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ORIGINAL ARTICLE

Laparoscopic Cholecystectomy in patients with mild and moderate Chronic Obstructive Pulmonary Disease (COPD):Our experience in Hepatobiliary & Pancreatic Surgery Division in BSMMU

Nur-E-Elahi M[1], DasBC[2], Uddin MS[3], Imdad S[4], Chowdhury MM[5], Khan ZR[6]

Abstract:

Background: *Laparoscopic Cholecystectomy (LC), the gold standard for surgical treatment of many Gall Bladder diseases may render some additional adverse effectsin COPD patients due to the creation of CO_2 pneumoperitoneum in a patient with already reserved pulmonary capability. In our study, the clinical outcome of patients with COPD who underwent LC was compared with the outcome of non-COPD patients to clarify the effects and potential hazards of a CO_2 pneumoperitoneum, if any, in patients with COPD.*

Method: *Twenty patients with COPD (Group-I) and undergoing LC were compared with 25control patients without COPD and also undergoing LC (Group-II). Patient demographics, intraoperative end-tidal CO2 (both before and after CO2 insufflation), and clinical outcome, including surgical duration, length of postoperative hospital stay, and any associated complications, were analyzed.*

Results: *The procedures of 02 Group-I patients were converted to the open method, and these patients wereexcluded from the study. Comprising the COPD group were 20 patients with mild COPDand one patient with moderate COPD. With similar settings of tidal volume and ventilation rate forthe two groups, the measured end-tidal CO2 value was significantly greater for Group-I than forGroup-II patients after the creation of a CO2 pneumoperitoneum (35.4 ± 1.9 vs. 31.5 ± 3.1 mm Hg, P=.012). The duration of surgery was similar for Groups I and II (65 ± 20.7 vs. 58 ± 18.6 minutes), as was the duration of the postoperative hospital stay (4.1 ± 2.2 vs. 4.0 ± 1.6 days; P=.800). No pulmonary complications were noted for any of the patients.*

Conclusion: *Laparoscopic Cholecystectomy (LC) can be safely performed in COPD patients with mild or even a moderate degreeof airway obstruction. Intraoperative CO_2 retention did not complicate the postoperative recoveryin terms of the complication rate or the duration of the postoperative hospital stay.*

Key Words:*LC, Laparoscopic Surgery, COPD, Co_2 Pneumoperitoneum*

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1. Md. Nur-E-Elahi, Assistant Professor, Department of Hepatobiliary, Pancreatic & Liver transplant Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh.
2. Bidhan C Das, Associate Professor, Department of Hepatobiliary, Pancreatic & Liver Transplant Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh.
3. Md. Saief Uddin, Assistant Professor, Department of Hepatobiliary, Pancreatic & Liver transplant Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh.
4. Sadia Imdad, Junior Consultant, Department of Surgery, Shaheed Suhrawardy Medical College Hospital, Dhaka.
5. Prof. Md. Mohsen Chowdhury, Professor, Department of Hepatobiliary, Pancreatic & Liver transplant Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh.
6. Prof. Zulfiqur Rahman Khan, Chairman, Department of Hepatobiliary, Pancreatic & Liver transplant Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh.

Correspondence to: Dr. Md. Nur-E-Elahi, Assistant Professor, Department of Hepatobiliary, Pancreatic & Liver Transplant Surgery, Room# 914, Block 'C, Department of Hepatobiliary, Pancreatic & Liver Transplant Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh. Mobile: +8801713130501; E-mail: nureelahi@outlook.com

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Introduction

In last one decade, increasing worldwide prevalence of COPD can be attributed to smoking, increased life expectancy, and less active lifestyles. For adults older than 40 years, COPD's worldwide prevalence (as defined physiologically) is ~9–10%.[1,2] This high prevalence is putting a burden on both surgeons and anesthesiologists, who are both seeing an increase in the volume of high-risk respiratory patients. These high-risk patients who are undergoing laparoscopic procedures, especially those with COPD, have unique issues that require careful consideration by the surgeons.[3]

Laparoscopic cholecystectomy (LC) was approved for use in 1988, and since then, it has been used as the gold standard treatment method for symptomatic cholelithiasis.[4]During LC, A carbon dioxide (CO2) pneumoperitoneum, the most common means of accomplishing laparoscopic surgery, has been noted to result in net CO_2 retention, arterial hypercarbia, and subsequent arterial acidosis, even for relatively healthy individuals,with associated adverse effects that include increased intracranial pressure and possible cardiac dysrhythmia.[4,5,6] The above-mentioned adverse effects associated with a CO_2 pneumoperitoneum have been shown to occur to a greater degree in patients with chronic obstructive pulmonary disease (COPD), who often exhibit a rather limited cardiopulmonary reserve.[4]

In our study, the clinical outcome of patients with COPD who underwent LC was compared with the outcome of non-COPD patients to clarify the effects and potential hazards of a CO_2 pneumoperitoneum, if any, in patients with COPD.

Materials & Methods:

We prospectively included 22 patients with established COPD(Group-I) who underwentLaparoscopic Cholecystectomy (LC) during the period fromJanuary 2016 to June 2018 in Hepatobiliary & Pancreatic Surgery Division in Bangabandhu Sheikh Mujib Medical University (BSMMU). During the same period oftime, a total of 42 LC procedures were performed on patientswithout COPD. Of these patients, 25 were randomly selected to be a case-matched control group (Group-II). Statistical investigationof the clinical characteristics of these25 patients, including their age, sex, leukocyte count, andsurgical outcome, was undertaken to ensure that they constituted a random and fairly representative subsample ofthe 42 non-COPD patients who had undergone LC(Table 1).

The procedures of two patients in Group-I were convertedto open cholecystectomy because of the presence of sinistroposition of Gall Bladder in one case and difficult anatomy in another case and these patients were excluded fromthe study. Of the remaining 20Group-I patients, elevenwere male and nine were female, with a mean age of 53years (range, 41–67 years). Four of them had hypertension, twodiabetes mellitus, and one congestive heart failure. Nopatient in this group had more than one other concurrentdisease. Indications for LC in these Group-I patients included symptomatic cholelithiasis in thirteen, acute cholecystitis in five, gallbladder polyp in one, and cholelithiasisaccompanied by an impacted choledocholithiasis, whichwas removed before the LC, in one patient. The Group II patientswere comparable with their Group-I counterparts in respect to clinical characteristics, including age, sex distribution, specific disease pattern, and associated diseases(Table 2).

All the patients in Group I had COPD as determinedby appropriate chest specialists according to their history,clinical presentation, and preoperative pulmonary function test results. Following the criteria of the American Thoracic Society, the pulmonary function tests were performed with three acceptable attempts within 5% of one another, under the maximal efforts of each patient. The severity of COPD for each patient was determined according to the widely accepted classification listed in Table 3, primarily by the ratio of the forced expiratory volume at the first second of the test to the

forced vital capacity (FEV1/FVC, expressed as a percentage) and the degree of reduction of the FEV1 in comparison with its predicted value (expressed as percent predicted).[7]

Informed consent was obtained from every patient involved, each of whom was provided with a preoperative explanation of the procedure and rationale behind the study, in addition to training related to appropriate postoperative pulmonary toilet, including cough management and deep inspiration techniques. Postoperative respiratory therapy was provided for the COPD patients and commenced on the first day postoperatively under the instruction of respiratory therapists. Chest physiotherapy mainly consisted of a number of techniques, includingchest percussion, postural drainage, and deep-breathing exercises. Oral medications for preexisting lung diseaseswere resumed as soon as possible. Postoperative pulmonary complications were defined as fever persistingfor more than 1 day with associated clinical evidence of atelactasis or pneumonia, the need for prolonged intubation, or refractory bronchospasm.

LC was performed according to a well-established protocol. In brief, under general anesthesia, a pneumoperitoneum was created by CO2 insufflation until an intra-abdominal pressure of 12 mm Hg had been established. The patient was then kept in the reverse Trendelenburg position with a slight left lateral tilt during the surgical procedure to provide a maximal exposure of the gallbladder and facilitate optimal retraction of the gallbladder fundus. After dissection was complete, the gallbladder was removed via the umbilical port.

The partial pressure of CO_2 measured in exhaled gas (end-tidal CO_2) was continuously monitored during theprocedure, although arterial blood gas analysis (ABG) is not performed as a routine examination during LC in ourinstitution.The tidal volume, minute ventilation, and volume of oxygen flow were all set to a level that was deemed appropriate according to the general condition of each patient. The values of end-tidal CO2 at the time just before the creationof pneumoperitoneum and 15 minutes after insufflation were chosen to represent the pre-insufflation and post-insufflation values of end-tidal CO2. The ventilator settings at both time points were also recorded.

The measured end-tidal CO2 values, clinical demographics, and surgical outcomes, including surgical duration, complications, and length of postoperative stay in the hospital, were compared between groups. Patientswere discharged from the hospital when they were able to tolerate oral intake without the need of parenteral fluid and when they were able to manage bedside activity by themselves.All data were analyzed with Student's *t* test. A *P* value of less than .05 was considered significant.

Results

Among the patients with COPD, two patients' ratio of FEV1 to FVC was 67%, with a predicted FEV1 of 56%. This was categorized as moderate COPD. The remaining patients had FEV1/FVC values between 50% and 70%, but their predicted FEV1 was greater than 80%, and they were categorized as having mild COPD.[7](Table 3)

The tidal volumes for Group I and Group II patients before CO2 insufflation were 587 ± 75.7 and 611. 3±65.2 mL, respectively, and they became 641±121.5 and 687.9 ± 130.0 mL, respectively, after CO2 insufflation. Although the tidal volume for patients in each group generally increased after insufflation, the difference was not statistically significant between the two groups when they were compared either before or after insufflation. The ventilation rates were unchanged before and after insufflation in both groups, which were 11.1/min in group 1 and 11.2/min in Group-II. The measured mean 6 standard deviation end-tidal CO2 values before CO2 insufflation for Group I and Group II patients were 31.2 ± 2.2 and 27.4 ± 3.3mm Hg, respectively (P= .08). A significant increase in the value of end tidal CO2 after CO2 insufflation was observed for both groups of patients, the post-

insufflation value being 35.4 ± 1.9mm Hg for COPD patients (P = .004) and 31.5 ± 3.1mm Hg for non-COPD patients (P=.001).After the creation of a CO2 pneumoperitoneum, however, Group I patients exhibited a significantly greater mean value for end-tidal CO2 when compared with patients from Group II (35.4 ± 1.9vs. 31.5 ± 3.1mm Hg, P=.012) (Table 2).

The duration of surgery was 65 ± 20.7minutes for Group-I patients and 58 ± 18.6minutes for Group II patients (P = .222). Nebulization was given to all patients in Group I, and bronchospasm was well controlled after the use of bronchodilators in all patients. The duration of the postoperative hospital stay was 4.1 ± 2.2days for the COPD group and 4.0 ± 1.6days for the nonCOPD group (P=.800; Table 2). No pulmonary complications, such as prolonged intubation and postoperative ventilator support for hypoxemia, respiratory acidosis, pneumonia, or refractory bronchospasm, occurred in the Group-I patients. Postoperative respiratory therapy was successfully performed by a well-trained staff without any occurrence of clinically significant atelactasis or a complicated pulmonary infection. One patient in Group I had a wound infection that was noted one week after surgery.

Table-I

Clinical Parameter and Outcome of 25 randomly selected Non-COPD Patients of G-II and All Non-COPD Patients.

	G-II (n=25)	All non-COPD Patients (n=42)	P Value
Age (Years)	44.3 ± 13.6	44.0 ± 12.9	.310
M:F	11:14	18:23	-
Leukocyte Count (X 10^9/L)	0.87 ± 2.7	0.79 ± 3.1	.651
Operative Time (Minutes)	65 ± 20.7	58 ± 18.6	.277
Length of Postoperative Stay (Days)	4.0 ± 1.6	4.12 ± 2.14	.589

Table-II

Clinical Parameters and Outcome of COPD (G-I) & Non-COPD (G-II) Patients.

	G-I (n=20)	G-II (n=25)	P Value
Age (Years)	53 ± 11.2	44.3 ± 13.6	.067
M: F	11: 9	11:14	
Length of Postoperative Stay	4.1 ± 2.2	4.0 ± 1.6	.800
Indication (n)			
Cholelithiasis	13	14	
Acute Cholecystitis	4	6	
GB Polyp	1	2	
Choledocholithiasis with Cholelithiasis	2	3	
Tidal Volume (mL)			
Before CO_2 Insufflation	587 ± 75.7	611 ± 65.2	.959
After CO_2 Insufflation	641 ± 121.5	687.9 ± 130	.869
End-tidal CO_2 (mm of Hg)			
Before CO_2 Insufflation	31.2 ± 2.2	27.4 ± 3.3	.08
After CO_2 Insufflation	35.4 ± 1.9	31.5 ± 3.1	.012

Table-III

Classification of COPD by Severity [7] and the number of patients in the COPD Group-I in each stage of severity.

Stage	Characteristics
0: At risk	Normal Spirometry Chronic Symptoms (cough, sputum production)
I: Mild COPD (n=18)	$FEV_1/FVC < 70\%$ FEV_1 e" 80% Predicted With or without Chronic Symptoms (cough, sputum production)
II: Moderate COPD (n=2)	$FEV_1/FVC < 70\%$ 30% d" FEV_1< 80% Predicted (IIA: 50% d" FEV_1< 80% Predicted) (IIB: 30% d" FEV_1< 50% Predicted) With or without Chronic Symptoms (cough, sputum production)
III: Severe COPD (n=0)	$FEV_1/FVC < 70\%$ FEV_1< 30% Predicted, or The presence of respiratory failure[a], or Clinical signs of right-sided heart failure.

[a]Respiratory failure: PaO_2< 8.0 kPa(60mm Hg) with or without PaO_2> 6.7 kPa (50 mm Hg) while breatihing air at sea level.

Discussion

LC has been demonstrated to be superior to open cholecystectomy surgery. With less injury to the abdominal musculature and less intraoperative manipulation of adjacent organs, improved respiratory responses and fewer acute phase responses have been observed, as well as less postoperative pulmonary dysfunction.[8–10] These results, and a reported incidence of postoperative pulmonary complications for patients with COPD following open surgery of 25% to 100%, [11] indicate that it is appropriate to perform cholecystectomy by the laparoscopic technique.However, the considerable systemic adverse effects of the CO2 pneumoperitoneumused in LC have been widely studied and reported; they include the following:[4-12]

1. An increased risk for the development of myocardial ischemia as a consequence of increased myocardial wall tension caused by increased mean arterial pressure and increased systemic venous resistance.
2. The development of cardiac dysrhythmia.
3. The direct vasoconstriction of pulmonary vessels as a consequence of hypercarbia, hypoxemia, and hypoventilation in the context of preexisting lung disease.

Many studies [4,5,10,12] have focused on these changes incirculatory hemodynamics and pulmonary function before and after LC, although the clinical outcome for patients with COPD undergoing LC has not been thoroughly discussed.

In our study, even with similar ventilator settings, we found increased CO_2 retention in patients with COPD after the creation of a CO_2 pneumoperitoneum, as reflected by a significantly increased end-tidal CO_2 pressure. This, however, was not associated with a greater likelihood of postoperative pulmonary complications or a prolonged postoperative hospital stay in comparison with non COPD patients. This observation may be partially explained by the work of Fahyet al.[13]They found that large increases in lung resistance and lung and chest wall stretch, which occur during abdominal CO_2 insufflation before laparoscopic surgery, are largely reversible on abdominal deflation. In addition, Galiziaet al.[14] compared hemodynamic and pulmonary changes during

open CO_2 pneumoperitoneum with those during abdominal wall lifting cholecystectomy. They found that CO_2 insufflation produced a complex hemodynamic and pulmonary syndrome resulting in increased right- and left-sided filling pressures, significant cardiac index reduction, and derangement of the respiratory mechanics, and respiratory acidosis, all of which normalized after desufflation.

LC is superior to its open surgery counterpart in regard to a reduced level of postoperative pulmonary function complications and a faster recovery of normal pulmonary function postoperatively[8,9,15,16] and the noted adverse effects of a CO_2 pneumoperitoneum on respiratory mechanics are largely and quickly reversible following abdominal desufflation. This further supports our conclusions that LC can be safely performed in COPD patients because pulmonary function recovers to normal levels more quickly than with open surgery, and most side effects of a CO_2 pneumoperitoneum are reversible and well-tolerated by patients (mild & moderate COPD).

An alternative explanation of our favorable finding is that patients who undergo LC generally resume their intake of oral medication sooner than those who undergo open cholecystectomy.[17] Thus, their medication for pulmonary disease is likely to be well maintained, without any prolonged interruption or adjustment to an intravenous form. In addition, all but one of our patients have had mild COPD as revealed by their pulmonary function test results; the remaining patient was categorized as having moderate COPD (FEV1/FVC = 68%, predicted FEV1 = 55%).[7] No patients in the COPD group (Group-I) had severe airway obstruction. Hence, it is unclear whether LC in COPD patients with a severe form of airway obstruction would be tolerated as well as it is in patients with a milder form of obstruction.

Based on the previously mentioned criteria for hospital discharge, the mean length of the postoperative stay in both groups was 4 days, which seems longer than that in most other published reports (usual range, 1–2 days). A possible explanation is that some of the patients asked to stay in the hospital longer because they felt discomfort subjectively, even though their general condition had fully reached the criteria for discharge. However, this deviation from the discharge criteria was considered to be acceptable because no negative effects on patient outcome were noted.

In conclusion, there is no contraindication to LC for patients with mild or moderate COPD. Problems with CO2 retention, hypercarbia, and the associated systemic side effects do not complicate the postoperative recovery from LC in terms of frequency of complications and duration of postoperative hospital stay for COPD patients, although the results of LC for patients with severe COPD are still unknown, warranting further study.

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