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Comparison of Three-Port Cholecystectomy with Four-Port Cholecystectomy among Patients Undergoing Laparoscopic Cholecystectomy at a Tertiary Care Center in Haryana – A Randomized Control Study

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Abstract

Background: Laparoscopic cholecystectomy (LC) is the standard treatment for gallstone disease. While the conventional four-port LC provides excellent access and safety, the three-port modification may offer benefits such as less postoperative pain, shorter operative time, and improved cosmetic outcomes. This study aimed to compare intraoperative and postoperative outcomes between three-port and four-port LC.

Methods: A prospective randomized clinical study was conducted on 148 patients with symptomatic cholelithiasis and cholecystitis at Bhagat Phool Singh Government Medical College for Women, Sonepat, from January 2023 to July 2024. Patients aged 18–70 years were randomized equally to undergo either three-port or four-port LC. Operative parameters, complications, pain (VAS at 6 h, 24 h, and day 7), analgesic requirements, hospital stay, drain use, and cosmetic satisfaction were analyzed using SPSS v24.0, with $p<0.05$ considered significant.

Results: Both groups were demographically comparable. Mean operative time was significantly shorter in the three-port group (48.6±23.9 vs 56.2±20.0 min; $p<0.01$). Conversion to four-port occurred in 10.8% of cases. Complication rates were similar (bile spillage 14–15%, liver bleeding 5–9%, gallbladder perforation 7–8%; $p>0.05$). Mean hospital stay (3.5 vs 3.3 days) and analgesic use (1.7 doses) were comparable. Pain scores were lower in the three-port group on day 7 ($p<0.05$), and cosmetic satisfaction was significantly higher (87.8% vs 67.6%; $p<0.01$).

Conclusion: Three-port LC is a safe and effective alternative to the four-port technique, offering shorter operative time, reduced late postoperative pain, and superior cosmetic satisfaction without increasing complications or hospital stay.

Keywords: Laparoscopic cholecystectomy, three-port technique, four-port technique, operative time, postoperative pain, cosmetic satisfaction, randomized controlled trial.

Introduction

The history of endoscopy dates back to 500 B.C., when Hippocrates used the first rectal speculum, and primitive gynecologic endoscopy also dates to the same era [1]. Direct observation of internal cavities through a metal tube was gradually replaced by semi-flexible endoscopes, allowing visualization of internal organs through natural body passages. Although the guiding tubes evolved in design and material, the limitations of early light sources and optical systems restricted the rapid advancement of laparoscopy for centuries [2]. Eventually, with the integration of multidisciplinary medicine and modern technology, laparoscopic surgeries are now routinely performed worldwide for a wide range of surgically manageable diseases.

Laparoscopic cholecystectomy has become the gold standard for the surgical removal of the gallbladder as it results in a shorter hospital stay, reduced postoperative pain, faster return to normal activities, superior cosmetic results, and significantly lower morbidity rates [3,4]. In 1985, Prof. Dr. Erich Mühe of Germany performed the first laparoscopic cholecystectomy (LC), revolutionizing biliary surgery and marking a milestone in minimally invasive techniques.

The four-port technique is currently the standard procedure for performing laparoscopic cholecystectomy. However, newer techniques have emerged, including the three-port method that uses conventional laparoscopic instruments [5]. In this modified technique, the lateral-most port used for retracting the gallbladder fundus over the liver surface is omitted. Instead, the gallbladder infundibulum is held through the right upper quadrant port (mid-clavicular line), which alone is used to facilitate visualization of Calot's triangle [6].

The rationale behind the three-port technique lies in achieving adequate exposure of Calot's triangle without the need for an additional port for fundal retraction. With one less incision, tissue trauma is minimized, leading to less pain, inflammation, and better cosmetic outcomes [5]. Several early studies demonstrated that the three-port technique is feasible and safe, showing comparable outcomes to the traditional four-port technique [6,7]. This is particularly relevant in the current era where single-incision laparoscopic surgery has lost popularity and only a few centers are equipped for its performance [7].

A recent meta-analysis by Nip et al. found that the length of hospital stay and postoperative analgesia requirement favored the three-port group, while there were no significant differences in operative time, success rate, or adverse events between the three-port and four-port groups[8]. The authors concluded that although the three-port technique demonstrated promising results, the overall quality of available evidence remains low.

Two previous systematic reviews have also examined the comparison between three-port and four-port laparoscopic cholecystectomy. In 2009, Sun et al. performed a meta-analysis that reported similar outcomes to those found by Nip and colleagues, indicating that both techniques were equally effective and safe [9]. In 2014, Gurusamy et al. compared fewer-than-four-port laparoscopic procedures to the conventional four-port approach and found that there was very low-quality

evidence, insufficient to determine any significant clinical benefit of using fewer ports [10].

As current evidence remains inconclusive regarding the safety, complication rate, and cost-effectiveness of the three-port technique, its widespread adoption is limited. Therefore, in light of these findings, the present study was designed to compare intraoperative and postoperative outcomes between three-port cholecystectomy and four-port cholecystectomy. This study aims to provide additional evidence to clarify whether the three-port approach can serve as a safe, efficient, and less invasive alternative to the standard four-port laparoscopic cholecystectomy.

Material and methods

This prospective randomized clinical study was conducted over a period of 18 months, from January 2023 to July 2024, in the Department of General Surgery at Bhagat Phool Singh Government Medical College for Women, Sonepat, Haryana. The study was designed to compare the intraoperative and postoperative outcomes of three-port laparoscopic cholecystectomy with the conventional four-port technique in patients presenting with symptomatic cholelithiasis and cholecystitis. Patients aged between 18 and 70 years of either gender were included after obtaining written informed consent. Individuals with pre-existing comorbidities such as malignancies, uncontrolled diabetes, kidney or liver diseases, those on immunosuppressive therapy, and immunocompromised patients were excluded. Patients with empyema or mucocele of the gallbladder, acute cholecystitis with mass formation, or a body mass index (BMI) greater than 35 kg/m² were also excluded from the study.

A total of 148 patients fulfilling the eligibility criteria were enrolled and randomly assigned to one of two groups, each comprising 74 patients. The sample size was calculated for a parallel design clinical trial comparing the superiority of the three-port technique based on an expected difference of 21% in postoperative pain prevalence between the two techniques, with 80% power and a 5% alpha error. Randomization was performed using a chit-box method, where an anaesthetist selected the chit blindly to allocate the patient to either the three-port or the four-port laparoscopic cholecystectomy group.

All patients were operated on under general anaesthesia after overnight fasting. A prophylactic dose of intravenous ceftriaxone (1 gram) was administered 30 minutes before surgery. Local infiltration with 2% lignocaine was given at all port sites before incision. Postoperatively, patients were kept nil per oral on the day of surgery and received intravenous diclofenac sodium 75 mg as needed for pain control. Oral fluids were introduced on the first postoperative day, and oral diclofenac 50 mg was prescribed as required.

In the three-port laparoscopic cholecystectomy, two 10 mm trocars were introduced—one at the epigastrium for working instruments and another at the supraumbilical region for the camera—along with one 5 mm trocar at the right mid-clavicular line. The gallbladder infundibulum was grasped through the 5 mm port to facilitate visualization of Calot's triangle. The cystic duct and artery were dissected, clipped, and divided, followed by separation of the gallbladder from the liver bed. The gallbladder was extracted through the epigastric port, and the operative field was irrigated in case of bile spillage. A drain was placed when required, and the incisions were closed after infiltration with 2% lignocaine. In the four-port technique, an additional 5 mm port was introduced at the right anterior axillary line to grasp the fundus of the gallbladder for better exposure of Calot's triangle. The rest of the surgical procedure remained the same.

Conversion from the three-port to four-port method was undertaken in cases of intraoperative complications such as excessive bleeding, bile spillage, or when drain placement was necessary.

Preoperative evaluation included detailed history taking and clinical examination, emphasizing symptoms such as pain, nausea, vomiting, fever, and jaundice. Comorbidities like diabetes, hypertension, and cardiac or pulmonary diseases were noted. Ultrasonography of the abdomen was performed in all cases to confirm the diagnosis and evaluate gallbladder morphology. Intraoperative parameters recorded included the duration of surgery (from skin incision to closure), intraoperative complications, and the need for conversion. Postoperative outcomes assessed were pain intensity using the Visual Analogue Scale (VAS) at 6 hours, 24 hours, and on postoperative day 7, analgesic requirement in terms of the number of diclofenac doses, need for drain placement, duration of hospital stay, and cosmetic satisfaction using a Likert scale.

Data were compiled and analyzed using the Statistical Package for the Social Sciences (SPSS) version 24.0. Quantitative variables were expressed as mean and standard deviation, while categorical variables were represented as frequencies and percentages. The Student's t-test was used for comparing continuous variables, and the Chi-square test was employed to evaluate categorical data. A p-value of less than 0.05 was considered statistically significant.

The study was conducted after obtaining approval from the Institutional Ethics Committee and adhered to the principles of the Declaration of Helsinki. All participants provided written informed consent after a detailed explanation of the study procedure. The research involved no additional costs, risks, or invasive procedures beyond standard clinical care, ensuring the safety and ethical protection of all participants.

Results

The comprehensive analysis of 148 patients undergoing laparoscopic cholecystectomy (74 in each group) revealed several important findings comparing four port and three port techniques. Both groups were well-matched at baseline with no significant differences in age distribution ($p=0.51$), gender distribution (82.3% female overall, $p=0.63$), BMI categories (43.2% overweight, $p=0.41$), presenting complaints (97% with pain abdomen), past medical history ($p=0.72$), local examination findings ($p=0.51$), or preoperative laboratory parameters including hemoglobin, total leucocyte count, AST, and ALT (all $p>0.05$). Operative characteristics demonstrated that three port LC had a significantly shorter mean operative time (48.6 minutes vs 56.2 minutes, $p<0.01$), but paradoxically required conversion to four port technique in 10.8% of cases compared to 0% in the four port group ($p<0.01$). Intra-operative calculi findings were similar between groups ($p=0.41$). Post-operative complications showed no significant differences, with 76-77% of patients experiencing no complications ($p=0.84$). Common complications included bile spillage (14-15%), bleeding from liver (5-9%), and gallbladder perforation (7-8%), none reaching statistical significance. Hospital stay duration (3.3-3.5 days, $p=0.35$) and analgesic requirements (1.7 doses each, $p=0.89$) were comparable. Pain assessment revealed similar VAS scores at 6 hours ($p=0.24$) and 24 hours ($p=0.47$) post-operatively, but significantly lower pain in three port LC group at day 7 (0.3 vs 0.6, $p<0.05$). Most notably, patient cosmetic satisfaction was significantly higher with three port LC (87.8% vs 67.6%, $p<0.01$), representing a major patient-centered advantage.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants

Parameter	Four Port LC (n=74)	Three Port LC (n=74)	Total (n=148)	p-value
Age Groups, n (%)				0.51
Up to 20 years	0 (0.0%)	2 (2.7%)	2 (1.4%)	
21 to 40 years	39 (52.7%)	37 (50.7%)	76 (51.7%)	
41 to 60 years	27 (36.5%)	28 (38.4%)	55 (37.4%)	
61 to 80 years	8 (10.8%)	6 (8.2%)	14 (9.5%)	
Gender, n (%)				0.63
Female	62 (83.8%)	59 (80.8%)	121 (82.3%)	
Male	12 (16.2%)	14 (19.2%)	26 (17.7%)	
BMI Categories, n (%)				0.41
Underweight (<18.5)	5 (6.8%)	2 (2.7%)	7 (4.7%)	
Ideal (18.5-22.9)	19 (25.7%)	25 (33.8%)	44 (29.7%)	
Overweight (23-27.5)	35 (47.3%)	29 (39.2%)	64 (43.2%)	
Obese (≥27.5)	15 (20.3%)	18 (24.3%)	33 (22.3%)	
Presenting Complaints, n (%)				
Pain abdomen	71 (96%)	72 (97%)	143 (97%)	0.64
Vomiting	5 (7%)	2 (3%)	7 (5%)	0.24
Fever	0 (0%)	2 (3%)	2 (1%)	0.15
Bloating	0 (0%)	2 (3%)	2 (1%)	0.15
Follow-up cholecystectomy	3 (4%)	1 (1%)	4 (3%)	0.31
Past Medical History, n (%)				0.72
No significant history	39 (52.7%)	43 (58.1%)	82 (55.4%)	
Tubal ligation	19 (25.7%)	17 (23.0%)	36 (24.3%)	
Hypertension	2 (2.7%)	3 (4.1%)	5 (3.4%)	
Pancreatitis	1 (1.4%)	3 (4.1%)	4 (2.7%)	
Hypothyroidism	2 (2.7%)	1 (1.4%)	3 (2.0%)	
Others	11 (14.8%)	7 (9.3%)	18 (12.2%)	
Local Examination, n (%)				0.51
Normal	60 (81.1%)	63 (85.1%)	123 (83.1%)	
Scar of previous surgery	8 (10.8%)	8 (10.8%)	16 (10.8%)	
Tenderness	5 (6.8%)	2 (2.7%)	7 (4.7%)	
Reducible umbilical hernia	0 (0.0%)	1 (1.4%)	1 (0.7%)	
Hepatomegaly	1 (1.4%)	0 (0.0%)	1 (0.7%)	

Table 2: Comparison of Laboratory Investigations Between Groups

Laboratory Parameter	Four Port LC (n=74)	Three Port LC (n=74)	p-value
	Mean ± SD	Mean ± SD	
Hemoglobin (g/dL)	11.8 ± 1.5	12.0 ± 1.3	0.56
Total Leucocyte Count (cells/cumm)	6754.1 ± 1716.7	7120.3 ± 2374.9	0.28
AST (IU/L)	38.0 ± 14.9	41.3 ± 17.0	0.22
ALT (IU/L)	37.1 ± 17.9	40.2 ± 17.8	0.31

Table 3: Comparison of Operative Characteristics and Intra-operative Findings

Parameter	Four Port LC (n=74)	Three Port LC (n=74)	p-value
Duration of Surgery (minutes)			
Mean ± SD	56.2 ± 20.0	48.6 ± 23.9	<0.01*
Intra-operative Calculi Finding, n (%)			0.41
Multiple calculi	62 (83.8%)	58 (78.4%)	
Single calculus	12 (16.2%)	16 (21.6%)	
Conversion to 4 Port, n (%)			<0.01*
No conversion	74 (100.0%)	66 (89.2%)	
Conversion required	0 (0.0%)	8 (10.8%)	

*Statistically significant ($p<0.05$)

Table 4: Comparison of Post-operative Outcomes and Complications

Parameter	Four Port LC (n=74)	Three Port LC (n=74)	p-value
Intra & Post-operative Complications, n (%)			
No complication	56 (76%)	57 (77%)	0.84
Bile spillage	10 (14%)	11 (15%)	0.81
Bleeding from liver	7 (9%)	4 (5%)	0.34
Gallbladder perforation	6 (8%)	5 (7%)	0.75
Stone spillage	1 (1%)	1 (1%)	0.99
Adhesions	1 (1%)	0 (0%)	0.31
Bile leak	0 (0%)	1 (1%)	0.31
Difficult dissection	0 (0%)	1 (1%)	0.31
Duration of Hospital Stay (days)			
Mean ± SD	3.3 ± 1.0	3.5 ± 1.6	0.35
Analgesic Doses Required			
Mean ± SD	1.7 ± 1.0	1.7 ± 1.4	0.89
Drain Use, n (%)			0.07
No	62 (83.8%)	69 (93.2%)	
Yes	12 (16.2%)	5 (6.8%)	

Table 5: Comparison of Post-operative Pain Scores and Patient Satisfaction

Parameter	Four Port LC (n=74)	Three Port LC (n=74)	p-value
VAS Pain Score (Mean ± SD)			
At 6 hours post-op	4.3 ± 1.4	4.0 ± 1.6	0.24
At 24 hours post-op	2.5 ± 1.5	2.4 ± 1.7	0.47
At day 7 post-op	0.6 ± 0.9	0.3 ± 0.7	<0.05*
Patient Cosmetic Satisfaction, n (%)			<0.01*
Satisfied	50 (67.6%)	65 (87.8%)	
Not satisfied	24 (32.4%)	9 (12.2%)	

***Statistically significant (p<0.05)**

Discussion

The present prospective randomized clinical study conducted at the Department of General Surgery, Bhagat Phool Singh Government Medical College for Women, Sonepat, compared outcomes between three-port and four-port laparoscopic cholecystectomy (LC). A total of 148 patients were randomized equally into two groups. The demographic characteristics, including age, sex, and BMI, were similar between both groups, with the majority being females aged between 21 and 60 years. These findings were consistent with those of Shishodia et al. [11] and Biswas et al. [12], who also reported comparable demographic profiles across both groups. The predominant presenting symptom in this study was pain abdomen (97%), followed by vomiting, fever, and bloating, similar to findings by Singh et al. [13].

The mean operative time was significantly lower in the three-port group (48.6 minutes) than in the four-port group (56.2 minutes, p<0.01). Similar results were reported by Rai et al. [14], Biswas et al. [12], Shivakumar et al. [15], and Chauhan et al. [16], who found reduced operative duration in the three-port group, indicating that omission of one port does not increase operative difficulty when performed by experienced surgeons. However, studies such as those by Garg et al. [17] and Kumar et al.[18] observed slightly longer or comparable operative times in the three-port group, suggesting variability due to surgical expertise, case complexity, and definitions of operative duration used across studies.

Intraoperative and postoperative complications were minimal and comparable between both groups in this study. The most frequent complications included bile spillage, bleeding from the liver bed, and gallbladder perforation, none of which showed statistically significant differences between groups. These findings align with those of Shivakumar et al. [15] and Chauhan et al. [16], who reported similar complication rates and emphasized that reduced-port surgery does not compromise safety. Rai et al. [14] noted slightly higher postoperative complications in the four-port group, supporting the notion that three-port LC is a safe alternative.

The conversion rate from three-port to four-port LC in this study was 10.8%, comparable to previous reports by Singh et al. [13] (6.6%) and Garg et al. [17] (10%). Conversion should not be viewed as a failure but rather as a precautionary decision to ensure patient safety in difficult cases. The variability in conversion rates across studies could be attributed to surgeon experience (we had involved all faculty, junior as well as senior which had led to higher conversion rate by junior faculty), patient selection, and degree of inflammation in the gallbladder. Conversion rates can be further reduced by giving proper

training to surgeons before directly involving in 3 port cholecystectomy.

Postoperative recovery indicators, including hospital stay, pain scores, and analgesic requirement, were favourable for the three-port technique. The mean hospital stay was similar between the two groups (3.3 vs. 3.5 days), consistent with the findings of Shishodia et al. [11] and Chauhan et al. [16]. However, Biswas et al. [12] reported a significantly shorter hospital stay in the three-port group, attributing this to reduced pain and early mobilization. In the current study, pain scores on the Visual Analogue Scale (VAS) at 6 and 24 hours were comparable, but on the seventh postoperative day, pain was significantly lower in the three-port group ($p<0.05$). This correlates with the findings of Rai et al. [14], Singh et al.[13], and Chauhan et al.[16], who all observed reduced postoperative pain and analgesic requirement in three-port LC. The likely explanation is reduced tissue trauma and fewer incisions, which improve postoperative comfort and recovery.

Drain usage was lower in the three-port group (6.8%) compared to the four-port group (16.2%), similar to the observations by Shah et al. and Kumar et al.[18]. Literature suggests that routine drain placement after uncomplicated LC provides no added benefit and may even increase postoperative discomfort and infection risk. Recent systematic reviews recommend selective rather than routine drain usage after LC.

Cosmetic outcomes and patient satisfaction were markedly better in the three-port LC group in the present study (87.8% vs. 67.6%, $p<0.01$), reflecting fewer incisions and less visible scarring. Comparable findings were reported by Kumar et al. [18] and Biswas et al. [12], who found higher satisfaction with the three-port technique, although some studies such as Shishodia et al. [45] did not find statistically significant differences. Cosmetic considerations are increasingly relevant in modern surgery, particularly among young and female patients, making the three-port approach an attractive option.

In summary, the present study reinforces that the three-port laparoscopic cholecystectomy is a safe, effective, and cosmetically superior alternative to the traditional four-port technique. Operative time, postoperative pain, and cosmetic satisfaction significantly favoured the three-port group, while complication rates, hospital stay, and analgesic requirements were comparable. The 10% conversion rate underscores that the fourth port can be added when required without compromising safety. These findings are in agreement with prior research indicating that three-port LC can be safely adopted for elective cholecystectomy without additional risk to patients.

Overall, the study supports the use of the three-port technique as a viable modification of standard LC. However, as with all single-centre studies, the findings should be interpreted cautiously. Multicentric randomized controlled trials with larger sample sizes and longer follow-up are recommended to validate these results and establish standardized guidelines for the broader implementation of three-port laparoscopic cholecystectomy in clinical practice.

Conclusion

In conclusion, the present study demonstrated that three-port laparoscopic cholecystectomy is a safe, effective, and patient-friendly alternative to the conventional four-port technique. It was associated with a significantly shorter operative time, reduced postoperative pain by the seventh day, and higher cosmetic and overall patient satisfaction, while maintaining comparable rates of intraoperative and postoperative complications, hospital stay, and analgesic requirements. Only about 10% of cases required conversion to the four-port approach,

emphasizing the feasibility of the three-port method in most patients. Given its advantages in terms of patient comfort and aesthetic outcomes without compromising surgical safety, the three-port technique can be confidently offered for elective laparoscopic cholecystectomy. However, larger multicentric randomized controlled trials are warranted to further validate these findings and establish standardized recommendations for its widespread adoption in clinical practice.

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