











A study on the effect of insufflation gases employed in laparoscopy on various organs: A rat model

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ABSTRACT

Introduction: In laparoscopic surgery, pneumoperitoneum is created using carbon dioxide, helium, or ambient air. We aimed to investigate the effects of these gases on the organs.

Materials and Methods: The experiment involved 25 male Sprague-Dawley rats aged 5-6 months, were divided into four groups. Group 1 (n=4) was the control group. Pneumoperitoneum was induced in Groups 2 (n=7), 3 (n=7), and 4 (n=7) using carbon dioxide, helium, and room air, respectively. After 2 hours, the gas was evacuated, and blood samples were collected. Blood was drawn 24 h later. The rats were euthanized, and tissue samples from the liver, pancreas, kidney, intestine, and lungs were collected for examination.

Results: There were no significant differences in the severity of inflammation or intestinal effects between the groups. Adverse effects on the lungs, liver, and pancreas were greater in the carbon dioxide group. All groups showed negative effects on the kidneys, regardless of the gas type. Although laparoscopic surgery has many advantages over open surgery, the type of gas used and the increased intra-abdominal pressure can cause adverse effects. However, we believe that these effects are likely transient and should be verified through clinical experience.

Conclusion: In laparoscopic surgery, the choice of insufflation gas and elevated intra-abdominal pressure may induce transient adverse effects in various organs, highlighting the need for further clinical studies to substantiate these findings.

Keywords: Pneumoperitoneum, carbon dioxide, helium, laparoscopic surgery



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Introduction

Laparoscopic surgery is frequently used in intra-abdominal operations and offers advantages over open surgery, including reduced postoperative pain, shorter hospital stays, lower re-operation rates for ileus, favorable cosmetic results, and preservation of immune function.^[1,2] During laparoscopic surgery, inflammatory mediators are produced at lower levels than in open surgery.^[2] A pneumoperitoneum was created during laparoscopic surgery to provide an adequate exposure field. Pneumoperitoneum alters homeostasis of the abdominal cavity and may induce metabolic changes via both mechanical and biochemical mechanisms.^[3]

Various gases have been used to induce pneumoperitoneum, with the primary objective of mitigating both local and systemic adverse effects.^[3] Carbon dioxide (CO₂) is the gas most commonly used for insufflation. It is non-flammable and carries a low embolism risk; it is buffered and discharged from the lung when mixed into the blood.^[4,5] Cytokine release and neutrophil migration are inhibited in pneumoperitoneum using CO₂.^[4] One disadvantage of CO₂ is the development of metabolic acidosis during prolonged laparoscopic surgery.^[6,7] It can be retained percutaneously in the preperitoneal cavity or retroperitoneum, omentum, mediastinum, pericardium, and pleural cavity, and therefore needs particular attention in evacuation. Other gases used for pneumoperitoneum insufflation include helium (He) and room air (AA). Although no risk of metabolic acidosis arises from helium, which is an inert gas, it is reported to increase the risk of gas embolism.^[8] Room air insufflation is a cost-effective option, but it carries risk of gas embolism and infection.^[9] Argon gas may be used because it is inert and affordable, but it has a higher risk of embolism.^[10-12]

The occurrence of certain adverse effects is attributable to both the specific gas used in this technique and the consequent elevation in intra-abdominal pressure resulting from gas insufflation. Therefore, our study aimed to investigate the effects of CO₂, He, and AA air pneumoperitoneum on organs in a rat model.

Materials and Methods

We commenced our experimental animal study after obtaining approval from the animal ethics committee on 26/10/2016 (Approval number 246/2016).

Our study consisted of three study groups of seven rats

and a control (C) group of four rats. Male Sprague-Dawley rats of 5-6 months were used in our study. The study was conducted at the Istanbul Bezmi Alem Vakif University Laboratory of Experimental Animals.

Groups

Group 1: Control or sham (C) group (n=4): The rats in this group were anesthetized for the same period as the other groups. No surgical procedure was performed.

Group 2: Carbon dioxide (CO₂) group (n=7): Pneumoperitoneum created with CO₂.

Group 3: Helium (He) group (n=7): Pneumoperitoneum was created using helium.

Group 4: Ambient air (AA) group (n=7): Pneumoperitoneum was created using room air.

Operations Applied to Rats

All rats were anesthetized by intraperitoneal injection of xylazine (5 mg/kg) and ketamine (75 mg/kg). An 18 French catheter was introduced into the abdomen from the left lower quadrant of the rats in Groups 2, 3, and 4 to create a pneumoperitoneum. In contrast, only anesthesia was administered to the control group.

Pneumoperitoneum was created in the CO₂ group using a Sopro 640 pneumatic 30 L insufflator (Sopro Comeg S 640-3005, Tuttlingen, Germany) and a heater humidifier system. Using a Storz brand (Tuttlingen, Germany) mechanical insulator, helium and ambient air were applied to a 3. and 4. group rats. Peritoneal cavities were inflated to a pressure of 10 mmHg in all rats.

At the end of the 2-hour pneumoperitoneum, gas was evacuated from the peritoneal cavities of the rats, and 0.6 ml of blood was drawn from the jugular vein of each rat. Rats were placed into their cages, and 1.0 ml blood was drawn from all rats 24 h after the operation, and sera were separated for laboratory tests. All rats were subsequently euthanised according to institutional guidelines with the neck broken for tissue sampling from the liver, pancreas, kidney, small intestine, and lungs of the animals.

Biochemical Evaluation

Venous blood samples collected in MiniCollect® Serum tubes (North Carolina, USA) were centrifuged at 2000 × g for 10 min, and the separated sera were stored at -20 °C. Whole blood count (WBC) and C-reactive protein (mg/dl)

(CRP), aspartate aminotransferase (U/L) (AST), alanine aminotransferase (U/L) (ALT), amylase, lipase, urea, and creatinine levels were measured consecutively. Cell Dyn 3700 (Abbott, New York, USA) was employed for whole blood count with the Laser/impedance method. The levels of AST, ALT, amylase, lipase, urea, and creatinine in the serum were measured by photometric methods using an auto analyzer (Abbott, Architect C 16000, New York, USA) and commercial kits (Abbott, New York, USA). CRP levels were measured using the same commercial kit on an auto analyzer (Abbott, Architect C 8000, New York, USA) by the immuno-turbidimetric method.

Pathological Examination

All tissue sections were stained with hematoxylin and eosin.

1. Liver:

Microscopic evaluation demonstrated histopathological changes, such as portal inflammation, intralobular inflammation, sinusoidal dilatation, sinusoidal hyperemia, pericentral ischemia, presence of acidophilus, and vacuolization in hepatocytes. Findings were evaluated subjectively and recorded as either available or absent.

2. Kidney:

The kidneys were evaluated using the endothelial glomerular tubular interstitial (EGTI) histological grading system. Tubules, glomeruli, tubulointerstitial areas, and endothelial cells were evaluated, and the degree of injury was graded from 0 to 4.

3. Pancreas:

In the pancreas, necrosis of the acinar and epithelial vacuoles was assessed and documented as either present or absent.

4. Intestine:

The intestines were evaluated according to the Chiu scoring system in six phases.

Phase 0: Normal mucosa

Phase 1: Formation of subepithelial Guenhagen cavities in the apex of the villi, usually accompanied by capillary congestion

Phase 2: Expansion of the subepithelial area and slight separation of epithelium from Lamina propria

Phase 3: Epithelial separation of the upper part of the villi

Phase 4: Lamina propria and villus spill, capillary dilatation, increased cellularity in Lamina propria

Phase 5: Decreased digestion and integrity of the lamina propria, bleeding, and ulceration.

5. Lung:

Polymorph-core leukocyte infiltration, interstitial/intra-alveolar edema, perivascular and/or intra-alveolar hemorrhage, and the presence of hyaline membrane formation were evaluated in five phases according to the following findings:

Phase 0: Lung parenchyma appears normal

Phase 1: Lung parenchyma with 25% findings

Phase 2: Lung parenchyma with 50% findings

Phase 3: Lung parenchyma with 75% findings

Phase 4: Lung parenchyma was evaluated to have 100% of findings.

Statistics

SPSS 15.0 (New York, USA) for Windows was used for the statistical analysis. Descriptive statistics: Numbers and percentages were indicated for categorical variables, and mean standard deviation and median were indicated for numerical variables. As the numerical variables did not normally distributed, the Kruskal–Wallis test was used to compare more than two groups. The Mann-Whitney U test was used for subgroup analysis and interpreted with Bonferroni correction. The ratios in the groups were compared using chi-square analysis. The statistical significance level was set at $p < 0.05$.

Results

Blood samples were drawn from rats at 2 hours showed a significant difference between the groups only in terms of WBC count and lipase levels (Table 1A). Blood samples collected from the rats at 24 hours showed a significant difference between the groups only in WBC, HGB, HCT, UREA, ALT, and AST (Table 1B).

In the subgroup analysis, there was a significant difference between the control group and CO₂ group in terms of WBC and lipase, control group, and between the control and ambient air groups in urea levels, respectively (Table 2A). There was a significant difference between the con-

Table 1A. Values of variabilities of groups at Hour 2

	Group C		Group CO ₂		Group He		Group AA		p
	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	Mean	Median	
WBC	2.9±0.9	3.2	5.1±1.0	4.7	3.7±0.7	3.1	3.8±0.5	3.8	0.008
PLT	552.7±339.5	654.0	687.7±56.0	717	730.0±77.5	735	619.7±110.7	661	0.168
HGB	15.0±0.8	15.1	14.8±0.6	14.7	14.2±0.7	14.3	14.1±1.1	14.6	0.282
HCT	42.4±2.7	42.4	42.2±1.4	41.9	43.8±3.0	44.6	41.8±3.2	43	0.361
AST	66.5±12.4	66.0	70.3±5.8	71	66.7±7.9	65.0	62.1±7.9	60	0.318
ALT	58.3±10.8	59.0	51.9±5.4	51	59.0±8.8	59.0	48.6±5.4	49	0.100
UREA	41.3±2.6	41.0	47.6±6.4	48	48.4±5.0	49	53.6±10.4	52	0.057
AMYL	965±29.7	968.5	1113±334.3	932	979.7±112.4	930	997.6±87.5	952	0.869
LIPASE	7.3±1.0	7.5	15.4±6.1	13	7.7±3.2	8	11.0±4.5	9	0.025
CRP	2.31±0.35	2.35	1.75±1.20	1.67	1.54±1.28	1.31	2.42±1.37	2.11	0.213

C: Control; He: Helium; AA: Ambient air.

Table 1B. Values of variabilities of groups at Hour 24

	Group CO ₂		Group He		Group AA		p	
	Mean±SD	Mean±SD	Median	Mean±SD	Median	Mean		Median
WBC	6.2±1.6	6.3±1.2	6.7	3.4±1.0	3.4	4.3±1.1	4.7	0.002
PLT	635.3±65.8	668.4±41.2	664	724.6±111.2	705	620.6±87.9	633	0.166
HGB	11.9±0.6	13.1±0.5	13.2	11.9±0.8	12.1	12.3±1.0	12.8	0.014
HCT	34.7±1.9	39.3±1.7	39.7	35.4±2.0	36.0	36.2±3.2	37.2	0.009
AST	72.0±13.7	114.9±15.2	115	64.1±24.0	74.0	160.3±204.7	88	0.001
ALT	120.3±15.6	42.4±6.5	44	29.1±5.7	27	45.7±20.3	40	0.001
UREA	56.5±9.0	28.6±8.0	27	35.3±3.5	34	34.6±7.7	34	0.011
AMYL	1317.8±506.2	1748.6±1079.6	1649	1378.1±621.8	1085	1943.4±685.6	1844	0.247
LIPASE	6.5±2.4	28.7±10.5	33	30.9±20.6	24	24.4±11.9	26	0.071
CRP	3.54±1.03	1.80±1.22	1.76	1.75±1.30	1.94	2.47±1.30	2.02	0.250

C: Control; He: Helium; AA: Ambient air.

control and the helium groups in WBC, ALT, and urea levels ($p<0.05$). Significant differences were also observed between the control and the CO₂ groups with respect to HGB, HCT, ALT, AST, urea, and lipase values ($p<0.05$). Additionally, the control group differed significantly from the ambient air group in terms of ALT and urea levels ($p<0.05$) (Table 2B).

T-score 1-2 of the kidney was high in the Helium group. The liver por score of 1 was high in the CO₂ and He groups, and the liver nec 1 score was also high (Table 3). Pulmonary biopsy scores were significantly higher in the CO₂ group than in the control group ($p=0.014$) (Table 4).

When the blood tests of the four groups were evaluated, there was a statistically significant difference in terms of the total RBC count (erythrocytes), HCT, and HGB at the 2 and 24 hours in all groups ($p<0.05$) (Table 1).

In the histopathological evaluation with x20 magnification, the liver tissue showed a regular appearance in the control group (Fig. 1A), while vacuolization was observed only in the hepatocyte cytoplasm of the liver tissues in the CO₂ group (Fig. 1 C). Normal-appearing liver tissue was observed in the other groups (Fig. 1.B & D). Regular renal tissue was observed in the pathological assessment of all the groups (Fig. 1 E, F, G & H).

Table 2A. Subgroup analysis for 2. hours

	Group C vs. CO ₂ p	Group C vs. He p	Group C vs. AA p
WBC-2	0.008	0.257	0.089
PLT-2	0.732	0.425	0.732
HGB-2	0.636	0.130	0.130
HCT-2	1.000	0.505	0.770
AST-2	0.635	1.000	0.507
ALT-2	0.343	0.850	0.130
UREA-2	0.106	0.035	0.010
AMYL-2	0.850	0.776	0.705
LIPASE-2	0.029	0.774	0.099
CRP-2	0.186	0.131	0.850

C: Control; He: Helium; AA: Ambient air.

Table 2B. Subgroup analysis for 24. hours

	Group C vs. CO ₂ p	Group C vs. He p	Group C vs. AA p
WBC-24	0.850	0.014	0.059
PLT-24	0.343	0.131	0.850
HGB-24	0.008	0.924	0.185
HCT-24	0.008	0.449	0.186
AST-24	0.008	0.850	0.088
ALT-24	0.008	0.008	0.008
UREA-24	0.008	0.008	0.014
AMYL-24	0.571	1.000	0.131
LIPASE-24	0.014	0.036	0.058
CRP-24	0.107	0.130	0.450

C: Control; He: Helium; AA: Ambient air.

Table 3. Biopsy results

	Group C Median (IQR)	Group CO ₂ Median (IQR)	Group He Median (IQR)	Group AA Median (IQR)	p
LUNG	1 (1-1.75)	3 (2-3)	1 (1-2)	3 (2-3)	0.004
INTESTINES	2 (1.25-2.75)	2 (1-2)	2 (2-3)	2 (1-2)	0.064
PANCREAS VAC	0 (0-0.75)	1 (0-4)	0 (0-0)	0 (0-1)	0.095
	n (%)	n (%)	n (%)	n (%)	
PANCREAS ASNEC	0	4 (100)	7 (100)	7 (100)	-
KIDNEY T	0	4 (100)	7 (100)	3 (42.9)	0.027
	1	0 (0.0)	0 (0.0)	3 (42.9)	
	2	0 (0.0)	0 (0.0)	1 (14.3)	
KIDNEY E	0	4 (100)	7 (100)	7 (100)	-
KIDNEY G	0	4 (100)	7 (100)	7 (100)	-
KIDNEY TI	0	4 (100)	7 (100)	7 (100)	-
LIVER POR	0	4 (100)	2 (28.6)	7 (100)	0.010
	1	0 (0.0)	5 (71.4)	0 (0.0)	
LIVER IN	0	4 (100)	2 (28.6)	6 (85.7)	0.021
	1	0 (0.0)	5 (71.4)	1 (14.3)	
LIVER SIN	0	1 (25.0)	2 (28.6)	5 (71.4)	0.345
	1	3 (75.0)	5 (71.4)	2 (28.6)	
LIVER SEN	0	4 (100)	7 (100)	7 (100)	
LIVER CON	0	4 (100)	7 (100)	7 (100)	
LIVER NEC	0	2 (50.0)	6 (85.7)	7 (100)	0.014
	1	2 (50.0)	1 (14.3)	5 (71.4)	

C: Control; He: Helium; AA: Ambient air; VAC: Pancreas epithelial vacuole; ASNEC: Necrosis of the acinar; T: Tubules; G: Glomeruli; TI: Tubulointerstitial area; E: Endothelial cells; 0-4: Degree of injury for kidney parameters; POR: Portal inflammation; IN: Intralobular inflammation; SIN: Sinusoidal dilatation; SEN: Sinusoidal hyperemia; CON: Congestion; NEC: Necrosis; 0: absent; 1: available.

Table 4. Subgroup analysis

	Group C vs. CO ₂ p	Group C vs. He p	Group C vs. AA p
LUNG	0.014	0.903	0.036
KIDNEY T	-	0.302	-
LIVER POR	0.061	-	0.236
LIVER IN	0.061	1.000	0.061
LIVER NEC	0.491	0.576	0.109

C: Control; He: Helium; AA: Ambient air; T: Tubules; POR: Portal inflammation; IN: Intralobular inflammation; NEC: Necrosis.

On microscopic evaluation of the pancreas, the tissue showed a regular appearance in the control group (Fig. 1.K), and vacuolization was observed in the acinus in the CO₂ group (Fig. 1.M), whereas the other groups showed regular pancreatic acinus, ductus, and neuroendocrine islets (Fig. 1 L & M).

Regular appearance of liver tissue, B. Sparse focal necrosis in parenchyma, C. Mildly increased Kupffer cells in sinusoids, D. Mild congestion, E, F, G. Regular appearance of glomeruli, tubules and interstitial areas, G. Mild congestion in interstitium, K, L, N. Regular appearance of

pancreas, M. Presence of vacuolization in exocrine pancreas (H&E, x100)

In the histopathological evaluation of lung tissues stained with hematoxylin-eosin, under x200 magnification, lung tissue in the control group showed a regular appearance (Fig. 2 A), whereas in the AA group, inflammatory cell infiltration, including increased polymorphous leukocytes in the lung parenchyma, interalveolar edema, and hyaline membrane formation was observed (Fig. 2 B). Diffuse intra-alveolar hemorrhage was observed in the CO₂ group (Fig. 2 C). In the helium group, elevated mononuclear inflammatory cell patches were detected in the lung parenchyma (Fig. 2 D). Regarding the pathological evaluation of the intestines, the intestinal mucosa in the control group was largely normal (Fig. 2 E), whereas the other groups had mucosal damage, villus irregularity, and epithelial spillage (Fig. 2 F, G & H).

Inflammatory cell infiltration including increased polymorphonuclear leukocytes in the lung parenchyma, intraalveolar edema, hyaline membrane formation, C. Diffuse intra-alveolar hemorrhage, D. Increased mononuclear inflammatory cells in the lung parenchyma, E. Partially regular intestinal mucosa, F, G, H. Mucosal damage, irregularity of villi, epithelial shedding (H&E, x 200)

The classification of the groups according to their pathological status is shown in Table 3.

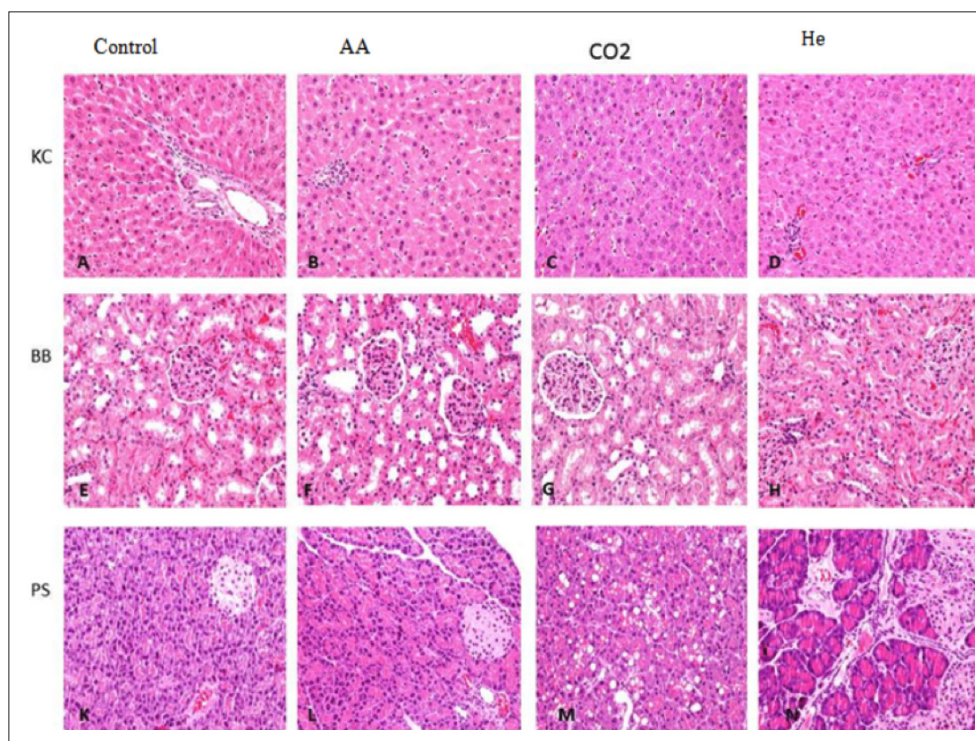


Figure 1. Microphotographic images of liver, kidney, and pancreatic biopsies.

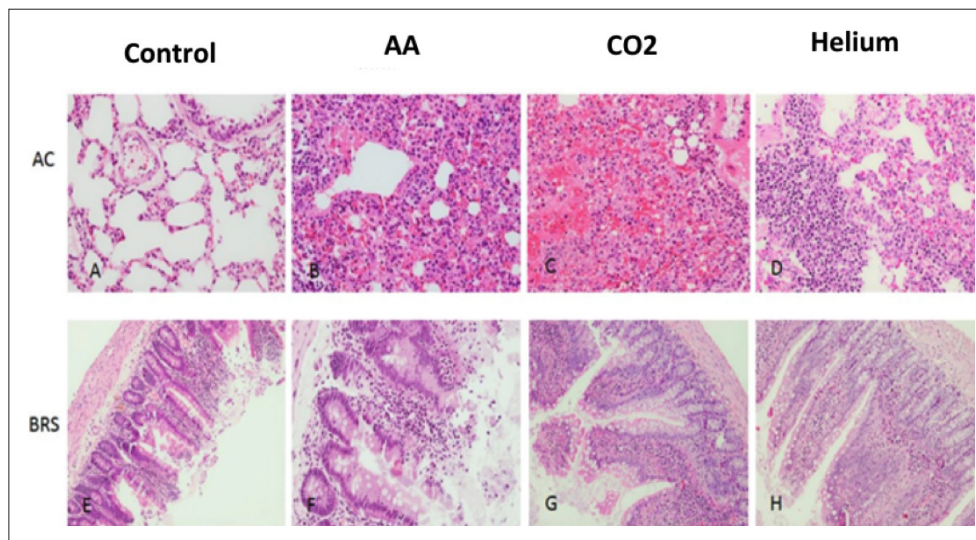


Figure 2. Pathological evaluation of lungs and intestines.

Discussion

In our rat model designed to compare the effects of certain insufflation gases employed to create pneumoperitoneum during laparoscopic procedures, the overall WBC and CRP levels, as indicators of infection or inflammation, showed no statistically significant difference. However, WBC values 2 hours after insufflation were significantly higher in the CO₂ group than in the control group. WBC values at 24 hours were significantly lower in the helium group than in the control group.

Similar to our findings, no statistically significant difference was observed in WBC and CRP levels between the CO₂ and ambient air groups in the two studies.^[9,10] It has been proposed that tissue contact with CO₂ causes a more favorable immune response than ambient air.^[11] In contrast, we found an increase in WBC count at 2 hours after insufflation in the CO₂ group, which may be an indicator of acute inflammation.^[12] In one study in which the effects of CO₂ insufflation on the peritoneum were examined, the changes started 1–2 h after the gases were evacuated from the abdominal cavity. Macrophage and neutrophil migration occurred at 12 h after evacuation and peaked at 24 hours. The preoperative levels were restored after 48 h.^[13] In another study in which interleukin 10 (IL-10), tumor necrosis factor-alpha (TNF-alpha), and interferon-gamma (IF-gamma) were compared in the serum and cerebrospinal fluid (CSF) of neonatal and adult rats insufflated with CO₂, CSF values in neonatal rats were found to be statistically higher than those in adults. Surgery and anesthesia are thought to have effects of Central Nervous System (CNS) in neonatal rats.^[8] Another finding of our

study was that a decrease in WBC values was observed in the helium group compared to the control group 24 hours after insufflation. Another study reported that helium did not cause a difference in WBC values. In the same study, the helium group showed an increase in CRP levels after 1 day compared to the CO₂ group. However, this disparity disappeared after two days.^[7] Similarly, no difference was observed between insufflation gases and other inflammatory parameters.^[14] The results regarding the inflammatory effects of insufflation gases are conflicting. There appears to be a minor difference between the gases in terms of their effects on the inflammatory system.

As for the mean values of HB and HCT, as expected, the mean values at 2 and 24 hours were significantly lower in all groups. In addition, the mean HB and HCT values after 24 hours were significantly higher in the CO₂ group than in the control group. We believe that this is coincidental. The mean AST level at 24 hours was significantly higher in the CO₂ group than that in the control group. The mean ALT values at 24 hours were significantly lower in the CO₂, He, and AA groups than in the control group. Our findings of higher AST values at 24 hours in the CO₂ group than in the other groups suggest that CO₂ could affect the liver directly. It has been reported that hemodynamic and cardiac changes, such as the reduction in venous return following CO₂ insufflation and increased systemic vascular resistance, may occur, and these changes result in a decrease in the perfusion, portal, and flow of abdominal organs.^[15,16]

Histopathological examination of the liver revealed higher portal and interstitial damage scores in the CO₂ and AA groups than those in the control group. The liver necrosis

scores were higher in the He group. Histopathological, we obtained higher liver injury scores in all groups except the control group, possibly due to the effects of intra-abdominal pressure.

The mean blood urea at 2 hours was significantly higher in the AA group than in the control group. The mean values at 24 hours were significantly higher in the CO₂, He, and AA groups than those in the control group. Although the mean value of blood urea in the AA group at 2 hours was found to be relatively high, we believe that the elevation of urea, in this case, may result from possible hemodynamic effects, since values at 24 h do not correlate with other parameters and are lower than those of the control group.

There were no significant differences in creatinine levels between the groups. Histopathological examination of the kidneys revealed that the tubules in the He group were affected to a greater extent than those in the other groups. The effects of laparoscopy on the renal unit are primarily related to the renal blood flow and glomerular filtration. Hemodynamic parameters due to increased intra-abdominal pressure are known to affect kidney function.^[11] Hein et al.^[17] reported that the reduction in renal blood flow was independent of the type of gas used for insufflation. All alterations in the kidney function were transient. It could not be proven that any histological damage occurred in the kidney in the short- and long-term after laparoscopy. The serum creatinine level returned to normal within 2 hours after desufflation and 22 hours after the start of urine flow.^[18]

The mean values of lipase at 2 and 24 hours were significantly higher in the CO₂ group than in the control group. Histopathological evaluation revealed no significant differences between groups in terms of pancreatic histology. There was no significant difference in amylase values. During laparoscopic surgery, decreased blood flow is observed in organs other than the kidneys (such as the liver, spleen, pancreas, abdomen, and small and large intestines). This decrease is likely to arise from compression of the mesenteric vessels.^[19] Decreased blood flow in the mesentery may rarely cause mesenteric embolism and has been observed later in the postoperative period.^[20] Caldwell et al.^[21] report in their animal studies that increased intraabdominal pressure results in a decrease in the organ blood flow index (organ blood flow/cardiac output) in all organs, except adrenal. Reduced blood flow can lead to ischemia and functional impairment of these organs. In our study, no significant differences were found between the groups in histopathological examination of the intestines.

The lung biopsy score was higher in the CO₂ group than that in the control group. The adverse effects of CO₂ insufflation on the lungs were more pronounced than those in the He and AA groups. In cases in which pneumoperitoneum was created with a pressure of 15 mmHg, a 27% decrease occurred in respiratory system compliance. Under the same pressure, a 35% decrease was observed in inspiratory peak pressure (IPP). However, these changes returned to control values 90 min after the end of pneumoperitoneum. Prolongation pneumoperitoneum duration may result in longer-lasting changes in pulmonary compliance.^[22] In laparoscopic surgery, hypercarbia may occur secondary to transperitoneal absorption of CO₂, pneumoperitoneum-associated diaphragm and intercostal muscle damage, Trendelenburg position, use of anesthetics leading to hypoventilation, and use of muscle relaxants.^[17,18] Respiratory acidosis, which develops as a result of hypercapnia due to the systemic absorption of CO₂ gas, is responsible for any changes caused by hypercarbia. Respiratory acidosis is generally well-tolerated in healthy individuals. It may increase blood pH to normal levels in patients with pathologies such as Chronic Obstructive Pulmonary Disease (COPD) that affect respiratory functions in the preoperative period. In laparoscopic operations, partial CO₂ pressure returns to normal levels at 1 hour after desufflation.^[23] Therefore, cardiovascular effects, hypercapnia, and acidosis are responsible for the damage to the lungs caused by CO₂. However, if the period is not extensive and underlying pulmonary pathology does not exist, the adverse effects observed are temporary and reversible.

Conclusion

In conclusion, in our rat model, we found that CO₂ had higher adverse effects on the lung, liver, and pancreas than He and ambient air as insufflation gases. Low levels of adverse effects on kidney function were also detected, and in general, the inflammatory reaction seemed to be higher. However, we believe that these effects are likely to be transient, and the experimental findings should be corroborated by clinical experience.

Disclosures

Ethics Committee Approval: We commenced our experimental animal study after obtaining approval from the Bezmi Alem Vakif University Animal Ethics committee (No: 246/2016, Date: 26/10/2016).

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