Impact of carbon-dioxide pneumoperitoneum on liver function in laparoscopic cholecystectomy – A prospective study

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ABSTRACT

Background: Laparoscopic cholecystectomy has become the gold-standard surgical treatment for uncomplicated symptomatic cholelithiasis. Although carbon dioxide pneumoperitoneum used during laparoscopic procedures may influence hepatic physiology, these effects are generally considered transient and clinically insignificant in patients with normal liver function. This study aimed to evaluate the impact of pneumoperitoneum on biochemical liver function parameters in patients undergoing laparoscopic cholecystectomy. **Objective:** To assess alterations in liver function following laparoscopic cholecystectomy. **Methods & Materials:** This prospective observational study was conducted in the Department of Surgery, Dinajpur Medical College Hospital, Bangladesh, from July 2013 to June 2014. A total of 100 patients with uncomplicated symptomatic cholelithiasis were enrolled, including 70 patients undergoing laparoscopic cholecystectomy and 30 undergoing open cholecystectomy. Serum bilirubin, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) levels were measured preoperatively and at 12, 48, and 72 hours postoperatively. A uniform anesthetic protocol was applied, and intra-abdominal pressure during laparoscopic procedures was maintained at ≤14 mmHg. **Results:** In the laparoscopic group, serum ALT, AST, and bilirubin levels showed a statistically significant increase 12 hours after surgery (ALT: 49.3 U/L, AST: 53.1 U/L, bilirubin: 1.38 mg/dL; $P<0.001$). These values gradually declined and approached baseline levels within 72 hours. In contrast, patients in the open cholecystectomy group demonstrated no significant postoperative elevation in liver function parameters at any time point ($P>0.05$). **Conclusion:** Laparoscopic cholecystectomy is associated with a transient and reversible elevation of liver enzymes and bilirubin, likely related to CO_2 pneumoperitoneum. These changes appear to have no lasting clinical significance in patients with uncomplicated cholelithiasis and normal preoperative liver function.

Keywords: *Carbon-dioxide, cholecystectomy, laparoscopic, pneumoperitoneum*

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Introduction

Gallstone disease is one of the most common gastrointestinal disorders encountered in surgical practice worldwide and remains a significant cause of morbidity across all age groups. Symptomatic cholelithiasis frequently presents with biliary colic, acute or chronic cholecystitis, and related complications, often necessitating surgical intervention. Over the past few decades, major advances in minimally invasive surgery have dramatically altered the management of gallstone disease, with laparoscopic cholecystectomy (LC) now firmly established as the treatment of choice for uncomplicated cases[1]. Owing to continuous improvements in surgical techniques, instrumentation, and perioperative care, LC is currently applicable to more than 95% of patients with symptomatic cholelithiasis when performed by adequately trained surgeons[1].

The widespread acceptance of LC is largely attributable to its well-recognized benefits compared with open cholecystectomy. These advantages include reduced postoperative pain, shorter hospital stay, faster return to normal activities, improved cosmetic outcomes, and lower rates of wound-related complications[2]. Furthermore, the development and refinement of fluoroscopic intraoperative cholangiography and laparoscopic common bile duct exploration have expanded the indications of laparoscopic techniques, enabling effective management of both gallbladder and bile duct stones during the same procedure[3]. As a result, laparoscopy has become an integral component of modern hepatobiliary surgery.

Despite these advantages, LC is not entirely free of physiological consequences. The creation of carbon dioxide (CO_2) pneumoperitoneum, which is essential for adequate visualization and working space during laparoscopy, has been shown to influence several organ systems[4]. In particular, concerns have been raised regarding its effects on hepatic function. CO_2 pneumoperitoneum increases intra-abdominal pressure, which may reduce splanchnic and portal venous blood flow, potentially leading to transient hepatic ischemia[5]. These changes may be more pronounced in patients with pre-existing liver disease or in those with compromised cardiovascular, respiratory, or renal function[6].

Hypercapnia resulting from CO_2 absorption and elevated intra-abdominal pressure can further exacerbate hemodynamic alterations during LC[7]. Experimental and clinical studies have demonstrated that increased intra-abdominal pressure may compress portal venous structures, thereby decreasing hepatic perfusion and oxygen delivery[8]. Such physiological disturbances are believed to contribute to postoperative alterations in liver biochemical parameters, even in patients undergoing uncomplicated laparoscopic procedures[9]. These effects have prompted ongoing debate regarding the safety of pneumoperitoneum, particularly in high-risk patient populations.

Conversely, several investigators have reported that pneumoperitoneum maintained within a moderate pressure range does not significantly compromise splanchnic circulation. Intra-abdominal pressures between 11 and 13 mmHg are commonly used during routine LC and have been suggested to preserve adequate hepatic and mesenteric blood flow in otherwise healthy individuals[10]. These conflicting findings highlight the complexity of hepatic hemodynamics during laparoscopy and suggest that multiple factors—including pressure level, duration of insufflation, patient characteristics, and anesthetic management—may influence postoperative liver function changes[11].

Transient elevations in serum liver enzymes following uneventful LC have been consistently documented in the literature[12]. Increases in aspartate aminotransferase (AST) and alanine aminotransferase (ALT) are the most frequently reported abnormalities, while changes in serum bilirubin, gamma-glutamyl transferase (GGT), and alkaline phosphatase (ALP) are less consistent[13]. These biochemical alterations are generally reversible and return to baseline within a few days after surgery, suggesting a functional rather than structural hepatic insult. Splanchnic ischemia induced by pneumoperitoneum remains the most widely accepted explanation for these changes[14].

Other mechanisms have also been proposed to explain postoperative hepatic enzyme elevation after LC. Thermal injury from diathermy, direct liver manipulation, patient positioning, and anesthetic agents may contribute to transient hepatocellular stress during surgery[15]. Nevertheless, studies comparing laparoscopic and open cholecystectomy have demonstrated that postoperative liver enzyme alterations are more commonly observed following laparoscopic procedures, further supporting the role of pneumoperitoneum as a key contributing factor.

In contrast to LC, open cholecystectomy does not require insufflation of the abdominal cavity and therefore avoids the physiological effects associated with increased intra-abdominal pressure. Although open surgery is associated with greater tissue trauma and longer recovery time, its impact on hepatic perfusion is thought to be less pronounced. Comparative evaluation of liver function changes between laparoscopic and open cholecystectomy may therefore provide valuable insight into the specific role of pneumoperitoneum in postoperative hepatic dysfunction.

The biochemical assessment of liver function remains an essential component of perioperative evaluation in hepatobiliary surgery. Serum bilirubin, AST, ALT, GGT, and ALP are routinely used to detect hepatocellular injury and cholestasis. Among these, AST and ALT are particularly sensitive indicators of hepatocellular stress and are frequently employed to monitor transient liver function changes following abdominal surgery.

Given the widespread use of laparoscopic cholecystectomy and the ongoing debate regarding its impact on hepatic function, further investigation is warranted. The present study aims to evaluate changes in selected biochemical parameters of liver function—specifically AST, ALT, and serum bilirubin—in patients with symptomatic cholelithiasis undergoing laparoscopic cholecystectomy and to compare these changes with those observed in patients undergoing open cholecystectomy. A clearer understanding of these alterations may help optimize perioperative management and improve surgical outcomes, particularly in patients with increased operative risk.

Materials & Methods

This prospective observational study was conducted over a one-year period from July 2013 to June 2014 in the Department of Surgery at Dinajpur Medical College Hospital, Dinajpur, Bangladesh. The study population comprised patients presenting with uncomplicated symptomatic cholelithiasis. A convenient sampling technique was employed, and a total of 100 patients were enrolled, of whom 70 underwent laparoscopic cholecystectomy (LC) and 30 underwent open cholecystectomy (OC). Patients aged between 20 and 70 years without pre-existing liver disease or abnormal liver function were included. Individuals with prior endoscopic retrograde cholangiopancreatography and sphincterotomy, intraoperative cholangiography, complicated biliary disease, requirement of pneumoperitoneum pressure exceeding 14 mmHg, significant cardiopulmonary or renal comorbidities, or hematological disorders were excluded.

After obtaining written informed consent, detailed clinical information including history, physical examination findings, and relevant investigation reports was collected using a predesigned data collection sheet. Baseline investigations included complete blood count, plain X-ray of the kidney–ureter–bladder region, ultrasonography of the whole abdomen, and preoperative liver function tests (serum bilirubin, AST, and ALT). Diagnosis of cholelithiasis was confirmed, and complicated cases were excluded prior to surgery. Both LC and OC were performed under general anesthesia using a uniform anesthetic protocol and antibiotic regimen. During laparoscopic procedures, intra-abdominal pressure was maintained at or below 14 mmHg. Operative duration, intraoperative events, and postoperative complications were carefully recorded. Liver function tests were repeated at 12-, 48-, and 72-hours following surgery, and postoperative values were compared with baseline levels in both groups.

Statistical analysis was performed using SPSS software (version 17). Preoperative and postoperative liver function parameters between the LC and OC groups were compared using Student's *t*-test. A *p* value of less than 0.05 was considered statistically significant. Ethical approval was obtained, and all procedures were conducted in accordance with ethical standards, ensuring confidentiality, voluntary participation, and absence of physical or psychological harm to participants.

Results

Table I shows statistical data processing proved that the age of the patients ranged from 20 to 70 years with 42% patients being in the 30 to 40 years age group. In the LC group of patients, the average age was 43.77, while in the control, OC group control, the average age was 43.00 years. The average age of the patient did not differ statistically between the open and laparoscopic groups. Age wise distribution of all patients were shown below.

Table I
Age-wise distribution of total patients (*n* =100).

Age distribution (years)	n=100	%
20-30	15	15.0
31-40	42	42.0
41-50	30	30.0
51-60	10	10.0
≥61	3	3.0

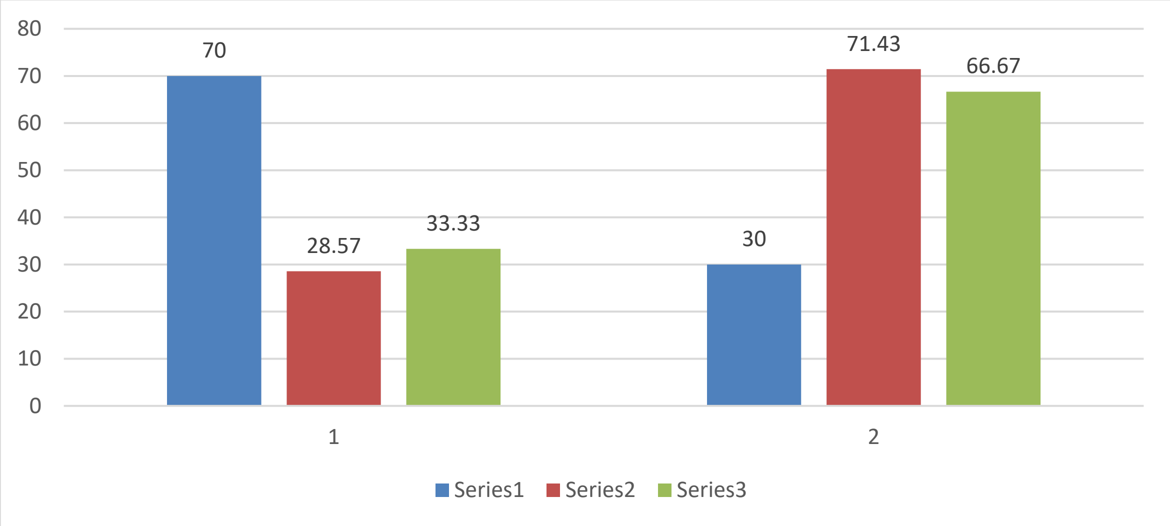

Figure 1 Multiple bar diagram showing sex distribution of patient.

Figure 1 shows the ratio of female patient in our study was 70% (n=70) while male was 30% (n=30%). There was a statistically significant difference in sex ratio between the LC group and OC group of patients. IN LC group male was 28.57% and female was 71.43% while in OC group male was 33.33% and female was 66.67%. So, the open group had more male patient then LC group. The sex distributions of patients were showed below.

The difference between the tested preoperative values of ALT, AST and bilirubin were not statistically significant between the LC and OC groups of patients, which indicates that the two tested groups were homogenous in terms of these tested parameters.

Table II shows ALT Values in the LC group after 12 hours rose significantly (P<0.01) from 27.1 to 49.3. After 48 hours, ALT values decreased to 30.4. Value also decreased after 72 hours to 28.2, which was near to pre-operative value (27.1). ALT values in the open group fell after the operation insignificantly during the testing period from 27.2 to 26.5 and to 26.0, 72 hours after the operation.

Table II
Mean and SD of ALT at different time intervals in LC group & OC group.

Liver Function	Time of Assessment	Mean±SD
ALT (U/L) in LC	Postoperative	27.1±3.62
	12 hours after operation	49.3±8.43
	48 hours after operation	30.4±4.91
	72 hours after operation	28.2±3.77
ALT (U/L) in OC	Postoperative	27.2±3.62
	12 hours after operation	26.5±3.14
	48 hours after operation	26.16±3.13
	72 hours after operation	26±3.05

**SD=Standard Deviation*

The average pre-operative value of AST was 31.1 in LC group of patients but after 12 hours post-operation is was 53.1 which was more than the pre-operative ones. After 48 hours it decreased gradually to 33.2 and after 72 hours which was near to pre-operative value.

Table III shows AST values in the LC group after 12 hours rose significantly (P<0.01) from 31.6 to 53.1. After 48 hours, AST values decreased to 33.2. Values also decreased to 33.2 after 72 hours, which was near to preoperative value (31.6). AST values in the open group fell after the operation insignificantly during the testing period from 31.5 to 31 and 10 30.72 hours after the operation. The results were presented in table.

Table III
Mean and SD of AST at different time intervals in LC group & OC group.

Liver Function	Time of Assessment	Mean±SD
ALT (U/L) in LC	Postoperative	31.6±4.33
	12 hours after operation	53.1±9.18
	48 hours after operation	33.2±5.65
	72 hours after operation	31.1±4.18
ALT (U/L) in OC	Postoperative	31.5±4.65
	12 hours after operation	31±4.15
	48 hours after operation	30.5±3.92
	72 hours after operation	30±3.80

**SD=Standard Deviation*

The average pre-operative value of serum bilirubin was 0.82. After 12 hours it was 1.38, which was statistically significant (P<0.01) but after 48 hours the measured average value was 0.84 and after 72 hours the average value was 0.83 which was near to the pre-operative one.

Table IV shows the values of serum bilirubin in the laparoscopic group after 12 hours also rose statistically significantly from the average value 0.82 to 1.38 mg/dl. After 48 hours there was a statistically significant insignificant drop in bilirubin values 0.84. The value dropped after 72 hours to 0.83 and approached values in the open group. Values of bilirubin 72 hours after the operation were near to pre-operative values. In the open group of patients there was no statistically significant difference in values of bilirubin during testing period, with an insignificant drop of average values. The results were presented in *Tables IV*.

Table IV
Mean and SD of Bilirubin at different time intervals in LC group & OC group.

Liver Function	Time of Assessment	Mean±SD
ALT (U/L) in LC	Postoperative	0.82±0.109
	12 hours after operation	1.38±0.241
	48 hours after operation	0.84±0.121
	72 hours after operation	0.83±0.115
ALT (U/L) in OC	Postoperative	0.83±0.14
	12 hours after operation	0.82±0.092
	48 hours after operation	0.81±0.089
	72 hours after operation	0.80±0.087

**SD=Standard Deviation*

Table V shows moreover, the elevations in hepatic enzymes particularly, ALT and AST were more marked in patients who had longer durations of CO2 insufflation.

Table V
Correlation of CO2 insufflation time with levels of serum liver enzymes.

Percentage of Patients (%)	Duration of CO2 insufflation (Minutes)	Elevation in levels of hepatic enzymes observed 12 hours post-operation		
		ALT (%)	AST (%)	Bilirubin (%)
30	Up to 50	70	60	45
50	Up to 60	95	80	70
20	Above 60	100	100	80

Discussion

The present study evaluated the impact of CO_2 pneumoperitoneum on postoperative biochemical liver function by analyzing changes in serum AST, ALT, and bilirubin levels following laparoscopic cholecystectomy. A statistically significant rise in all three parameters was observed in the laparoscopic group as early as 12 hours after surgery when compared with preoperative values ($P < 0.01$). These elevations were transient, with a gradual decline noted over time and near normalization within 72 hours postoperatively. In contrast, patients who underwent open cholecystectomy demonstrated no significant postoperative increase in liver enzymes or bilirubin; rather, a mild and clinically insignificant decline was observed during the same postoperative period.

These findings are consistent with previous reports suggesting that pneumoperitoneum-induced elevation of intra-abdominal pressure plays a central role in transient postoperative hepatic dysfunction. Sakorafas et al. demonstrated a significant increase in AST and ALT levels within 24 hours following laparoscopic cholecystectomy compared with both preoperative values and those observed in patients undergoing open cholecystectomy, with normalization occurring within one-week[16]. Similarly, Guven et al. reported a significant postoperative rise in transaminases at 24 hours after laparoscopic cholecystectomy, which resolved within 72 hours, while no significant enzyme alterations were noted in the open surgery group[17]. These observations reinforce the concept that laparoscopic procedures exert a temporary physiological impact on hepatic function that is not typically seen with open techniques.

Further evidence supporting the role of pneumoperitoneum has been provided by studies examining hepatic blood flow. Jakimowicz et al. demonstrated, using Doppler ultrasonography, that intra-abdominal pressure of 14 mmHg can reduce portal venous blood flow by approximately 50%, thereby predisposing the liver to transient ischemia[18]. This reduction in hepatic perfusion is believed to underlie the reversible elevations in transaminases and bilirubin observed after laparoscopic procedures. Valeriu et al. also documented significant postoperative increases in transaminases and bilirubin following laparoscopic cholecystectomy, which returned to baseline within 72 hours, supporting the ischemia–reperfusion hypothesis[19].

Comparable biochemical changes have been reported in other laparoscopic abdominal procedures. Tan et al. observed significant postoperative elevations of AST and ALT in patients undergoing laparoscopic intestinal resections, whereas no such changes were seen in patients treated with open techniques[20]. This suggests that the observed hepatic enzyme alterations are related more to the physiological effects of pneumoperitoneum than to the specific surgical site or pathology. Moreover, Hasukić et al. demonstrated that the magnitude of postoperative liver enzyme elevation was directly influenced by the level of intra-abdominal pressure used during laparoscopy, with lower pressures resulting in significantly smaller changes in AST and ALT values[21].

An important observation in the present study was that patients with elevated preoperative transaminase levels did not achieve complete normalization within 72 hours postoperatively, unlike those with normal baseline values. This finding suggests that pre-existing hepatic inflammation or subclinical liver dysfunction may exacerbate the hepatic response to pneumoperitoneum. The persistence of elevated enzyme levels in such patients may reflect a compounded effect of baseline inflammation and transient ischemic stress induced during laparoscopy.

Taken together, the findings of this study and those reported in international literature indicate that laparoscopic cholecystectomy is associated with a transient, reversible elevation of liver enzymes and bilirubin in the absence of clinical hepatic impairment. These biochemical changes are most likely attributable to CO_2 pneumoperitoneum and increased intra-abdominal pressure leading to temporary reduction in hepatic blood flow. Importantly, these alterations resolve spontaneously within 72 hours in patients with normal preoperative liver function and do not appear to carry significant clinical consequences.

Conclusion

Transient elevation in liver function test is a usual finding after un-eventful laparoscopic cholecystectomy without any significant clinical consequences and it is mainly attributed to the high intra-abdominal pressure of CO2 pneumoperitoneum but other factors such as surgical manipulation, use of electrosurgery etc. any contribution.

Recommendations

Due to short period of study and lack of other facilities for working on this topic in this setup, further research and studies are suggested to prove its point of view.

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