# Comparative Evaluation of High Versus Low Pressure Pneumoperitoneum in Causing Acute Kidney Injury During Laparoscopic Cholecystectomy

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**Abstract**

**Objective:** Aim of our study is to monitor low- and high-pressure pneumoperitoneum effects and find optimum intra-abdominal pressure that is safe to avoid or minimise acute kidney injury.

**Method:** This study was conducted at Fatima Memorial hospital from July 2022 to December 2022. A total of 80 patients were segregated into two groups of 40 each. Group A had laparoscopic cholecystectomy with 15 mmHg pneumoperitoneum pressure while Group B had 20 mmHg pneumoperitoneum pressure. Patients were monitored postoperatively for creatinine and urine output changes at 8 hours, 24 hours and 72 hours interval.

**Results:** Post-operative creatinine rise and fall in urine output was statistically significant between both groups, indicating 15 mmHg pneumoperitoneum is safer for laparoscopic cholecystectomy to avoid acute kidney injury (AKI). Operation time, inflation time and blood loss were statistically significant and remain the key factors in predicting AKI after laparoscopic cholecystectomy.

**Conclusion:** AKI is a transient condition that can arise after laparoscopic cholecystectomy. It can be minimized by keeping intra-abdominal pressure ⩽ 15mmHg. Operation time, inflation time and perioperative blood loss can predict AKI per-operatively.

**Keywords:** Laparoscopic cholecystectomy, Pneumoperitoneum, Acute kidney injury

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## Introduction

Gall stone disease is a chronic hepatobiliary disease impacting negatively on world economy.[1] Laparoscopic cholecystectomy has now been accepted as standard treatment worldwide for cholelithiasis.[2] Since the advent of laparoscopy, abdominal surgery has been revolutionized. Its merits include smaller incision size, lesser pain postoperatively, early ambulation with faster recovery and return to routine activities and work.[3,4] For successful and effective laparoscopy, creation of pneumoperitoneum is first and pivotal step as better perception and movement of laparoscopic instruments peroperatively is not possible without it. The commonly used gas to insufflate peritoneal cavity is carbon dioxide ($CO_2$). Certain physiological alterations have been reported while creating pneumoperitoneum, especially the renal functions.[4] Many authors have shown conflicting reports while trying to establish relationship between $CO_2$ induced pneumoperitoneum and renal functional changes in animal models. Chiu and colleagues used well hydrated pigs and reported a 60% reduction in blood flow to kidney after 2 hours of $CO_2$ insufflation which returned to normal after desufflation.[5] Kirsch and associates showed in pigs that at a pressure of 15mmHg of pneumoperitoneum, Inferior vena cava (IVC) blood flow decreases and resultantly decreasing urine output and increasing serum creatinine.[6] On the contrary, Ali and Yavuz with associates showed that renal perfusion is preserved even after a pneumoperitoneum greater

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than 15mmHg.[7,8] According to Kidney Disease Improving Global Outcomes (KIDGO) criteria, AKI is defined as increase in serum creatinine ≥ 0.3mg/dl within 48 hours or urine volume < 0.5ml/kg/hour for 6 hours.[9] Data in this context is Pakistan is almost nil. No human study is available in Pakistani set up to validate these findings for laparoscopic cholecystectomy.

## Material and Methods

After approval from IRB letter no. FMH-11/10/2022-IRB-1113 dated December 01,2022, this single centred quasi-experimental study was conducted at Surgical floor, Fatima Memorial hospital, Lahore between July 2022 to December 2022. Sample size was 80. All patients above 18 years of age, with ASA status between I to III, having symptomatic gall stones were included in the study. Patients with pre-existing chronic kidney disease and those on NSAID therapy were excluded from the study as they could affect post-operative renal physiology. After taking informed consent, all patients underwent laparoscopic cholecystectomy. Same anaesthetic agent with standard dose was used in all patients. Those patients who were suspected to have simple cholecystectomy were subjected to 15mmHg pressure of pneumoperitoneum and labelled as group A, while those with difficult cholecystectomy were subjected to 20mmHg pressure of pneumoperitoneum labelled as group B. Standard treatment was offered to all the patients post-operatively including IV fluids, IV antibiotics and analgesia. Blood samples were taken for serum creatinine estimation before surgery, 8 hours, 24 hours and 72 hours after surgery. Urine output was measured 8 hours, 24 hours and 72 hours after surgery. Similarly, operation time, insufflation time and blood loss were also calculated. All the data was recorded in structured proforma. AKI was assessed by following KIDGO criteria. Statistical analysis was performed on SPSS version 21. Descriptive statistics were computed and described as mean ± SD. Categorical variables were stated using frequency distribution. Paired samples were subjected to t test. P value of less than 0.05 was taken as significant.

## Results

A total of 80 patients were included in the study and divided into two groups of 40 patients each. Group A patients had 15mmH pressure while group B had 20mmHg pressure of pneumoperitoneum. The demographic characteristics of the two groups and its statistical significance is summarised in table 1. No statistical difference was found between two groups. The serum creatinine and urine output both started to be affected 8 hours after surgery. The serum creatinine reached its peak 24 hours after surgery. However, it started to decline and return to normal after 72 hours. Similarly, urine output declined to a minimum 24 hours after surgery but returned to normal after 72 hours of surgery. These results are shown in) Fig-1 & 2). Certain intraoperative parameters were calculated and measured and then compared in both groups to predict AKI postoperatively. Our results are summarised in (Table-2). The number of patients having AKI and non-AKI in both groups is summarised in (Table-3). These results make it clear that a pressure of 15mmHg is an optimum pressure to maintain pneumoperitoneum while minimising acute kidney injury during laparoscopic cholecystectomy.

**Table 1:** *Demographic Data & Statistical Significance*

| Variable | Group A | Group B | P value |
|---|---|---|---|
| Age (in years) | 41.92± 8.62 | 42.70± 8.07 | 0.681 |
| Gender (M: F) | 8: 32 | 12: 28 | 0.439 |
| BMI (Kg/m²) | 25.5± 3.88 | 26.1± 2.95 | 0.729 |
| Preoperative creatinine level(mg/dL) | 0.83± 0.24 | 0.88± 0.18 | 0.274 |

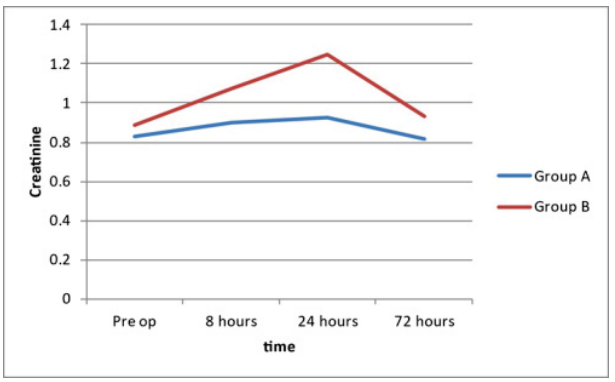


**Fig-1.** *Postoperative creatinine levels comparison at different time intervals.*

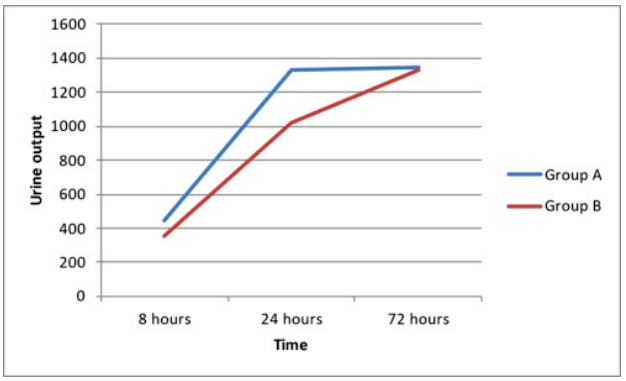


**Fig-2.** *Postoperative urine output comparison at different time intervals.*

**Table 2:** *Role of clinical intraoperative parameters in predicting AKI*

| variable | Group A | Group B | P value |
|---|---|---|---|
| Creatinine level 8 hours after surgery (mg/dL) | 0.89± 0.23 | 1.07±0.28 | 0.003 |
| Creatinine level 24 hours after surgery (mg/dL) | 0.92± 0.31 | 1.24±0.49 | 0.001 |
| Creatinine level 72 hours after surgery (mg/dL) | 0.81± 0.19 | 0.93±0.16 | 0.005 |
| Urine output 8 hours after surgery (ml) | 444± 83.26 | 357.75± 130.23 | 0.001 |
| Urine output 24 hours after surgery (ml) | 1333.25± 256.65 | 1017.25± 379 | 0.0001 |
| Urine output 72 hours after surgery (ml) | 1347.50± 160.50 | 1332.5± 153.81 | 0.671 |
| Operation time (minutes) | 119.05± 11.73 | 126.95± 14.39 | 0.009 |
| Insufflation time (minutes) | 92.50± 18.16 | 109.65±17 .40 | 0.0001 |
| Blood loss (ml) | 98± 34.5 | 137.75± 39.6 | 0.0001 |
| Length of stay (days) | 4.05± 4.9 | 4.08± 1.8 | 0.976 |

**Table 3:** *Crosstabulation of patients having AKI &non-AKI in both groups.*

| AKI | Group A | Group B | Total |
|---|---|---|---|
| Yes | 4 (10%) | 15 (37.5%) | 19 (23.9%) |
| No | 36 (90%) | 25 (62.5%) | 61 (76.1%) |
| Total | 40 (100%) | 40 (100%) | 80 (100%) |

## Discussion

This study demonstrated the fact that AKI is a fairly common condition that can occur during laparoscopic cholecystectomy. Incidence of AKI in our study is 19 (23.9%) in total which is in contrast to other studies as shown by Boyer et al. and Abdullah et al. that found incidence of AKI of 2.3-2.9% following bariatric surgery.[10,11] The limitation of these studies is that urine output was not included in diagnostic criteria. We followed KIDGO guidelines using both serum creatinine and urine output as an AKI detection criterion. However, Srisawat et al. concurred with our findings by using KIDGO guidelines and reported AKI incidence of 35.9%.[12] Our study proposed that operation time and insufflation time both is strongly associated with AKI with group B patients affected more for having an intra-abdominal pressure of 20mmHg. This fact is supported by Brusasco et al. who showed decreased renal function in pigs with an intra-abdominal pressure of ≥20mmHg.[13] Similarly, operation time was associated with AKI after laparoscopic cholecystectomy which is also concurred by some authors that an operation time of >210 minutes enhanced AKI risk from 0.8-4.4%.[4,14] We strongly suggest not only to keep intra-abdominal pressure at ≤ 15mmHg but also limit operation time and insufflation time to avoid risk pf perioperative acute kidney injury.

Increased intra-abdominal pressure cause renal function disturbance by three proposed mechanisms. First is chemical mechanism caused by hypercarbia due to $CO_2$ inflation. Second is mechanical effect due to increased intra-abdominal pressure compressing renal veins and impeding blood flow to kidney.[13] Third mechanism is hormonal involving renin-angiotensin-aldosterone system. It denotes renal vasoconstriction thereby increasing renin, aldosterone and antidiuretic hormone during laparoscopic gastric bypass surgery.[15] It is important to clarify that all the patients in our study had transient AKI, resolving spontaneously after 72 hours with nil mortality. This finding is in contrast to other researchers who have reported a higher mortality by 1.07-2.01 times.[16,17] We owe this difference to better ICU facilities with dedicated doctors and paramedical staff, an aggressive management of AKI since the start and better selection of patients. Blood loss was also noted to be a statistically significant factor in our study in predicting AKI. It occurred during dissection within calots triangle. Our findings are in accordance with the studies done earlier in this regard.[18]

## Conclusion

AKI is a transient condition that can arise after laparoscopic cholecystectomy. It can be minimized by keeping intra-abdominal pressure ≤ 15mmHg. Operation time and inflation time can predict AKI perioperatively. Further studies with large randomized controlled trial using novel biomarkers for kidney injury is required to validate this notion.

**Conflict of interest** *None*

**Funding Source** *None*

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## Authors Contribution

**AM:** Conceptualization of Project
**TH:** Data Collection
**STB:** Literature Search
**OA:** Statistical Analysis
**SA:** Drafting, Revision
**JKL:** Writing of Manuscript