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A Prospective Comparative Study on Postoperative Spirometry in Patients Undergoing Laparoscopic Cholecystectomy versus Laparoscopic Appendicectomy

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Abstract
Background: Laparoscopic procedures are now the norm in abdominal surgery because of their minimally invasive techniques and attendant advantages. Postoperative pulmonary dysfunction still poses a problem, though, particularly after upper abdominal surgery. This investigation contrasts pulmonary function alteration after elective laparoscopic cholecystectomy and laparoscopic appendicectomy. Methods: A prospective observational study was conducted at Rajiv Gandhi Government General Hospital, Chennai, from March to June 2015. Forty adult patients (ASA Grade I/II, BMI <30 kg/m²) undergoing elective laparoscopic cholecystectomy (Group CHOLE, n=20) or laparoscopic appendicectomy (Group APPEND, n=20) were evaluated. Spirometry (FVC, FEV1, PEFR) was performed preoperatively, and at 6 and 24 hours postoperatively. Pain was monitored using a Visual Analog Scale. Data were analysed using SPSS v16, with significance set at p<0.05. Results: At 6 hours post-op, Group CHOLE showed significantly greater reductions in FVC (26.47% vs 16.54%, p=0.0006), FEV1 (25.30% vs 16.58%, p=0.0033), and PEFR (24.36% vs 16.17%, p=0.0007) compared to Group APPEND. At 24 hours, partial recovery was observed in both groups, but Group CHOLE continued to show more pronounced deficits. Duration of pneumoperitoneum was longer in Group CHOLE (80.6 Vs 71.15 minutes, p = 0.0027). Conclusion: Laparoscopic cholecystectomy, produces more and prolonged post operative pulmonary dysfunction than low abdominal laparoscopic appendicectomy. This indicates the vital role of spirometry and respiratory physiotherapy, particularly in high abdominal operations, to enhance recovery and minimize complications.

Key words: *Laparoscopic cholecystectomy, laparoscopic appendicectomy, postoperative pulmonary dysfunction, spirometry, FVC, FEV1, PEFR, abdominal surgery.*

INTRODUCTION

In the contemporary era of minimally invasive surgeries, laparoscopic procedures have revolutionized abdominal surgery, offering patients quicker recovery, reduced postoperative pain and shorter hospital stays. Among these procedures, laparoscopic cholecystectomy and laparoscopic appendicectomy are the most commonly performed interventions.(1,2) Although laparoscopic approaches significantly minimize postoperative complications compared to open techniques, they are not entirely devoid of physiological consequences. One such important but often under-monitored aspect is postoperative pulmonary dysfunction which poses risks of increased morbidity, particularly in vulnerable patients.(3,4)

Pulmonary complications following abdominal surgeries arise from a combination of factors, including the effects of general anaesthesia, postoperative pain, impaired diaphragmatic motion and physiological changes associated with the surgical site. Elements such as the induction of pneumoperitoneum, carbon dioxide insufflation, and surgical positioning also significantly influence respiratory mechanics. Notably, the anatomical location of surgery whether in the upper or lower abdomen has been shown to distinctly impact postoperative pulmonary function with upper abdominal surgeries generally causing greater impairment.(5,6) Studies suggest that laparoscopic cholecystectomy, involving the upper abdomen and performed in head-up tilt, affects diaphragmatic movement and reduces lung volumes more significantly than laparoscopic appendicectomy, which is a lower abdominal procedure done in head-down tilt. These observations point toward the surgical site playing a pivotal role in the extent and duration of pulmonary impairment postoperatively.(7,8)

Given the clinical importance of identifying and quantifying this postoperative dysfunction, spirometry serves as a valuable tool; spirometry parameters such as Forced Vital Capacity (FVC), Forced Expiratory Volume in 1

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second (FEV1), and Peak Expiratory Flow Rate (PEFR) allow objective assessment of lung mechanics, offering insight into the restrictive or obstructive nature of dysfunction.(9) This study aimed to compare the postoperative pulmonary dysfunction following elective laparoscopic cholecystectomy and laparoscopic appendicectomy using spirometry and evaluate the statistical significance of differences observed.

MATERIALS AND METHODS

This prospective observational study was conducted in a Tertiary Care Hospital at Chennai, between March 2015 and June 2015. Ethical clearance was obtained (ECR/270/Inst./TN/2013) and written informed consent was taken from all participants. A total of 40 patients were included, with 20 patients each in Group CHOLE (Laparoscopic Cholecystectomy) and Group APPEND (Laparoscopic Appendicectomy). A total enumeration sampling method was employed where all eligible patients scheduled for elective surgery and meeting inclusion criteria were considered.

Inclusion Criteria: The study included adult patients between the ages of 18 and 60 years, classified as American Society of Anaesthesiologists (ASA) Grade I or II, with a Body Mass Index (BMI) of less than 30 kg/m². Eligible participants were those scheduled to undergo elective laparoscopic cholecystectomy or laparoscopic appendicectomy and who provided valid written informed consent. Exclusion Criteria: Patients were excluded from the study if they were undergoing emergency surgeries, had a diagnosis of acute cholecystitis or acute appendicitis, suffered from any form of cardiorespiratory disease or acute respiratory infection, had a history of smoking, or were unable to perform acceptable spirometry procedures.

All patients underwent preoperative evaluation including history, physical examination, chest X-ray, ECG, and baseline spirometry. Only those with normal baseline spirometry were included. All surgeries were performed under general anaesthesia using standard protocols: premedication with glycopyrrolate, analgesia with fentanyl (2 µg/kg), maintenance with sevoflurane, and muscle relaxation with atracurium.

Laparoscopic procedures were conducted using CO_2 insufflation, maintaining intra-abdominal pressure at 12-14 mmHg. Patients in the cholecystectomy group were operated in a reverse Trendelenburg position, while those in the appendicectomy group were in Trendelenburg position. The duration of pneumoperitoneum was recorded for each patient.

Postoperative analgesia was standardized with intramuscular tramadol (1 mg/kg). Visual Analog Scale (VAS) was used to ensure pain did not interfere with spirometry; if VAS >40, IV paracetamol was administered before testing.

Spirometry named EasyWarePro (nddMedizintechnik AG, Software version 1.9.0.18) was performed preoperatively and repeated at 6 hours and 24 hours postoperatively using bedside spirometry. Parameters recorded included FVC, FEV1, and PEFR. Acceptability and reproducibility criteria per ATS/ERS guidelines were followed. Vitals were measured using Pulse oximeter and VAS scale for pain assessment.

Statistical Analysis: Data were analysed using SPSS v16 and MS Excel 2007. Descriptive statistics were presented as means and standard deviations. Group comparisons for continuous variables were done using unpaired t-tests. Categorical variables were analysed using Chi-Square or Fisher's exact test. Statistical significance was considered at $p<0.05$.

RESULTS

The demographic characteristics of the two groups were comparable with no statistically significant difference in age, sex, BMI, height, weight, and baseline spirometry (Table 1). Association between type of surgery and spirometry outcomes were given in table 2. Percentage changes in postoperative spirometric parameter between two groups were depicted in table 3. Comparison of mean Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 Second (FEV1), Peak Expiratory Flow Rate (PEFR) at preoperative, 6 hours and 24 hours postoperative time points for both groups elicited in Figure 1.

At 6 hours postoperatively, FVC decreased by 26.47% in Group CHOLE and by 16.54% in Group APPEND ($p=0.0006$), FEV1 decreased by 25.30% in Group CHOLE and by 16.58% in Group APPEND ($p=0.0033$), PEFR decreased by 24.36% in Group CHOLE and by 16.17% in Group APPEND ($p=0.0007$). Whereas, at 24 hours postoperatively: FVC recovered by 17.52% in Group CHOLE and 14.23% in Group APPEND, but remained lower than baseline in CHOLE (10.86% below baseline). Likewise, FEV1 recovered by 16.58% in Group CHOLE and 15.96% in Group APPEND; still 10.46% below baseline in CHOLE. Similarly, with PEFR, improved by 13.25% in Group CHOLE and 12.27% in Group APPEND; CHOLE group still had 12.82% reduction compared to baseline. Duration of pneumoperitoneum was longer in Group CHOLE (80.6 minutes vs 71.15 minutes, p=0.0027). At 24 hours postoperatively, although partial recovery was seen in both groups, patients in the cholecystectomy group continued to exhibit lower pulmonary function values compared to their baseline, indicating more prolonged impairment. These findings suggest that the site of surgery (upper abdomen vs. lower abdomen) significantly affects postoperative spirometry, with upper abdominal procedures leading to more marked and sustained dysfunction.

DISCUSSION

This study demonstrated significant postoperative pulmonary function impairment in both laparoscopic cholecystectomy and appendicectomy, with greater and more persistent deficits in the cholecystectomy group. The decline in FVC, FEV1, and PEFR was statistically and clinically significant, reflecting restrictive ventilatory pattern.

The findings align with those of Joris et al. and Karayiannakis et al., who reported more pronounced reductions in lung volumes following upper abdominal laparoscopic procedures compared to lower abdominal ones who reported more pronounced reductions in lung volumes following upper abdominal laparoscopic procedures compared to lower abdominal ones.(10,11) The physiological rationale includes diaphragmatic dysfunction due to surgical site, patient positioning, and effects of pneumoperitoneum. Hasukić et al., and Bablekos et al., also documented impaired pulmonary function in patients undergoing laparoscopic cholecystectomy, especially within 24 hours.(12,13) Tiefenthaler et al. highlighted delayed recovery in upper abdominal surgery patients reinforcing the importance of monitoring pulmonary function, especially after upper abdominal laparoscopic surgeries.(14) Chumillas et al. and McKeague et al. further validate that spirometry deterioration correlates with surgical site.(15,16)

The literature supports the use of incentive spirometry and preoperative physiotherapy, as shown in Cochrane reviews by Nascimento et al. and trials by Alaparthi et al. These interventions accelerate pulmonary recovery and reduce complications.(17, 18)

CONCLUSION

Laparoscopic cholecystectomy is associated with more significant and prolonged postoperative pulmonary dysfunction than laparoscopic appendicectomy, independent of anesthesia, analgesia, or patient demographics. The site of surgery, influencing diaphragmatic mechanics, plays a critical role in determining postoperative spirometric outcomes. This study highlights the need for routine use of spirometry and early initiation of respiratory physiotherapy to facilitate optimal postoperative recovery.

Recommendations: Routine pre- and post-operative spirometry should be considered, particularly in upper abdominal laparoscopic surgeries. Physiotherapy and incentive spirometry may aid in early recovery of lung function. Future studies with larger sample sizes and longer follow-up may provide further insights into the clinical significance of these findings.

Limitations: The relatively small sample size (n=40) limits the generalizability of the findings to broader populations. Additionally, the postoperative follow-up period was confined to 24 hours, which may not fully capture the trajectory of pulmonary function recovery or delayed complications. The study also excluded smokers and patients with respiratory comorbidities which reduces external applicability to real-world surgical populations. Furthermore, the absence of long-term spirometric follow-up or correlation with clinical outcomes like oxygen saturation or respiratory symptoms limits the depth of clinical interpretation.

Table 1: Socio-demographic Characteristics of Study Participants

Variable	Group CHOLE (n=20)	Group APPEND (n=20)	p-value
Age (mean ± SD)	31.55 ± 8.34	29.60 ± 11.16	0.5355
Gender (M/F)	7 / 13	10 / 10	0.5231
Height (mean ± SD)	157.95 ± 8.94	160.25 ± 9.24	0.4285
Weight (mean ± SD)	57.85 ± 6.98	55.00 ± 11.26	0.3431
BMI (mean ± SD)	23.30 ± 3.22	21.31 ± 3.36	0.0635
Respiratory Rate (mean ± SD)	13.65 ± 1.09	13.70 ± 1.38	0.8995

Table 2: Association between type of surgery and spirometry outcomes

Parameter	Group	Pre-op	6 hrs Post-op	24 hrs Post-op	p-value (6 hrs)	p-value (24 hrs)
FVC (L)	CHOLE	2.76	2.03	2.46	0.0027	0.0014
FVC (L)	APPEND	3.17	2.65	3.08		
FEV1 (L)	CHOLE	2.47	1.85	2.21	0.0096	0.0014
FEV1 (L)	APPEND	2.78	2.35	2.78		
PEFR (L/sec)	CHOLE	6.50	4.92	5.67	0.0272	0.0100
PEFR (L/sec)	APPEND	7.09	5.96	6.78		

Table 3: Percentage Change in Postoperative Spirometric Parameters between two groups

Parameter	Time Point Comparison	Group CHOLE (% Change)	Group APPEND (% Change)	p-value
FVC	Pre-op vs 6 hrs Post-op	-26.47%	-16.54%	0.0006*
	6 hrs vs 24 hrs Post-op	+17.52%	+14.23%	0.0134*
	Pre-op vs 24 hrs Post-op	-10.86%	-2.81%	0.0298*
FEV1	Pre-op vs 6 hrs Post-op	-25.30%	-16.58%	0.0033*
	6 hrs vs 24 hrs Post-op	+16.58%	+15.96%	0.0243*
	Pre-op vs 24 hrs Post-op	-10.46%	-0.74%	0.0054*
PEFR	Pre-op vs 6 hrs Post-op	-24.36%	-16.17%	0.0007*
	6 hrs vs 24 hrs Post-op	+13.25%	+12.27%	0.0402*
	Pre-op vs 24 hrs Post-op	-12.82%	-4.45%	0.0112*

*Statistically significant at p<0.05

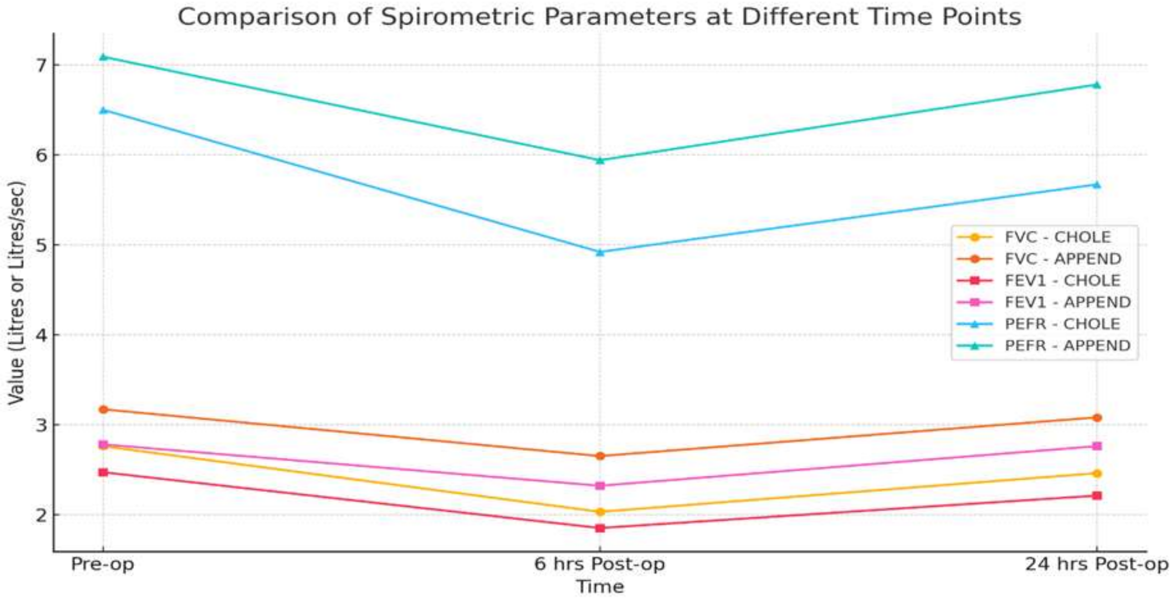

Figure 1: Line graph comparing mean Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 Second (FEV1), Peak Expiratory Flow Rate (PEFR) at preoperative, 6 hours and 24 hours postoperative time points for both groups.

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