III	LSC IV	LSC V	p-value
Surgical drain tube	Yes	7 (87.50%)	8 (100.0%)	8 (100.0%)	8 (100.0%)	8 (100.0%)	<0.0001
	No	1 (12.50%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	
Bleeding from trocar site	Yes	1 (12.50%)	0 (0.0%)	0 (0.0%)	1 (12.50%)	1 (12.50%)	<0.0001
	No	7 (87.50%)	8 (100.0%)	8 (100.0%)	7 (87.50%)	7 (87.50%)	
Liver bed bleeding	Yes	4 (50.00%)	3 (37.50%)	5 (62.50%)	5 (62.50%)	5 (62.50%)	0.0004
	No	4 (50.00%)	5 (62.50%)	3 (37.50%)	3 (37.50%)	3 (37.50%)	
Spillage of stone	Yes	1 (12.50%)	0 (0.00%)	1 (12.50%)	8 (100.0%)	2 (25.00%)	<0.0001
	No	7 (87.50%)	8 (100.0%)	7 (87.50%)	0 (0.00%)	6 (75.00%)	
Port site infection	Yes	2 (25.00%)	0 (0.00%)	1 (12.50%)	2 (25.00%)	0 (0.00%)	<0.0001
	No	6 (75.00%)	8 (100.0%)	7 (87.50%)	6 (75.00%)	8 (100.0%)	
Postoperative hospital stay	2 days	1 (12.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	<0.0001
	3 days	4 (50.0%)	6 (75.0%)	3 (37.5%)	6 (75.0%)	2 (25.0%)	
	4 days	2 (25.0%)	2 (25.0%)	5 (62.5%)	2 (25.0%)	6 (75.0%)	
	5 days	1 (12.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	

Mean ± SD		**3.38 ± 0.92**	**3.25 ± 0.46**	**3.63 ± 0.52**	**3.25 ± 0.46**	**3.75 ± 0.46**	
Time to return to normal activity	4 days	4 (50.0%)	3 (37.5%)	1 (12.5%)	5 (62.5%)	2 (25.0%)	<0.0001
	5 days	3 (37.5%)	4 (50.0%)	6 (75.0%)	2 (25.0%)	5 (62.5%)	
	6 days	0 (0.0%)	1 (12.5%)	1 (12.5%)	1 (12.5%)	1 (12.5%)	
	7 days	1 (12.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Mean ± SD		**4.75 ± 1.04**	**4.75 ± 0.71**	**5.00 ± 0.53**	**4.50 ± 0.76**	**4.88 ± 0.64**	

We assessed the distribution of surgical outcomes across LSC grades, which showed a few clear trends, though not always in a perfectly linear fashion. Use of a surgical drain was nearly universal from LSC II onwards (100%) compared to 87.5% in LSC I and this difference was statistically significant (p<0.0001). Bleeding from the trocar site was infrequent overall, observed in only 12.5% of cases in LSC I, IV, and V, and absent in LSC II and III (p<0.0001). In contrast, liver bed bleeding was relatively common, seen in 50% of LSC I cases and increasing to 62.5% in LSC III–V, with a significant association (p=0.0004). Spillage of stones demonstrated a striking variation, occurring in all LSC IV cases (100%), compared to 12.5% in LSC I and III, and absent in LSC II (p<0.0001). Port site infection was variable with highest in LSC I and IV (25% each), but not observed in LSC II and V (p<0.0001). Regarding recovery, most patients had a postoperative hospital stay of 3–4 days across all grades, with mean duration ranging from 3.25±0.46 (LSC II, IV) to 3.75±0.46 (LSC V) (p<0.0001). Time to return to normal activity was typically 4–5 days, with mean values between 4.50±0.76 (LSC IV) and 5.00±0.53 (LSC III) (p<0.0001).

Table 5: Predictors of difficult laparoscopic cholecystectomy based on relative risk and odds ratio with 95% confidence intervals

Variable	Relative Risk	95% CI	Odds Ratio	95% CI
Age (>50 years)	3.5	0.538 – 22.823	5.44	0.598 – 49.562
Sex (Male)	1.75	0.495 – 6.187	2.33	0.407 – 13.375
Aberrant anatomy	0.13	0.013 – 1.212	0.097	0.008 – 1.245
Cirrhosis / portal hypertension	0.33	0.093 – 1.199	0.238	0.040 – 1.403
Operation time (≥70 min)	0.56	0.232 – 1.366	0.391	0.080 – 1.191
Spillage of stone	2.75	0.413 – 18.292	3.667	0.399 – 33.715
Port site infection	0.37	0.075 – 1.881	0.31	0.042 – 2.278
Hospital stay (≥4 days)	1.25	0.475 – 3.289	1.471	0.299 – 7.218
Time to return activity (≥5 days)	1.31	0.628 – 2.743	1.909	0.399 – 9.141

Our study presented the association of various variables with difficult laparoscopic cholecystectomy as determined by relative risk and odds ratio with their respective 95% confidence intervals. The relative risk for age greater than 50 years was 3.50 and the odds ratio was 5.44, indicating a moderate association, although the wide confidence intervals suggest variability in the result. Male sex showed a weaker association, with an RR of 1.75 and OR of 2.33. Abnormal anatomy had a very low association, with RR of 0.13 and OR of 0.097. Cirrhosis or portal hypertension also had a low association, with RR of 0.33 and OR of 0.238. Longer operation time (≥70 minutes) showed a weaker association, with RR of 0.56 and OR of 0.391. Stone spillage was associated with difficult LSC, with an RR of 2.75 and OR of 3.667. Port site infection was less likely to be a factor, with RR of 0.37 and OR of 0.310. A hospital stay of ≥4 days showed a weak association with an RR of 1.25 and OR of 1.471, while time to return to normal activity (≥5 days) had a moderate association, with RR of 1.31 OR of 1.909. These results highlight the variables with moderate to weak associations with difficult laparoscopic cholecystectomy

DISCUSSION

In our study, 40 patients were randomized into two groups, 8 (20%) underwent traditional antegrade laparoscopic cholecystectomy, while 32 (80%) were managed with modified techniques, distributed evenly across LSC II to V (each 20%). We found a statistically significant age difference between patients who had traditional or modified laparoscopic cholecystectomy with elderly patients more likely to have modified dissection technique (mean age 50.69 ± 12.84 vs. 38.25 ± 12.43, p = 0.018) which is in agreement with Simopoulos C et al., (2005) and Kama NA et al., (2001) who observed that older patients may have increased anatomical difficulty such as thickened gallbladder wall, shrunken gallbladder or adhesions from

previous inflammation or surgery, which may require modification in technique to ensure operative safety and efficacy.[10,11] Gutt CN et al., (2013) also stressed using modified strategies in older patients to prevent complications.[12] Female patients were more likely to undergo the traditional approach, comprising 75% of that group, whereas the modified technique group had a higher proportion of male patients (43.75%), reflecting the higher prevalence of gallstone disease in females due to hormonal factors, as reported by Chen CH et al., (2006) and Stinton LM et al., (2012).[13,14] Acute calculous cholecystitis emerged as the most common diagnosis in both groups but was significantly more prevalent in patients who underwent modified laparoscopic procedures (71.88% vs. 50.00%, p = 0.050), which is in consonance with the studies by Lau H et al., (2002) and Giger UF et al. (2006), which highlights increased operative difficulty in inflamed gallbladders.[15,16] Conversely, chronic calculous cholecystitis was more frequently observed in the traditional technique group (25.00% vs. 12.50%, p = 0.042), possibly due to the relative ease of dissection in non-inflamed gallbladders as also documented by Trowbridge RL et al., (2003).[17]

We observed that aberrant biliary anatomy was unexpectedly more common in the traditional group (25.0% vs. 3.13%, p<0.0001), despite being a well-known indication for modified or cautious approaches due to the risk of bile duct injury, as described by Hugh TB (2002) and Way LW et al. (2003).[18,19] This may reflect careful case selection or surgeon experience. In contrast, frozen Calot's triangle was more frequent in the modified group (62.50% vs. 50.00%), consistent with increased operative difficulty (Singh K et al., 2006).[20] Contracted gallbladder and impacted stones were also higher in the modified group (21.88% each), stressing their role in prompting technique modification (Vivek MA et al., 2013).[21] We found that gallbladder distension was universal in the traditional group (100% vs. 78.13%), likely indicating selection of less complex cases (Alponat A et al., 1997).[22] Interestingly, cirrhosis and portal hypertension were significantly more common in the traditional group (37.50% vs. 12.50%, p<0.0001), despite their known operative challenges. However; rare conditions like Mirizzi syndrome, empyema and mucocele were observed sporadically without clear trends.

Operative duration was comparable between groups (66.88 ± 9.20 vs. 63.31 ± 7.69 minutes, p=0.265), suggesting that modified techniques do not prolong surgery. This aligns with Lo CM et al. (1997), while Sakpal SV et al., (2010) emphasize that surgical experience offsets complexity.[23,24] Postoperative drain removal timing was also similar (p=0.463), with most removed by POD 2 (75.00% vs. 84.38%). Slight delays in the modified group likely reflect case complexity as also reported by Petrowsky H et al., 2004 and drain practices remain guided by intraoperative findings, as noted by Gurusamy KS et al. (2008).[25,26] We compared the surgical outcomes wherein most complications were minor and broadly similar between groups, with no major adverse events. Liver bed bleeding was the most common complication in both groups (50.00% vs. 56.25%, p=0.383), suggesting it is more related to underlying inflammation or fibrosis than technique, in line with Strasberg SM (2008).[27] No major complications such as bile duct injury, vascular injury, bowel injury, or mortality were observed, stressing the safety of both approaches when performed by experienced hands, which is consistent with the observations made by Deziel DJ et al., (1993).[28] Interstingly, the absence of biliary or vascular injuries among the most serious complications supports the safety of both techniques, even in difficult cases and is in agreement with observations by Archer SB et al., (2001).[29]

Trocar site bleeding, though a minor complication, was observed in 12.50% of the traditional group and 6.25% of the modified group. This low incidence is consistent with Tonouchi H et al., (2004), who reported rates of 1–13% in laparoscopic procedures, aligning with our findings.[30] Stone spillage was significantly higher in the modified group (34.38% vs. 12.50%, p<0.0001), likely reflecting increased technical difficulty in complex cases with adhesions or inflammation. This is supported by Woodfield JC et al., (2004), who noted higher spillage rates in inflamed or fragile gallbladders, consistent with our results.[31] Port-site infections were more frequent in the traditional group compared to modified laparoscopic cholecystectomy (25.00% vs. 9.38%, p<0.0001), suggesting a higher risk of contamination or prolonged manipulation in traditional approach. Postoperative hospital stay showed a statistically significant difference (p<0.0001), although mean durations were similar (3.38 ± 0.92 vs. 3.47 ± 0.51 days). A slightly higher proportion of modified cases required 4 days of hospitalization, likely reflecting case complexity, as described by Kaushik R (2010).[32] Overall, hospital stay remained within the typical 2–4 day range reported by Gurusamy KS et al., (2010), consistent with our findings.[33] Time to return to normal activity was also comparable (4.75 ± 1.04 vs. 4.78 ± 0.66 days, p<0.0001), though early recovery was more frequent in the traditional group, while most modified cases resumed activity by day 5. This pattern aligns with Shamiyeh A et al., (2004), suggesting slightly prolonged recovery in technically demanding cases, consistent with our observations.[34] The use of surgical drain tubes demonstrated a statistically significant difference between the traditional and modified laparoscopic

cholecystectomy groups, with 100% of patients in the modified group requiring a drain, compared to 87.5% in the traditional group ($p < 0.0001$). This finding reflects the greater complexity and higher risk of postoperative collections in patients undergoing modified procedures, which are often employed in cases involving dense adhesions, empyema, or frozen Calot's triangle as reported by Simopoulos C et al., (2005); Giger U et al., (2006) and Singh K et al., (2006).[10,16,20] The complete utilization of drains in the modified group suggests a precautionary approach by surgeons to monitor for bile leaks or hemorrhage in technically demanding cases Martin DJ et al., (2006).[35]

Our study demonstrated a significant association between LSC technique and trocar site bleeding ($p<0.0001$). Bleeding occurred in 12.5% of cases in LSC I, IV, and V, while none was observed in LSC II and III. This variation likely reflects intraoperative factors such as port placement and dissection technique, as described by Targarona EM et al., (2000), and is consistent with our findings suggesting better visualization and controlled planes in retrograde approaches.[30] Liver bed bleeding also showed a significant association with LSC type ($p=0.0004$), being highest in LSC III–V (62.5%) and lowest in LSC II (37.5%). This supports the observation that fundus-first dissection may reduce bleeding through improved exposure, as noted by Strasberg SM et al., (2010), while more complex techniques increase manipulation and bleeding risk (Singh K et al., 2006), consistent with our results.[20,37] A strong correlation was observed between LSC technique and gallstone spillage ($p<0.0001$), with the highest incidence in LSC IV (100%) and none in LSC II. The higher spillage in LSC IV is likely due to early gallbladder entry during transection, increasing the risk of leakage, as reported by Schäfer M et al., (1998), aligning with our findings.[38] In contrast, the lower rates in LSC II, which preserves gallbladder integrity until later stages, are consistent with Neri V et al. (2014).[39] Our study demonstrated a significant association between LSC technique and port-site infection ($p<0.0001$). Infections were highest in LSC I and IV (25% each), followed by LSC III (12.5%), while none were observed in LSC II and V. This variation is likely influenced by factors such as extraction technique, port handling, and operative duration, as described by Mishra et al., (2020), consistent with our findings.[40] Postoperative hospital stay also varied significantly ($p<0.0001$). Longer stays were observed in LSC III and V (3.63 ± 0.52 and 3.75 ± 0.46 days), whereas LSC II and IV had shorter durations (3.25 ± 0.46 days), aligning with the relative complexity of procedures. Recovery patterns showed that simpler techniques like LSC I allowed earlier return to activity, with 50% recovering within 4 days. LSC II showed comparable recovery despite technical demands, while LSC III and V had slightly delayed recovery (5.00 ± 0.53 and 4.88 ± 0.64 days), reflecting more intricate dissection. Interestingly, LSC IV demonstrated relatively faster recovery (4.50 ± 0.76 days), suggesting a balanced approach, consistent with our results.

In our study, age >50 years showed a moderate association with difficult laparoscopic cholecystectomy (RR=3.50; OR=5.44), albeit with wide confidence intervals, this broadly aligns with findings from Bhandari et al., where increasing age (≥60 years) was associated with higher difficulty (OR≈2.06, $p=0.019$), although it lost strength on multivariate analysis.[41] Similarly, Prem Chand et al., reported that elderly patients (>65 years) had a significantly higher proportion of difficult cases ($p=0.004$), supporting the trend observed in our results.[42] So, while our estimates are somewhat higher, the direction of association is consistent. Male sex in our study showed only a weak association (RR=1.75; OR=2.33). This sits in an interesting middle ground. Larger datasets, like the Swiss analysis (n=22,953), by Giger et al., reported a modest but significant increase in complications in males (OR 1.16), whereas Akcakaya A et al., have shown more pronounced intraoperative difficulty in males, including longer operative time and higher adhesion rates.[16,43] On the other hand, Bazoua G et al., found no significant impact of gender on outcomes.[44] So our weak association is actually quite in line with this mixed evidence. Interestingly, aberrant anatomy and cirrhosis/portal hypertension showed low associations in our study (RR=0.13 and 0.33 respectively), which contrasts with classical teaching. Most literature emphasizes anatomical distortion and fibrosis as strong predictors of difficulty, particularly adhesions and fibrotic gallbladder, which showed very high odds ratios in Bhandari et al. study (e.g., fibrotic GB OR=166.6).[41] The discrepancy in our results likely reflects sample size or selection bias rather than a true lack of effect. Operative time ≥70 minutes in our study showed only a weak association (OR=0.391), which is somewhat counterintuitive. Giger UF et al., have demonstrated that increasing operative duration correlates with higher complication risk (OR=1.68 per 30 minutes).[16] This again suggests that in our dataset, operative time may be more a consequence rather than a predictor of difficulty. Stone spillage, however, showed a clearer signal (RR=2.75; OR=3.67), supporting its role as a marker of difficult dissection. While most studies describe spillage as a consequence of difficult cases rather than a predictor, its association with inflamed or fragile gallbladders indirectly reflects operative complexity, which is consistent with our findings. Postoperative variables such as port-site infection (OR=0.31) and hospital stay ≥4 days (OR=1.47)

showed weak or inconsistent associations. Literature generally supports that postoperative outcomes are influenced by intraoperative difficulty rather than serving as independent predictors. Similarly, delayed return to activity (OR=1.91) in our study showed a moderate association, which likely reflects downstream effects of surgical complexity rather than causation. Evidently, what emerges is a pattern where classical predictors like age and male sex retain some association, though modest in our cohort, while intraoperative events like stone spillage better reflect real-time difficulty. At the same time, some expected predictors appear attenuated, probably due to sample size or case selection, rather than contradicting established evidence.

CONCLUSION

The results of our study demonstrated that both traditional and modified laparoscopic cholecystectomy are safe and effective in difficult gallbladder cases with no major complications such as bile duct injury or mortality encountered. Modified techniques appear particularly useful in anatomically challenging situations like frozen Calot's triangle, dense inflammation, or impacted stones, without increasing operative time or delaying recovery in any meaningful way. Despite stone spillage was more frequent with modified approaches but careful intraoperative handling can reasonably contain this risk. Interestingly, the lower incidence of port-site infection in the modified group hints at a possible merit, though the reason is not entirely straightforward and may relate to operative dynamics rather than technique alone. Routine drain use in modified cases reflects surgical caution, but perhaps not all cases truly require it. What stands out is the need for flexibility in choosing technique based on intraoperative findings rather than rigid preference. We suggest for larger studies, with longer follow-up that would help settle some of these lingering uncertainties.

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