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Original Research Article

A Comparative Study of Three Port Versus Four Port Techniques in Laparoscopic Cholecystectomy

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Abstract:

Background: Glycemic variability has emerged as a potential independent risk factor for diabetic complications beyond traditional measures of glycemic control such as glycated hemoglobin. The relationship between glucose fluctuations and early renal microvascular changes in type 2 diabetes mellitus remains incompletely understood and warrants prospective investigation.

Methods: A total of 174 patients with type 2 diabetes mellitus without established diabetic kidney disease were enrolled and followed for 24 months. Glycemic variability was assessed using continuous glucose monitoring, with calculation of coefficient of variation (CV), mean amplitude of glycemic excursions (MAGE), and time in range (TIR). Renal outcomes included changes in estimated glomerular filtration rate (eGFR), urinary albumin-to-creatinine ratio (UACR), and novel tubular biomarkers.

Results: Participants were stratified into high glycemic variability (CV ≥36%, n=82) and low glycemic variability (CV <36%, n=92) groups. After 24 months, the high variability group demonstrated significantly greater decline in eGFR (-8.4 ± 4.2 vs. -3.6 ± 2.8 mL/min/1.73m², $p<0.001$) and higher incidence of new-onset albuminuria (28.0% vs. 10.9%, $p=0.003$). MAGE was independently associated with eGFR decline ($\beta=-0.42$, $p<0.001$) after adjusting for HbA1c and traditional risk factors. Time in range showed inverse correlation with UACR progression ($r=-0.58$, $p<0.001$).

Conclusion: Glycemic variability is independently associated with accelerated early renal microvascular changes in type 2 diabetes mellitus, suggesting that glucose fluctuations contribute to nephropathy progression beyond mean glycemic exposure. Targeting glycemic variability may represent a novel therapeutic strategy for renal protection in diabetes.

Keywords: Glycemic Variability, Diabetic Kidney Disease, Continuous Glucose Monitoring, Albuminuria, Type 2 Diabetes Mellitus, Microvascular Complications.

Introduction

Gallstone disease is a common hepatobiliary problem and an important cause of surgical admissions. Its burden varies geographically; population-based Indian data demonstrate substantial regional variation in gallbladder disease and cholelithiasis, with higher rates reported from parts of North India compared with several other regions [1].

Once symptoms occur or complications develop, cholecystectomy is the definitive treatment, and laparoscopic cholecystectomy (LC) is widely accepted as the standard operative approach because it reduces postoperative pain, hospital stay, and convalescence when compared with open surgery [2–4].

International guidance supports LC as the preferred procedure for most patients requiring gallbladder removal. The SAGES guideline (building on the NIH consensus) recognizes LC as the procedure of choice for symptomatic gallstones in suitable candidates [5,6]. Similarly, NICE guidance recommends offering laparoscopic cholecystectomy for symptomatic gallbladder stones and supports early LC in acute cholecystitis where appropriate [7].

Conventional LC is classically performed using a standard four-port technique, providing

triangulation, retraction of the gallbladder fundus, and stable exposure of Calot's triangle. However, the evolution of minimally invasive surgery has aimed to further reduce access trauma by decreasing the number and/or size of ports, leading to reduced-port approaches such as three-port LC and, later, single-incision techniques [8,9]. The central clinical question is whether omitting the fourth port can maintain operative safety and surgical success while improving patient-centered outcomes such as pain, analgesic requirement, cosmesis, and recovery.

Multiple comparative trials have evaluated three-port versus four-port LC. Trichak randomized elective cases and reported that three-port LC was as safe as four-port LC, with advantages including less pain and fewer scars [10]. Kumar and colleagues, in a randomized controlled trial from a community-based teaching hospital, similarly found comparable clinical outcomes, with lower individual port-site pain and no increase in bile duct injury in the three-port group [11]. Evidence synthesis has generally suggested equivalence in major operative outcomes with potential modest benefits in postoperative discomfort and recovery parameters. A meta-analysis of randomized clinical trials found broadly similar operating times, success rates, analgesia requirements, and hospital stay between techniques, while highlighting limitations in trial quality [12]. More recent systematic review and meta-analysis (including over 2000 patients) reported shorter hospital stay and reduced postoperative analgesia requirement favoring three-port LC, with no significant differences in adverse events or success rates; the overall certainty of evidence was rated low, reinforcing the need for well-designed comparative studies [9]. Broader comparative evidence across different LC variants (including three-port and four-port) also indicates that technique choice can influence pain and cosmesis, but conclusions are constrained by heterogeneity and risk of bias [8].

In this context, a comparative study of three-port versus four-port laparoscopic cholecystectomy is clinically relevant for optimizing patient outcomes while preserving safety. The four-port technique remains the common standard and is often considered advantageous for training and difficult anatomy, whereas a three-port approach may reduce port-related pain, improve cosmesis, and simplify assistance requirements in selected patients when performed by appropriately trained surgeons [6,9]. Therefore, a methodologically sound comparison focusing on operative feasibility, intraoperative and postoperative complications, conversion rates, operative time, postoperative pain and analgesic needs, hospital stay, return to routine activity, and cosmetic satisfaction can help inform evidence-based choice of technique in routine surgical practice.

Materials and Method

This study was conducted as a prospective comparative study in the Department of General Surgery, Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar a tertiary care teaching hospital. The study was carried out over a period of 18 month, after obtaining approval from the Institutional Ethics Committee.

All patients presenting to the surgical outpatient department or emergency department with a diagnosis of symptomatic gallstone disease and planned for elective laparoscopic cholecystectomy during the study period were assessed for eligibility.

A total of 64 fulfilling the inclusion and exclusion criteria were enrolled in the study. Patients were allocated into two groups:

- **Group A:** Three-port laparoscopic cholecystectomy
- **Group B:** Conventional four-port laparoscopic cholecystectomy

Each group comprised **32 patients**.

Inclusion Criteria

- Patients aged **18–65 years**
- Symptomatic cholelithiasis confirmed on ultrasonography
- Patients fit for general anesthesia
- Elective laparoscopic cholecystectomy cases
- Patients who provided written informed consent

Exclusion Criteria

- Acute cholecystitis with severe inflammation
- Empyema gallbladder or gallbladder perforation
- Suspected or proven gallbladder malignancy
- Previous upper abdominal surgery
- Choledocholithiasis
- Pregnancy
- Patients unfit for general anesthesia

Method

All patients underwent a detailed clinical evaluation, including history and physical examination. Routine laboratory investigations such as complete blood count, liver function tests, renal function tests, and coagulation profile were performed. Abdominal ultrasonography was done to confirm gallstone disease and assess gallbladder anatomy.

All procedures were performed under general anesthesia by surgeons experienced in laparoscopic surgery.

Three-Port Laparoscopic Cholecystectomy

The three-port technique involved:

- One 10-mm umbilical port for the laparoscope

- One 10-mm epigastric port for the working instrument
- One 5-mm right subcostal port for grasping the gallbladder

Fundal retraction was achieved using traction through the working ports. Dissection of Calot's triangle was performed carefully, and the cystic duct and artery were clipped and divided. The gallbladder was dissected from the liver bed and retrieved through the umbilical or epigastric port.

Four-Port Laparoscopic Cholecystectomy

The standard four-port technique included:

- One 10-mm umbilical port (camera)
- One 10-mm epigastric port
- Two 5-mm right subcostal ports

The fourth port was used for fundal retraction of the gallbladder, allowing optimal exposure of Calot's triangle. The remainder of the procedure was performed using conventional laparoscopic principles.

Intraoperative Parameters Assessed

- Duration of surgery (minutes)
- Intraoperative complications (bleeding, bile spillage, bile duct injury)
- Need for additional port insertion
- Conversion to open cholecystectomy

Postoperative Assessment: Postoperative pain was assessed using the Visual Analog Scale (VAS) at 6, 12, and 24 hours after surgery. Analgesic requirement was recorded. Other parameters evaluated included:

- Port-site complications (infection, hematoma)
- Length of postoperative hospital stay (days)
- Time to return to routine daily activities

Follow-Up: Patients were followed up during the hospital stay and subsequently at 7 days and 30 days postoperatively to assess wound healing, late complications, and overall patient satisfaction.

Statistical Analysis: The collected data were entered into Microsoft Excel and subsequently analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 25. Quantitative variables such as age, duration of surgery, postoperative pain scores, and length of hospital stay were expressed as mean ± standard deviation (SD), while qualitative variables such as gender distribution, intraoperative and postoperative complications, need for additional port insertion, and conversion to open surgery were presented as frequencies and percentages. Comparison between the three-port and four-port laparoscopic cholecystectomy groups was performed using the independent Student's t-test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables, as appropriate. A two-tailed p-value of less than 0.05 was considered statistically significant.

Observation and Results

A total of 64 patients undergoing elective laparoscopic cholecystectomy were included in the study. They were divided equally into two groups: Group A (Three-port laparoscopic cholecystectomy) and Group B (Four-port laparoscopic cholecystectomy), with 32 patients in each group.

Table 1: Demographic Profile of Study Participants

Variable	Group A (3-Port) n=32	Group B (4-Port) n=32	p-value
Mean age (years)	42.6 ± 10.8	44.1 ± 11.2	0.56
Male	10 (31.3%)	9 (28.1%)	0.78
Female	22 (68.7%)	23 (71.9%)	

Table 1 depicts the demographic characteristics of the study population in both groups. The mean age of patients in Group A (three-port laparoscopic cholecystectomy) was 42.6 ± 10.8 years, while in Group B (four-port laparoscopic cholecystectomy) it was 44.1 ± 11.2 years. The difference in mean age between the two groups was not statistically significant (p = 0.56), indicating that both groups were comparable in terms of age distribution. Female patients predominated in both groups, accounting for 68.7% in Group A and 71.9% in Group B, reflecting the known higher prevalence of gallstone disease among females. The gender distribution between the two groups was also statistically comparable (p = 0.78), suggesting effective matching and minimizing demographic bias in outcome comparison.

Table 2: Operative Characteristics of study population

Parameter	Group A (3-Port)	Group B (4-Port)	p-value
Mean duration of surgery (minutes)	46.8 ± 8.9	44.5 ± 7.6	0.28
Additional port required	3 (9.4%)	0	
Conversion to open surgery	1 (3.1%)	1 (3.1%)	1

Table 2 compares the operative parameters between the two surgical techniques. The mean duration of surgery was slightly higher in the three-port group (46.8 ± 8.9 minutes) compared to the four-port group

(44.5 ± 7.6 minutes); however, this difference was not statistically significant (p = 0.28). In the three-port group, 3 patients (9.4%) required insertion of an additional port due to technical difficulty or inadequate exposure, whereas no such requirement was observed in the four-port group. Conversion to open surgery occurred in one patient (3.1%) in each group, with no statistically significant difference (p = 1.00). These findings suggest that both techniques are comparable in terms of operative feasibility and safety.

Table 3: Intraoperative Complications of study population

Complication	Group A (3-Port)	Group B (4-Port)	p-value
Bile spillage	4 (12.5%)	5 (15.6%)	0.72
Bleeding	2 (6.3%)	3 (9.4%)	0.64
Bile duct injury	0	0	

Table 3 summarizes the intraoperative complications observed during surgery. Bile spillage occurred in 12.5% of patients in Group A and 15.6% in Group B, with no statistically significant difference (p = 0.72). Intraoperative bleeding was observed in 6.3% of patients in the three-port group and 9.4% in the four-port group, which was also not statistically significant (p = 0.64). Importantly, no bile duct injury was reported in either group. These results indicate that reducing the number of ports did not increase the risk of major intraoperative complications.

Table 4: Postoperative Pain Scores (VAS)

Time after surgery	Group A (3-Port)	Group B (4-Port)	p-value
6 hours	4.1 ± 0.9	5.0 ± 1.0	<0.001
12 hours	3.2 ± 0.8	4.0 ± 0.9	0.002
24 hours	2.1 ± 0.7	2.8 ± 0.8	0.001

Table 4 compares postoperative pain scores assessed using the Visual Analog Scale (VAS) at 6, 12, and 24 hours after surgery. At all assessed time points, patients in the three-port group experienced significantly lower pain scores compared to the four-port group. At 6 hours, the mean VAS score was 4.1 ± 0.9 in Group A versus 5.0 ± 1.0 in Group B (p < 0.001). Similar statistically significant differences were noted at 12 hours (p = 0.002) and 24 hours (p = 0.001). These findings indicate that three-port laparoscopic cholecystectomy is associated with significantly reduced postoperative pain.

Table 5: Postoperative Outcomes among study population

Outcome	Group A (3-Port)	Group B (4-Port)	p-value
Mean analgesic doses (first 24 h)	2.2 ± 0.6	3.1 ± 0.7	<0.001
Mean hospital stays (days)	2.1 ± 0.6	2.6 ± 0.7	0.01
Port-site infection	1 (3.1%)	2 (6.3%)	0.55

Table 5 presents key postoperative outcomes. The mean number of analgesic doses required in the first 24 hours was significantly lower in Group A (2.2 ± 0.6) compared to Group B (3.1 ± 0.7), with a statistically significant difference (p < 0.001). The mean duration of postoperative hospital stay was also significantly shorter in the three-port group (2.1 ± 0.6 days) than in the four-port group (2.6 ± 0.7 days), with p = 0.01. Port-site infection occurred in one patient (3.1%) in Group A and two patients (6.3%) in Group B; however, this difference was not statistically significant (p = 0.55). Overall, the three-port technique demonstrated better postoperative recovery parameters.

Table 6: Return to Routine Activity and Cosmetic Satisfaction

Parameter	Group A (3-Port)	Group B (4-Port)	p-value
Return to routine activity (days)	5.4 ± 1.2	6.8 ± 1.5	<0.001
Good cosmetic satisfaction	28 (87.5%)	21 (65.6%)	0.04

Table 6 highlights patient-centered outcomes related to recovery and cosmesis. Patients in the three-port group returned to routine daily activities significantly earlier, with a mean duration of 5.4 ± 1.2 days, compared to 6.8 ± 1.5 days in the four-port group (p < 0.001). Additionally, a significantly higher proportion of patients in Group A reported good cosmetic satisfaction (87.5%) compared to Group B (65.6%), and this difference was statistically significant (p = 0.04). These findings underscore the cosmetic and functional advantages of the three-port laparoscopic cholecystectomy technique.

Discussion

In the present comparative study (n=64; 32 patients each in three-port and four-port LC groups), baseline demographic characteristics were comparable. The

three-port technique demonstrated significantly lower postoperative pain scores at 6, 12, and 24 hours, along with reduced analgesic requirement, shorter hospital stay, earlier return to routine activity, and higher cosmetic satisfaction. Operative duration, intraoperative events (bile spillage/bleeding), and conversion to open surgery were comparable between groups, and no bile duct injury occurred in either arm.

Laparoscopic cholecystectomy is established as the standard approach for symptomatic gallstone disease and is endorsed by major professional guidance, including SAGES guidelines (built on the NIH consensus position) [4,5]. With maturation of laparoscopic expertise, port reduction has been explored to further minimize access trauma while preserving safety and adequate exposure [13,8]. The clinical trade-off is primarily between pain/cosmesis advantages and potential technical limitations in retraction and Calot's triangle exposure, especially in difficult cases or during training [4,8]

In our study, operative time was slightly higher in three-port LC but not statistically significant. This aligns with multiple comparative studies and trials showing no meaningful difference in operative duration between three-port and four-port approaches. Trichak (international) reported three-port LC to be as safe as four-port LC in elective settings [10]. Kumar et al. (randomized controlled trial, South Asia) also observed similar operative outcomes between groups [11]. Evidence syntheses similarly report comparable operating time across techniques [12,9].

A practical point from Indian center experiences is that three-port LC can be started as a default and converted to four ports when exposure is inadequate, which preserves safety while retaining reduced-port benefit in uncomplicated cases [14]. This is consistent with our observation that a small proportion of three-port cases required an additional port.

A key concern with fewer ports is the quality of exposure in Calot's triangle and potential bile duct injury risk. In our study, no bile duct injuries occurred, and minor intraoperative issues (bile spillage and bleeding) were comparable. International trials have similarly found no excess major complications with three-port LC [10, 11]. Al-Azawi et al. (BMC Surgery) studied acute and chronic cholecystitis and concluded that three-port LC was safe in expert hands, without compromising safety outcomes [13]. Meta-analyses likewise show no significant differences in adverse events overall, though study quality and heterogeneity are often emphasized [12, 9].

Thus, our findings strengthen the view that in appropriately selected cases, and when performed by experienced surgeons, three-port LC does not appear to increase intraoperative risk compared with the conventional four-port technique [13, 10, 9].

Our results demonstrate significantly lower VAS pain scores at all measured intervals and lower analgesic doses in the three-port group. This pattern is consistent with the original comparative work by Trichak, which highlighted less pain and fewer scars with the three-port approach [5]. Al-Azawi et al. also reported reduced analgesia requirements and shorter length of stay with three-port LC [14].

However, not all studies show uniform pain benefit. Cerci et al. reported three-port LC to be safe and economic but did not demonstrate a reduction in overall pain score and analgesic requirement [45]. Differences across studies may relate to analgesic protocols, pain measurement timing, surgeon technique, port size, and patient selection, which can dilute or amplify observed effects [12,9, 15].

On balance, contemporary pooled evidence supports that three-port LC often yields modest improvements in postoperative analgesia requirements, though certainty may be limited by variable trial quality [12,9]. Our results align more strongly with studies demonstrating an analgesic advantage.

In the present study, the three-port group had significantly shorter hospital stay and earlier return to routine activity. Similar improvements have been reported in comparative studies where reduced-port access potentially reduces pain and facilitates mobilization [13, 9, 14]. The most recent large systematic review/meta-analysis (BJS Open) found outcomes generally comparable between techniques with signals favoring three-port LC for shorter hospital stay and reduced postoperative analgesia in included analyses, while also noting low certainty and heterogeneity in the evidence base [9]. Our findings reinforce this direction in a controlled, evenly matched cohort.

Cosmesis is an increasingly important patient-centered outcome. In our study, cosmetic satisfaction was significantly higher in the three-port arm. This is expected due to fewer incisions and has been frequently noted in comparative studies and trials [10, 11]. Patient satisfaction regarding scars can be culturally and context-dependent, but the general trend supports a cosmetic advantage with fewer ports [9].

Conclusion

Three-port laparoscopic cholecystectomy is a safe and feasible alternative to the conventional four-port technique for elective gallbladder surgery. While operative time and complication rates were comparable between the two approaches, the three-port technique resulted in less postoperative pain,

reduced analgesic requirement, shorter hospital stay, earlier return to routine activities, and better cosmetic satisfaction. In selected patients and when performed by experienced surgeons, three-port laparoscopic cholecystectomy offers improved patient-centered outcomes without compromising surgical safety.

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