The effects of isothermic or hypothermic carbondioxide pneumoperitoneum on arterial blood gases

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ABSTRACT

Objectives: To investigate the effects of isothermic or hypothermic carbon dioxide used for pneumoperitoneum during laparoscopic cholecystectomy on blood gases.

Methods: Between 2004 and 2006, 62 patients (American Society of Anesthesiologists grade I, II, and III for elective laparoscopic cholecystectomy) (age between 18 and 70 years), were enrolled in this prospective randomized study. The patients were divided into 2 groups. In the isothermic group, 37^{0}C carbon dioxide was used, and 21^{0}C carbon dioxide was used in hypothermic group. Core body temperature at esophagus and skin temperature were measured at 10-minute intervals beginning just before insufflation and during pneumoperitoneum. Blood arterial pH, arterial carbon dioxide pressure, arterial oxygen pressure, and bicarbonate values were measured just before insufflation, at 30 minutes of pneumoperitoneum, and 30 minutes after desufflation.

Results: The mean skin body temperature was significantly higher in the isothermic group than the hypothermic group, no significant difference was observed in core body temperature and blood arterial pH, arterial carbon dioxide pressure, arterial oxygen pressure, and bicarbonate values.

Conclusion: Warming insufflated carbon dioxide in laparoscopy does not affect blood gases.

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Laparoscopic cholecystectomy has many advantages over open cholecystectomy, including less discomfort to the patient, decreased duration of hospitalization, minimal wound problems, cosmetic advantages, less postoperative pulmonary complications, and shorter full recovery time after surgery.[1-3] Nowadays, carbon dioxide (CO_2), with its high blood and tissue solubility, is used to create pneumoperitoneum (Pp) during laparoscopic cholecystectomy (LC). The CO_2 at 21^{o}C is routinely used to create Pp. There are investigators who argue that complications occur secondary to hypothermia caused by CO_2 at this temperature, and they suggest that CO_2 be heated up to 37^{o}C to prevent such complications. Other investigators, however, report that hypothermia induced by CO_2 at 21^{o}C during Pp has no clinical significance.[4-7] The aim of the present study is to explore and compare the effects of capnoperitoneum at 21^{o}C and 37^{o}C on blood gases.

Methods. Between 2004 and 2006, 62 patients were classified as ASA (American Society of Anesthesiologists) grade I, II and III,[6] and an elective LC was planned. Patients were randomly assigned to one of the 2 groups consisting of 31 subjects each. The first group (hypothermic group) had Pp using CO_2 at 21^{o}C. The second group (isothermic group) received CO_2 insufflation heated to 37^{o}C (H-500 Fluid Warmer, Level 1 Technologies, Inc., Rockland, MA, USA). An approval from the Ethics Board of Harran University Faculty of Medicine and informed written consent from the patients was obtained before the commencement of the study. Patients were excluded from the study if they had a history of obstructive jaundice, carcinoma of the gall bladder, bronchial asthma, chronic obstructive pulmonary disease, diabetes, hypertension, abnormal findings on chest radiographs or hematological analyses, abnormal findings during chest examination, respiratory distress, and a body mass index of 30 kg/m^2 and over.

Patients included in the study underwent ECG, chest x-ray, blood chemistry (glucose, urea, creatinine,

aspartate aminotransferase, alanine aminotransferase, total bilirubin, sodium, potassium, and chloride), hemoglobin, hematocrit, platelet, prothrombin time, bleeding time, and coagulation time before the operation.

The patients were premedicated with midazolam 0.1 mg per os approximately 40 minutes before starting the preoperative data collection. Anesthesia was induced with remifentanil 1 μg kg^{-1}, propofol 2 mg kg^{-1} and vecuronium 0.1 mg kg- intravenous, were used to facilitate endotracheal intubation. Anesthesia maintenance after intubation was performed with desflurane 5-8%, air 3 L/minute, oxygen 2 L/minute, and remifentanil 0.25 μg/kg/minute. Core body temperature, skin temperature, heart beat, systolic arterial pressure, diastolic arterial pressure, and end tidal CO_2 ($ETCO_2$) were measured at 10 minute intervals beginning just before insufflation and during pneumoperitoneum non invasive method by Datex-Ohmeda Type F-CU8-21-05, Finland. The left radial artery was annulated. Blood arterial pH, arterial carbon dioxide pressure, and arterial oxygen pressure were measured just before insufflation, at 30 minutes of pneumoperitoneum, and 30 minutes after desufflation.

The Statistical Package for Social Sciences (SPSS Inc, Chicago, Illinois, USA) was used for statistical analyses. Two-way analysis of variance and paired t-test were used for within-group comparisons. The Analysis of Variance and independent samples t-test were used to assess inter-group differences. A *p*-value less than 0.05 was considered significant.

Results. Age, gender, and duration of operation of the groups are shown in **Table 1**. According to these findings, there were no significant differences between the groups ($p>0.05$). The rates of heartbeat in both groups are seen in **Table 2**. The smallest value in heart rate that showed a tendency to decrease continuously throughout the operation in both groups was measured during desufflation. There was no significant statistical difference between groups according to heart rates ($p>0.05$). The mean arterial pressure values are seen in **Table 3**, and these values increased following Pp induction in both groups compared to pre-operative values. However, there was no significant difference between groups according to mean arterial pressures ($p>0.05$). The $ETCO_2$ values of both groups can be seen in **Table 5**. The $ETCO_2$ values with no significant difference pre-operatively, showed a decrease throughout the procedure, however, it was not significant ($p>0.05$). While pH values changed with time when compared in each group, the difference was not statistically significant

Table 1 - Demographic features of the patients and the duration of their operations.

Parameter	Group 1 (n=31) mean±sd	Group 2 (n=31) mean±sd
Age (years)	39 ± 7	41 ± 5
Sex (females/males)	23 / 8	26 / 5
Body weight (kg)	67 ± 3	64 ± 2
Duration of operations (min)	45 ± 4	48 ± 8

Table 2 - The rates of heart beat of the patients (KAH).

KAH	Group 1	Group 2
Induction	82 ± 11.1	83 ± 9.3
Insufflation	80 ± 10	80 ± 11.4
10 min	79 ± 11.4	80 ± 10.9
20 min	78 ± 10.5	78 ± 12.7
30 min	77 ± 11.2	76 ± 11.4
Desufflation	76 ± 11.7	75 ± 10.3

Table 3 - Mean arterial pressure values (OAB) of both groups.

OAB	Group 1	Group 2
Induction	89 ± 16	86 ± 2
Insufflation	88 ± 11	97 ± 12
10 min	95 ± 10	99 ± 20
20 min	96 ± 15	100 ± 13
30 min	97 ± 16	102 ± 18
Desufflation	98 ± 12	104 ± 14

Table 4 - End tidal carbon dioxide ($ETCO_2$) values of both groups.

$ETCO_2$	Group 1	Group 2
Induction	28 ± 4.90	26 ± 4.75
Insufflation	28 ± 4.90	28 ± 5.85
10 min	28 ± 4.85	27 ± 5.75
20 min	26 ± 4.65	27 ± 5.50
30 min	27 ± 4.30	27 ± 6.45
Desufflation	27 ± 4.20	27 ± 5.55

Table 5 - The pH values of both groups.

Time	pH		PCO_2		HCO_3		PO_2	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Before I	7.44 ± 0.05	7.4 ± 0.04	36 ± 5	37.4 ± 5.5	23.3 ± 2.4	23.3 ± 1	86 ± 14	94 ± 12
After I 30	7.35 ± 0.04	7.34 ± 0.06	41 ± 6	45 ± 9	23 ± 2.5	23.8 ± 1.5	115 ± 13	123 ± 11
After D 30	7.33 ± 0.04	7.29 ± 0.06	40 ± 9	50.6 ± 9.5	22.1± 9.0	23.1 ± 1	86 ± 18	81 ± 18

Group 1 - hypothermic, Group 2 - isothermic, I - insufflation, D - desufflation,
PCO_2 - phosphate, HCO_3, - bicarbonate PO_2 - partial pressure of carbon dioxide

in either group (p>0.05). No significant difference was observed when comparing pH values between groups (p>0.05). Likewise, there was no significant difference between groups when comparing the phosphate (PO_2), partial pressure of carbon dioxide (PCO_2), and bicarbonate (HCO_3) values (p>0.05 for all).

Discussion. Laparoscopic cholecystectomy is performed as a standard method in symptomatic gallbladder stones owing to advantages like less surgical trauma, shorter hospital stay, and cost effectiveness.[8,9] Carbon dioxide insufflation (hypothermic, 21^{0}C), routinely used to create pneumoperitoneum, is reported to cause various complications such as cardiac arrhythmia, depressed respiratory functions, decreased arterial blood gases, coagulation disorders, and post-operative pain.[10-12] Although these complications are reported to be overcome with warmed CO_2 insufflation (isothermic, 37^{0}C), the mechanism is yet unclear.[13-18] There are studies that have reported the occurrence of hypercarbia and acidosis by increasing the heat of CO_2 by 15^{0}C, insufflated into the peritoneum under 12-14 mm Hg of pressure. The mechanisms of an increase in $PaCO_2$ during laparoscopy practices are controversial. There are studies demonstrating that $PaCO_2$ is affected by features such as absorption of insufflated CO_2 by surrounding tissues, negative effects of intraabdominal pressure on the respiratory system, patient position, controlled ventilation, technique of anesthesia, obesity, and accompanying diseases.[12,19,20] Diffusion of intra-abdominal insufflated gases increases by warming. Therefore, since the diffusion of warmed CO_2 gas increases, pH levels will decrease. However, our study did not show confirm these results when CO_2 gas was warmed. This result suggests that warmed CO_2 gas does not readily pass into the blood at a level of being able to affect the laboratory results, or even if it passes into blood at this level, it is immediately buffered by buffer systems. It is reported that hypercarbia and the decrease in pH that occurs during insufflation, recover following desufflation, however, except for open cholecystectomy (OC) patients, these may recur in LC patients in the recovery room due to CO_2 absorption from the tissues and early diaphragm dysfunction.[14,21,22] In our study, when PaO_2 and $PaCO_2$ levels of both groups were compared, O_2 and CO_2 levels increased with time and reached the maximum in 30 minutes following insufflation and then decreased. When PaO_2 and $PaCO_2$ levels were compared between groups, there was no significant difference in the 3 time periods. In the isothermic group, the high PaO_2 and $PaCO_2$ levels in both groups, which mostly occurred at 30 minutes following insufflation suggested that diffusion was at a maximum, and that warmed CO_2 contributed to this. In the study of Vatansev et al,[23] cholecystectomies by laparoscopy, and mini-laparotomy were investigated for their effects on blood gases; as a result, it was reported that $PaCO_2$ increased significantly in the laparoscopy group, O_2 saturations were significantly low, and that respiratory functions were affected to a lower extent than in the mini-laparotomy group in the postoperative period. Some studies in the literature demonstrate that when CO_2 is used, besides the decrease in pH, $PaCO_2$ increased, HCO_3 levels showed no meaningful difference, and that this was a respiratory problem brought about by CO_2.[10,22-24] In our study, when pH values of both groups were compared, an important decrease was observed. However, this was not statistically significant. Comparison between groups revealed no significant difference in all 3 periods. We found no study on blood gases in hypothermic and isothermic pneumoperitoneum in the literature. However, in studies comparing open and laparoscopic cholecystectomy, $PaCO_2$ values increased compared to pre-operative values and a tendency towards acidosis emerged. This tendency is thought to be consequent to diffusion of insufflated CO_2.[10-12]

In conclusion, findings of the present study suggest that warming insufflated carbon dioxide in laparoscopy does not affect blood gases.

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