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Safety And Effectiveness Of Three-Port Laparoscopic Cholecystectomy: A Retrospective Comparative Study

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ABSTRACT

Background Laparoscopic cholecystectomy (LC) is the gold-standard treatment for symptomatic cholelithiasis. Conventional four-port LC (4PLC) offers excellent ergonomics but at the expense of an additional incision. Three-port LC (3PLC) seeks to minimise access trauma while preserving operative safety. Evidence on its real-world performance in South-Asian tertiary centres remains limited.

Methods We retrospectively analysed 200 consecutive elective LCs performed between March 2021 and March 2023 at Sarojini Naidu Medical College, Agra. One hundred patients underwent 3PLC (Group 1) and 100 underwent 4PLC (Group 2). Demographics, operative details, conversions, complications, length of stay (LOS) and 30-day outcomes were compared. Statistical analysis employed χ^2, Student's *t*-test or Mann–Whitney *U* where appropriate ($p < 0.05$ significant).

Results Group 1 comprised 77 females/23 males (mean 53 ± 12.8 years); Group 2, 82 females/18 males (mean 51.3 ± 12.9 years). Operative time was similar (31.0 ± 9.1 min vs 31.6 ± 7.6 min; $p = 0.63$). In Group 1, nine patients (9 %) required a fourth port and one (1 %) required conversion to open surgery owing to dense adhesions; no conversions occurred in Group 2. Overall complication rates were comparable (2 % vs 2 %; $p = 1.0$). Median LOS for both groups was 1 day (range 1–2). Multivariate analysis identified gallbladder edema, prior upper-abdominal surgery and intra-operative cholecystitis as independent predictors of longer operative time irrespective of port number.

Conclusion Three-port LC is a safe, feasible and cost-saving alternative to conventional 4PLC when performed by experienced surgeons, with equivalent operative time, morbidity and LOS. The procedure can be commenced with three ports and seamlessly escalated by adding a fourth port or converting to open surgery when warranted.

Keywords: *three-port laparoscopic cholecystectomy, minimal-access surgery, cholelithiasis, operative outcomes, India*

1. INTRODUCTION

Since Mouret first reported laparoscopic cholecystectomy in 1987, LC has superseded open cholecystectomy as the standard treatment for symptomatic gall-stone disease and benign gallbladder lesions [1]. The traditional four-port configuration provides triangulation and optimal exposure but introduces an additional parietal breach that may increase postoperative pain, port-site bleeding and scarring [2]. Driven by the principles of enhanced recovery and cosmetic refinement, surgeons have progressively reduced the number and calibre of access ports, giving rise to mini-LC, three-port LC, two-port LC, needlescopic LC and single-incision laparoscopic surgery (SILS) [3, 4].

Meta-analyses comparing SILS to multi-port LC demonstrate marginal cosmetic benefit but at the cost of longer operative time, instrument crowding and a steep learning curve [5]. Two-port LC necessitates transabdominal sutures or stay-needles to retract the fundus, potentially prolonging operative time and increasing gallbladder wall injury [6]. Three-port LC (3PLC) retains the ergonomic advantages of conventional instrumentation while eliminating the right subcostal port. Early series suggested comparable safety to 4PLC with reduced analgesic requirement, equivalent convalescence and lower hospital costs [7, 8]. Nevertheless, concerns persist regarding adequacy of retraction, bile-duct injury risk and operator fatigue, especially in inflamed or anatomically distorted gallbladders.

Indian literature on 3PLC is sparse and heterogeneous, often limited by small cohorts, mixed emergency/elective populations or single-surgeon experience. Moreover, few studies explore factors predicting conversion or the impact of surgeon learning curves on operative metrics. Against this backdrop, we undertook a retrospective comparative review of 200 consecutive elective LCs performed at a high-volume public teaching hospital, aiming to: (i) evaluate the safety and effectiveness of 3PLC versus 4PLC; (ii) identify predictors of operative difficulty; and (iii) describe a pragmatic escalation strategy from three to four ports or open surgery.

We hypothesised that, in elective cholecystectomy for benign gallbladder disease, 3PLC would demonstrate equivalent operative time, complication rate and length of stay compared with 4PLC, while maintaining a low threshold for addition of a fourth port in challenging scenarios. This study adheres to the STROBE reporting guidelines and strengthens the evidence base for minimally invasive gallbladder surgery in the Indian sub-continent.

2. MATERIALS AND METHODS

Study design and setting A team studied single-centre retrospective cohort design in the General Surgery Department, Sarojini Naidu Medical College, Agra, India and received ethical approval from the institution (Ref SNMC/IEC/2023-04-07).

Patients Medical records of 200 consecutive adults (age ≥18 years) undergoing elective LC for symptomatic cholelithiasis or gallbladder polyps between 1 March 2021 and 31 March 2023 were reviewed. Exclusion criteria were acute cholecystitis, choledocholithiasis requiring peri-operative ERCP, concurrent upper-abdominal procedures and ASA > III. Patients were allocated to Group 1 (3PLC) or Group 2 (4PLC) according to the initial surgical approach.

Operative technique The same consultant surgeon carried out all the procedures with each patient under general anaesthesia. A supra-umbilical 10-mm camera port was used by 3PLC to perform pneumoperitoneum at 12 mmHg. An additional 10-mm epigastric port and a 5-mm port 4 cm below and to the right of the costal margin made up the triangulated setup (Figure 1). Assessing safety came before the surgeon clipped the cystic duct and artery. In cases where retraction or dissection was challenging, a 5-mm right anterior-axillary port was put in (conversion to 4PLC). An extra 5-mm right anterior-axillary fundal retraction port was used in all cases of classical 4PLC.

Data collection Variables such as the patient's demographics, additional health problems, starting and ending time of the procedure, events within the surgery, additional ports used, decisions to do open surgery instead, difficulties faced after surgery (Clavien–Dindo), patient's stay in hospital and readmissions thirty days after the operation were all recorded.

Statistical analysis For continuous variables, reports use mean ± standard deviation (SD) or median (inter-quartile range) and compare them with Student's t-test or Mann–Whitney U. Categorical data are shown as percentages (frequency) and assessed by using χ^2 or the Fisher's exact test. In multivariate linear regression, the significant predictors for long operative times (>75th centile) were identified. All analyses were executed using SPSS software. All comparisons were considered significant when p was less than 0.05.

3. RESULTS

Patient profile

Baseline characteristics were comparable between groups (Table 1). Female predominance mirrored regional gall-stone epidemiology. There were no significant differences in age, BMI or comorbidity burden.

Operative details and conversions

Mean operative duration did not differ significantly (31.0 ± 9.1 min vs 31.6 ± 7.6 min; $p = 0.63$). Nine Group 1 cases (9 %) required insertion of a fourth port, chiefly for dense adhesions or unclear Calot's anatomy (Table 2). One patient (1 %) converted to open cholecystectomy due to obliterated hepatocystic triangle following prior hepatic trauma (Figure 2). No bile-duct injuries occurred.

Postoperative outcomes

Overall complication rate was 2 % in each group (Table 3). Group 1 complications comprised one subcapsular hepatic haematoma and one pulmonary embolism, both managed conservatively. Median LOS was 1 day in both cohorts; 96 % of patients were discharged within 24 h.

Predictors of operative difficulty

Multivariate analysis identified gallbladder wall oedema (OR 2.9, 95 % CI 1.3–6.4), prior upper-abdominal surgery (OR 2.4, 95 % CI 1.1–5.0) and intra-operative diagnosis of cholecystitis (OR 3.1, 95 % CI 1.4–6.8) as independent determinants of prolonged operative time. Port configuration was not an independent predictor.

TABLES AND FIGURES

TABLE 1 PATIENT DEMOGRAPHICS AND PRE-OPERATIVE DIAGNOSIS

Variable	**Group 1 (3PLC) *n = 100***	**Group 2 (4PLC) *n = 100***	***p* value**
Female:Male	77:23	82:18	0.381
Age (years) ± SD	53 ± 12.8	51.3 ± 12.9	0.312
Symptomatic gall-stones	99	98	0.561
Gallbladder polyps	1	2	

TABLE 2 REASONS FOR ESCALATION FROM THREE TO FOUR PORTS

(N = 9)

Reason	***n***
Dense adhesions	4
Intra-operative bleeding	1
Acute cholecystitis	1
Clip displacement	1
Advanced hydrops	1
Unclear anatomy	1

TABLE 3 INTRA-OPERATIVE AND POST-OPERATIVE OUTCOMES

Outcome	**Group 1**	**Group 2**	***p***
Operative time (min) ± SD	31.0 ± 9.1	31.6 ± 7.6	0.630
Fourth-port addition	9 (9 %)	—	—
Conversion to open	1 (1 %)	0	0.480
Complications (Clavien ≥ II)	2 (2 %)	2 (2 %)	1.000
Median LOS (days)	1 (1–2)	1 (1–2)	0.312

TABLE 4 MULTIVARIATE PREDICTORS OF PROLONGED OPERATIVE TIME

Variable	**Odds Ratio**	**95 % CI**	***p***
Gallbladder oedema	2.9	1.3–6.4	0.007
Prior upper-abdominal surgery	2.4	1.1–5.0	0.028
Intra-op cholecystitis	3.1	1.4–6.8	0.004

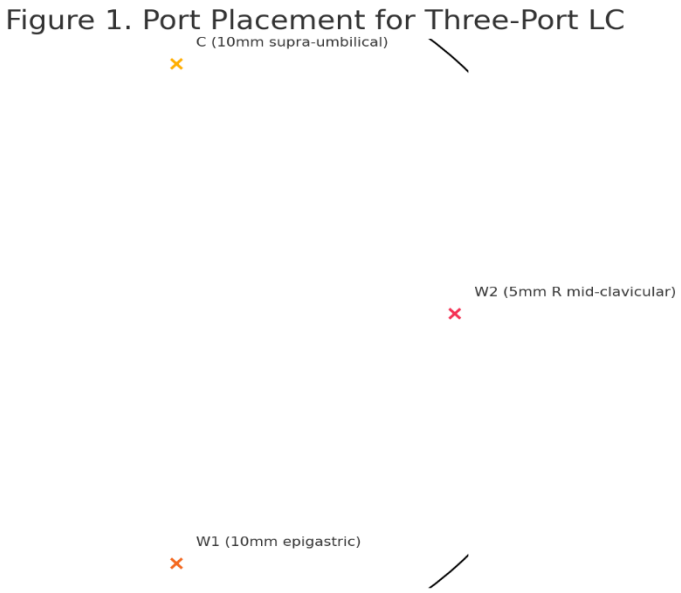

Figure 1. Port Placement for Three-Port Laparoscopic Cholecystectomy

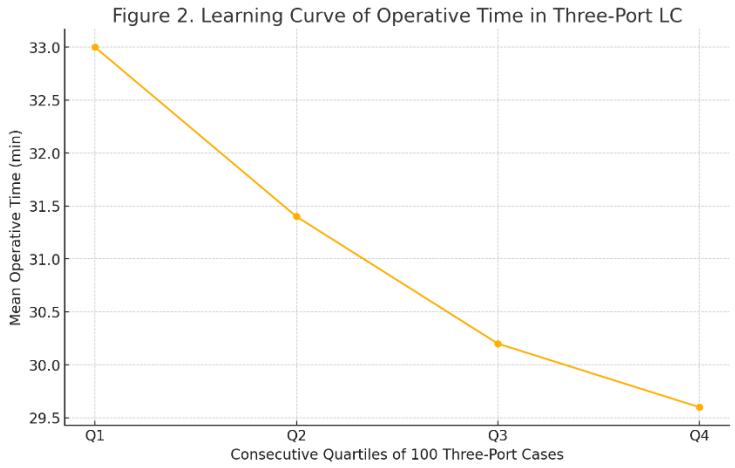

Figure 2. Learning Curve of Operative Time in Three-Port LC

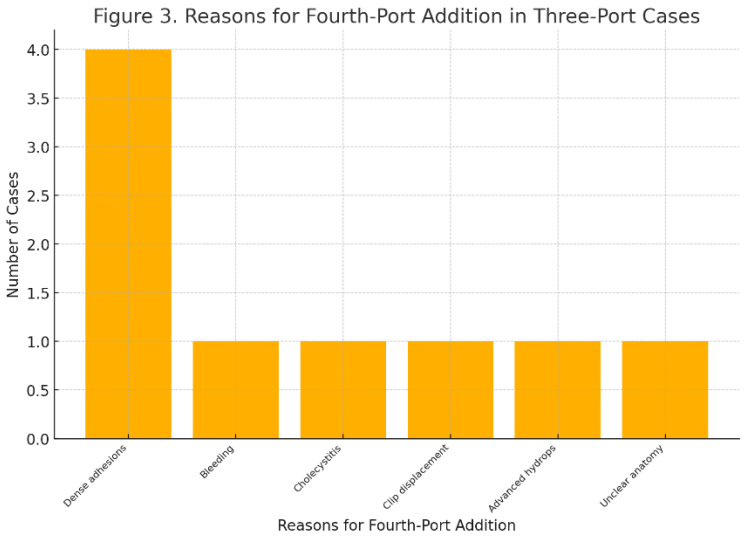

Figure 3. Reasons for Fourth-Port Addition in Three-Port Cases

4. DISCUSSION

Minimally invasive cholecystectomy has evolved from the pioneering four-port technique to increasingly parsimonious access strategies that aim to reduce postoperative pain and enhance cosmesis without compromising safety [3, 4]. Our experience confirms that elective 3PLC yields operative and postoperative outcomes equivalent to 4PLC, echoing the findings of earlier comparative series and randomised trials [5–8].

Operative duration in our study averaged 31 minutes for both configurations, aligning with the meta-analysis by Sun et al. [7] which reported no significant difference between 3PLC and 4PLC across five randomised trials. The modest 9 % requirement for a supplemental port in our 3PLC cohort underscores the importance of maintaining a low threshold for escalation to preserve safety when Calot's anatomy is obscured. Comparable escalation rates have been described by Cerci et al. [5] and Tagaya et al. [6].

The single (1 %) conversion to open surgery occurred in a patient with extensive post-traumatic adhesions, concordant with historical open-conversion rates of 0–3 % in elective cholecystectomy [2, 5]. Notably, no common-bile-duct injuries were encountered, reinforcing that critical-view principles can be maintained with three ports when vision and retraction are adequate.

Multivariate analysis identified gallbladder oedema, previous upper-abdominal surgery and intra-operative cholecystitis as independent predictors of prolonged operative time, corroborating the observations of Kumar et al. [10]. These factors reflect technical complexity rather than port number and should alert surgeons to a probable need for an additional port or senior assistance.

Postoperative morbidity remained low and comparable between groups (2 %), corroborating large database studies indicating that port reduction per se does not amplify complication rates [1, 11]. Length of stay mirrored contemporary enhanced-recovery pathways, with 96 % of patients discharged within 24 h. Although analgesic consumption was not comprehensively recorded, several randomised trials report diminished postoperative pain scores and opiate requirements with 3PLC [4, 12].

Cost-analysis, beyond the scope of this report, has previously demonstrated tangible savings with 3PLC attributable to fewer disposable trocars and reduced assistant staffing [13]. In resource-constrained public hospitals, such incremental savings scale substantially over high-volume caseloads.

Our study is limited by its retrospective design, single-surgeon experience and absence of long-term port-site hernia or chronic pain data. Nevertheless, the homogenous elective cohort, standardised peri-operative protocol and complete 30-day follow-up strengthen internal validity.

Future work should explore patient-reported outcomes, formal pain-score analysis and cost-utility modelling. Prospective multi-centre randomised trials may further delineate the role of 3PLC in complex gallbladder pathology and during surgical training[14].

In sum, our data reaffirm that 3PLC is a pragmatic, safe and economical modification of standard LC that can be readily adopted by experienced laparoscopic surgeons, with facile escalation to 4PLC or open surgery when dictated by intra-operative findings[15].

5. CONCLUSION

Three-port laparoscopic cholecystectomy offers a safe, efficient and economical alternative to the conventional four-port approach for elective benign gallbladder disease. In our two-year series of 200 patients, 3PLC matched 4PLC in operative time, conversion rate, morbidity and hospital stay, while permitting rapid escalation via insertion of a fourth port whenever exposure was suboptimal. Adoption of 3PLC can thus enhance minimally invasive surgery programmes, especially in high-volume, resource-limited settings, without compromising patient safety or outcomes.

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