

Effect of Different Carbon Dioxide Pressure Gradients in Capnoperitoneum for Laparoscopic Examination in Dogs

Swapan Kumar Maiti, Avijit Dutta, Jagadish Varshney, Naveen Kumar

ABSTRACT

Eighteen female mongrel bitches, equally divided into three groups (A, B and C) were subjected to CO₂ insufflation at 6, 10 and 14 mm Hg pressure gradient respectively to study the physiological changes of capnoperitoneum during laparoscopy. Optimum visualization of internal organs during laparoscopy was achieved at 10 and 14 mm Hg of CO₂ pressure gradient. The physiological effects were more pronounced at 14 mm Hg of CO₂ pressure gradient. Marked increase of respiration rate in correlation with increased pCO₂ and decreased pO₂ was observed in the group C. Bradyarrhythmia was observed in all three groups, however, myocardial ischemia or hypoxia as reflected through S-T segment depression and elevation was more pronounced in 14 mm Hg of CO₂ pressure gradient (group C). Alteration of liver function was within the physiological range in the animals of all the three groups. Physiological stress was remained significantly higher with 14 mm Hg intra-abdominal pressure. In conclusion, 10 mm Hg of CO₂ was found most suitable pressure gradient for laparoscopic examination in dogs.

Keywords: Capnoperitoneum, Dog, Intra-abdominal pressure, Electrocardiography, Laparoscopic surgery.

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INTRODUCTION

Laparoscopy is now considered as one of the most potent and promising aids for both its diagnostic and therapeutic use. It involves minimal invasiveness (keyhole surgery) with maximum visibility, shorter surgical time, decreased postoperative discomfort and pain, less incidence of infection, uncomplicated healing with minimal scarring, and minimal surgical morbidity.^{1,2} Laparoscopy is now emerging as a diagnostic and therapeutic tool in the medical field.³

Laparoscopic examination requires the separation of structures from the abdominal wall. Insufflations of the abdomen with most suitable gas CO₂ optimally separates the intra-abdominal organs from ventral and lateral walls.⁴ In response to CO₂ capnoperitoneum (CP) there are series of physiologic responses that have an impact on cardio-pulmonary function of animal. These responses include the hemodynamic changes related to mechanical and neuroendocrine effects of CP and effects of absorbed CO₂ on cardiovascular and respiratory function.⁵ Routine

electrocardiogram is therefore a very useful mean for continuous assessment of patient's condition during laparoscopy. In addition, blood gas analysis has been proved very useful to evaluate the effect of CP.⁶ Increased intra-abdominal pressure affects various intra-abdominal organs and is linearly regulated by its level and durations. Alteration of hepatic function has been reported following laparoscope surgery.¹

So far, very little works has been carried out on CP pressure gradient to establish a most suitable one for canine species with having minimum adverse effects. Therefore, the present study was undertaken to evaluate the physiological effect of CP using different CO₂ pressure gradients and to find a most suitable one for routine laparoscopic examination and surgery in canines.

MATERIALS AND METHODS

The study was conducted on 18 clinically healthy adult female mongrel dogs with body weights of 15 to 20 kg and aged 16 to 22 months. The animals were randomly divided into three equal groups (A, B and C) consisting of six animals each. Different CO₂ pressure gradients were used to produce CP for laparoscopic visualization of different intra-abdominal organs in these three groups of animals. In group A, CO₂ pressure gradient was 6 mm Hg, whereas, in groups B and C it was 10 and 14 mm Hg respectively. After administration of general anesthesia, the animals were placed in dorsal recumbency and then in the Trendelenburg position for laparoscopic visualization of different intraperitoneal organs.

A small 0.5 cm skin incision was made at the level of the umbilicus and a Veres needle was inserted. Insufflation of the abdominal cavity was achieved with carbon dioxide gas at the rate of 2 L/min with a pressure gradient of 6, 10 and 14 mm Hg in groups A, B and C respectively. A 6 mm safety trocar and cannula unit was inserted into the abdominal cavity. A rigid-type telescope connected to a light source and a digital camera was then introduced through the cannula. The intra-abdominal organs were visualized thoroughly. After completing the laparoscopic examination, CO₂ gas was allowed to escape through the cannula. The incisions were sutured with simple interrupted sutures. Antiseptic dressing was applied regularly for 3 days post-

surgery. The animals were evaluated on the basis following observations.

- *Intraoperative and postoperative observations:* Visualization of different peritoneal organs namely liver, spleen, urinary bladder, uterus, ovary, pancreas, gall bladder, stomach and intestine were assessed on the basis of scoring for each organ as: 0-no visualization of an organ; 1-difficult visualization of an organ; 2-moderate visualization of an organ and 3-optimum visualization of an organ.
- *Clinical observations:* The heart rate (beats/min), respiratory rate (breaths/min), and rectal temperature (°F) were recorded before and after anesthesia, 30, 60 and 120 minutes after establishment of CP and 24 hours postlaparoscopy.
- *Electrocardiographic observations:* A lead II ECG was recorded at 1 mV and 25 mm/s paper speed before and after anesthesia, 30, 60 and 120 minutes after establishment of CP and 24 hours after laparoscopy. The ECG was analyzed for heart rate, duration and amplitude of P-wave, QRS complex, T-wave and RR, P-R, S-T and Q-T intervals.
- *Hematological and biochemical observations:* Heparinized blood was collected before and after anesthesia, 30, 60 and 120 minutes after establishment of CP and 24 hours postlaparoscopy for estimation of packed cell volume (PCV), hemoglobin (Hb), total leukocyte count (TLC), differential leukocyte count (DLC), aspartate aminotransferase (AST), alanine aminotransferase (ALT), creatinine, blood urea nitrogen and uric acid using standard procedures.
- *Acid-base observations:* Different acid-base parameters like pH, partial pressure of oxygen (pO₂), partial pressure of carbon dioxide (pCO₂), sodium, potassium, chloride and base excess were estimated by using 0.5 ml an aerobically collected heparinized venous blood in blood gas analyzer.
- *Hormonal observations:* The plasma samples were used to estimate the cortisol by radioimmunoassay assay using RIA kit.
- *Statistical analysis:* The data were subjected to two-way analysis of variance (ANOVA) and the paired t-test, as per standard statistical methods.

RESULTS

Intraoperative and Postoperative Observations

The surgical phase of anesthesia in all the animals of different groups was achieved by administering xylazine and ketamine in combination. No additional anesthesia was required in any animal to complete the intraoperative

procedure. The postsurgical recovery from anesthesia in all of the animals of three groups was smooth and uneventful.

Establishment CP in each animal was easy and safe. Insufflation of the abdominal cavity with CO₂ gas at the flow rate of 2 L/min was found sufficient for establishment of CP within 1 to 2 minutes in all of the animals of three groups. All animals were closely monitored for their respiration and capillary perfusion. Each animal tolerated well during insufflation even at Trendelenburg position. Insufflation by CO₂ at 6, 10 and 14 mm Hg was maintained for 30 minutes in each animal of groups A, B and C respectively. During this period complication like emphysema or respiratory distress was not noticed in any animal.

The urinary bladder was visualized first by its characteristic tortuous structures of blood vessels. Uterine body was visualized next and it depended on the distension of the urinary bladder. The uterus and ovarian structure were thoroughly visualized with their characteristic ivory-colored, cord-like structure. Both the kidneys were identified by the presence of perirenal fat at the corresponding level of last costochondral junction (Fig. 1). Spleen was visualized in the upper left abdominal quadrant, cranial to the left kidney. It was tongue shaped and in close exposure its diaphragmatic surface was converse and cobbled. In the upper right abdominal quadrant, liver was identified by its bright red color and uniform smooth surfaces. Gallbladder was visualized in between right medial and right lateral lobes and appeared as distended, round and whitish to bluish in color (Fig. 1). The empty stomach appeared as dense, pale-red in color and was situated toward the mid-abdominal plane. Visualization of pancreas was found most difficult in this study. In contrary, intestine was visualized very easily and appeared as loop like structures (Fig.1) Different abdominal organs were evaluated in respect of their visualization pattern during laparoscopy in three groups. Observations were recorded on the basis of numerical score from '0' to '3' depending on the degree of visualization (Table 1). No differences in scores have been observed in groups B and C, but they significantly ($p < 0.05$) differed from group A.

Normal appetite returned within 2 to 4 hours after surgical intervention in all animals. No postoperative complications like emphysema, portal herniation, peritonitis, ascites, or stitch abscess were recorded in any animals of the three groups.

Clinical Observations

The respiration rate (breaths/min), heart rate (beats/min), and rectal temperature (°F) recorded in all of the animals of three groups are presented in Table 2. Respiration rate decreased significantly ($p < 0.05$) in all the animals of three groups after anesthesia. However, in group C, it was

significantly ($p < 0.05$) increased at 60 minutes interval after CP. Heart rate (beats/min) decreased nonsignificantly ($p > 0.05$) immediately after anesthesia and at 30, 60 and 120 minutes after CP in all of the animals of the three groups. However, it again nonsignificantly ($p > 0.05$) increased at 24 hours postlaparoscopy in all the three groups. This fluctuation in heart rate was more pronounced in the animals of group C than it was in groups A and B. Preoperative as well as postoperative mean rectal temperatures ($^{\circ}\text{F}$) recorded

in all three groups remained within the normal limits throughout the observation period.

Electrocardiographic Indices

The mean amplitude and duration of P-wave in all the animals of three groups did not differ significantly (Table 3). Wandering pacemaker was evident in three animals of groups A and B and one animal of group C after CP (Fig. 2). One animal of group C showed occasional

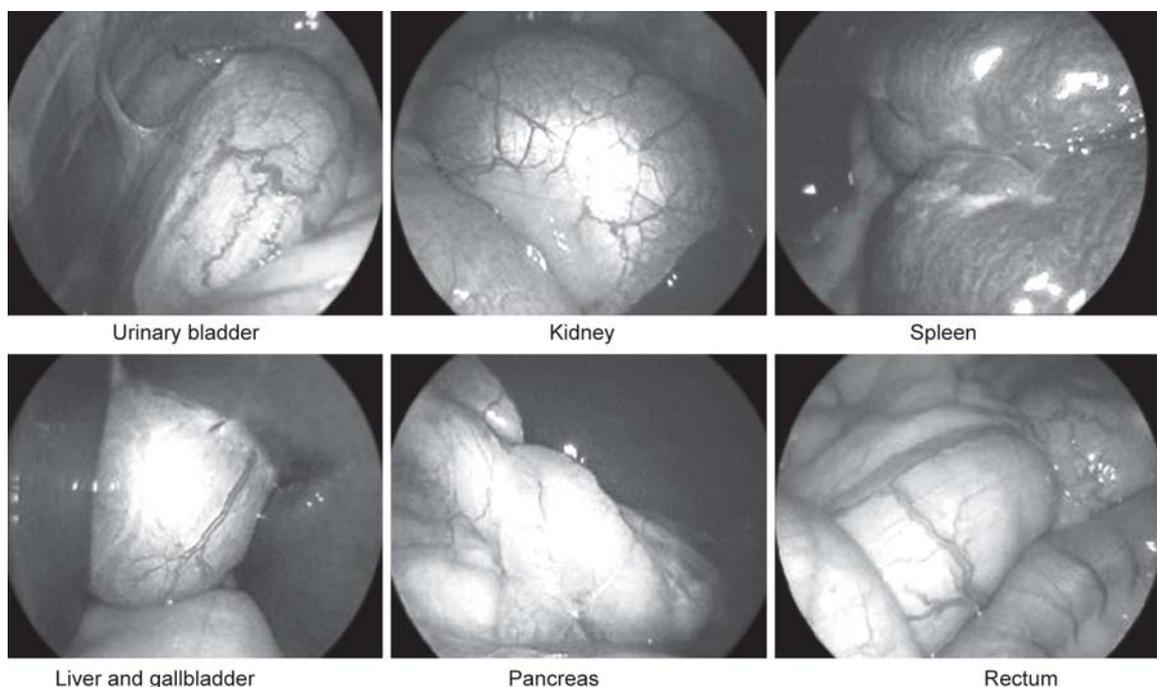


Fig. 1: Laparoscopic visualization of different intra-abdominal organs at 10 mm Hg of CO_2 pressure gradient

Table 1: Mean \pm SE of visualization score of internal organs during laparoscopy in animals of different groups

Groups	Liver	Spleen	Gallbladder	Pancreas	Intestine	Kidney	Ovary	Uterus
A	2.33 \pm 0.21	2.16 \pm 0.16	2.50 \pm 0.22	0.33 \pm 0.21	2.50 \pm 0.22	1.50 \pm 0.22	2.16 \pm 0.16	1.83 \pm 0.16
B	2.66 \pm 0.21	2.66 \pm 0.24	3.00 \pm 0.00	2.50 \pm 0.22	3.00 \pm 0.00	2.66 \pm 0.21	3.00 \pm 0.00	2.66 \pm 0.21
C	3.00 \pm 0.00	3.00 \pm 0.05	3.00 \pm 0.00	2.50 \pm 0.02	2.83 \pm 0.30	3.00 \pm 0.00	3.00 \pm 0.04	3.00 \pm 0.00

Table 2: Mean \pm SE value of respiration rate, heart rate and rectal temperature recorded at different time intervals

Groups	Before anesthesia	After anesthesia	Time intervals after establishment of capnoperitoneum			
			30 mins	60 mins	120 mins	24 hrs
<i>Respiration rate (beats/min)</i>						
A	26.83 \pm 1.13	20.16 \pm 0.98	28.16 \pm 1.11	28.66 \pm 1.33	26.16 \pm 0.74	28.66 \pm 1.08
B	29.16 \pm 1.01	23.00 \pm 1.39	29.66 \pm 1.52	30.16 \pm 1.93	28.66 \pm 1.56	28.86 \pm 0.84
C	28.50 \pm 0.92	23.50 \pm 1.05	31.83 \pm 1.60	32.8 \pm 1.07	30.16 \pm 1.37	30.33 \pm 0.88
<i>Heart rate (beats/min)</i>						
A	137.52 \pm 20.15	136.25 \pm 23.57	104.25 \pm 17.97	93.25 \pm 14.10	98.00 \pm 18.92	132.50 \pm 7.88
B	126.50 \pm 9.91	107.00 \pm 22.69	94.00 \pm 5.47	86.00 \pm 10.29	85.50 \pm 5.12	115.00 \pm 12.12
C	139.50 \pm 16.50	105.00 \pm 22.78	97.00 \pm 13.3	106.50 \pm 19.81	145.75 \pm 29.85	134.50 \pm 9.68
<i>Rectal temperature (F)</i>						
A	100.85 \pm 0.33	100.98 \pm 0.48	101.05 \pm 0.55	101.11 \pm 0.25	101.21 \pm 0.43	101.33 \pm 0.29
B	100.45 \pm 0.32	100.36 \pm 0.44	100.45 \pm 0.38	100.41 \pm 0.39	100.56 \pm 0.36	100.83 \pm 0.27
C	100.63 \pm 0.50	100.71 \pm 0.38	100.23 \pm 0.21	100.63 \pm 0.23	101.15 \pm 0.44	101.28 \pm 0.26

atrial premature complex after anesthesia and at 60 minutes post-CP (Fig. 2). Intermittent sinus arrest was also evident in one animal of group C after anesthesia (Fig. 2). The preanesthetic amplitude and duration of QRS complex and T-wave in all the animals of three groups also did not differ significantly (Tables 4 and 5). Changes of T-wave amplitude and duration were more marked in group C than groups A and B. After establishment of CP, characteristics T-wave were observed in the animals of different groups at different time intervals. In group A, T-wave became biphasic at 30 minutes (two animals), 60 minutes (three animals), 120 minutes (two animals) and 24 hours (one animal) (Fig. 2). In addition to biphasic, characteristic T-wave alternans was also observed in one animal of group A at 30- and 60-minute post-CP. In group C, two animals showed biphasic T-wave at 60 and 120 minutes post-CP. The initial mean duration of RR interval did not differ significantly in all of the animals of the different groups (Table 6). The initial mean duration of PR interval, ST interval and QT intervals were almost same in all of the animals of three different groups. The ST elevation (one

animal of group A at 60 minutes) and ST depression (one animal of group C at 30 and 60 minutes) were also recorded after establishment of CP (Fig. 2).

Hematological Observations

Mean \pm SE of PCV, Hb and TLC are presented in Table 7. Preanesthetic values of PCV and Hb in all of the animals of the three different groups were within the normal limit. No significant change was observed when comparisons were made between the groups at different time intervals. No significant leukocytosis or leukopenia was observed in any animal of the three groups before and after anesthesia, rather they were within the normal limit (Table 7). DLC of the animals of three different groups at different intervals did not reveal any significant differences. Only a mild neutrophilia and comparative lymphopenia were evident in groups B and C at 120 minutes post-CP.

Acid-base Analyses

Mean \pm SE values of pH in different groups are presented in Figure 3. No significant ($p > 0.05$) difference of pH value

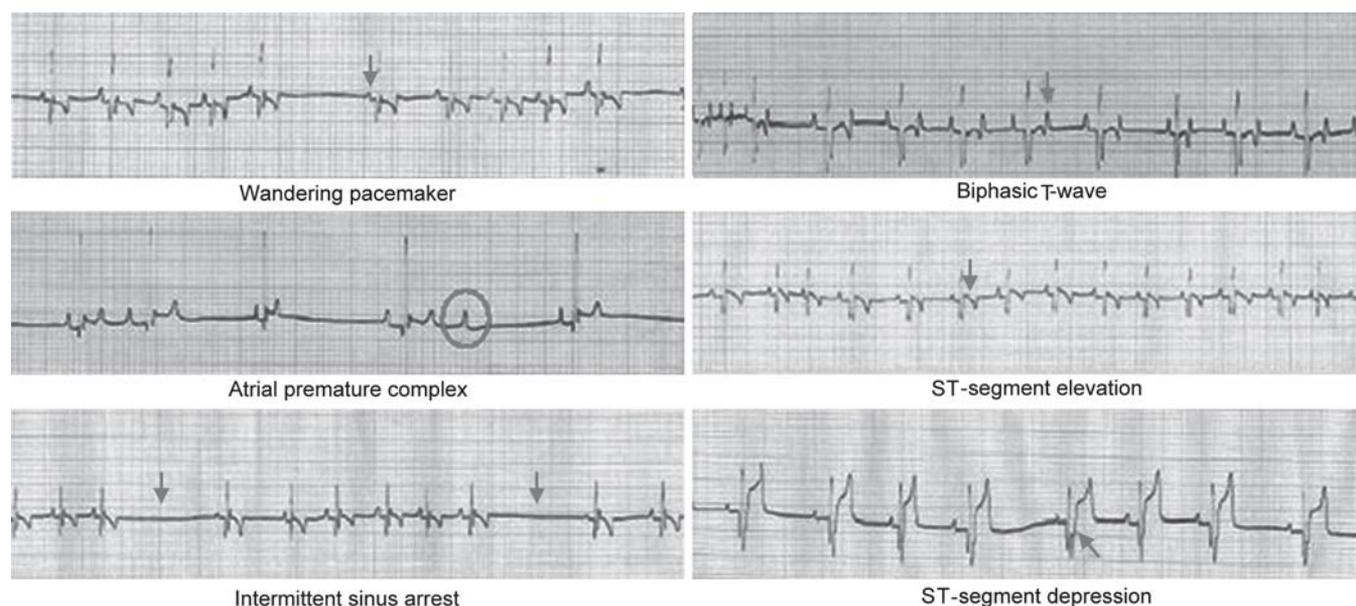


Fig. 2: Characteristic electrocardiograms in the animals of three different groups

Table 3: Mean \pm SE of P-wave (amplitude and duration) recorded at different time intervals

Groups	Before anesthesia	After anesthesia	Time intervals after establishment of capnoperitoneum			
			30 mins	60 mins	120 mins	24 hrs
Amplitude (mV)						
A	0.150 \pm 0.035	0.137 \pm 0.023	0.143 \pm 0.021	0.115 \pm 0.016	0.137 \pm 0.023	0.150 \pm 0.020
B	0.163 \pm 0.031	0.103 \pm 0.039	0.169 \pm 0.037	0.163 \pm 0.023	0.175 \pm 0.032	0.163 \pm 0.024
C	0.206 \pm 0.016	0.163 \pm 0.024	0.175 \pm 0.014	0.163 \pm 0.012	0.206 \pm 0.026	0.175 \pm 0.014
Duration (seconds)						
A	0.032 \pm 0.004	0.035 \pm 0.002	0.037 \pm 0.002	0.032 \pm 0.004	0.032 \pm 0.002	0.035 \pm 0.002
B	0.040 \pm 0.000	0.042 \pm 0.000	0.038 \pm 0.003	0.040 \pm 0.000	0.044 \pm 0.000	0.035 \pm 0.003
C	0.038 \pm 0.003	0.033 \pm 0.005	0.035 \pm 0.003	0.040 \pm 0.000	0.038 \pm 0.003	0.035 \pm 0.003

was recorded in any group at any time interval. Mean \pm SE values of partial pressure of carbon dioxide ($p\text{CO}_2$) in the animals of different groups are presented in Figure 4. Comparison among three groups revealed no significant variation among the mean values, in respect to different time intervals. Mean \pm SE values of partial pressure of oxygen ($p\text{O}_2$) in the animals of different groups are presented in Figure 5. In all the animals of the three groups a nonsignificant ($p > 0.05$) decrease of $p\text{O}_2$ were recorded

at 30 minutes after CP and it continued up to 120 minutes. Mean \pm SE values of base excess (BE-B) in the animals of three groups are presented in Table 8. No significant ($p > 0.05$) changes were observed at any time interval within a group or between the groups. Mean \pm SE values of sodium, potassium and chloride in animals of three groups are presented in Table 9. No significant ($p > 0.05$) changes were observed at any time interval within a group or between the groups.

Table 4: Mean \pm SE of QRS complex (amplitude and duration) recorded at different time intervals

Groups	Before anesthesia	After anesthesia	Time intervals after establishment of capnoperitoneum			
			30 mins	60 mins	120 mins	24 hrs
<i>Amplitude (mV)</i>						
A	0.975 \pm 0.189	1.112 \pm 0.198	1.087 \pm 0.25	1.025 \pm 0.221	1.075 \pm 0.221	1.025 \pm 0.193
B	1.075 \pm 0.048	1.275 \pm 0.048	1.313 \pm 0.148	1.225 \pm 0.184	1.325 \pm 0.103	0.887 \pm 0.174
C	0.900 \pm 0.141	0.988 \pm 0.238	0.975 \pm 0.149	0.901 \pm 0.119	0.850 \pm 0.137	0.925 \pm 0.165
<i>Duration (seconds)</i>						
A	0.042 \pm 0.006	0.040 \pm 0.004	0.045 \pm 0.005	0.045 \pm 0.006	0.040 \pm 0.004	0.042 \pm 0.006
B	0.048 \pm 0.005	0.043 \pm 0.005	0.053 \pm 0.003	0.043 \pm 0.003	0.045 \pm 0.003	0.0043 \pm 0.005
C	0.050 \pm 0.005	0.052 \pm 0.002	0.055 \pm 0.006	0.052 \pm 0.006	0.048 \pm 0.002	0.048 \pm 0.004

Table 5: Mean \pm SE of T-wave (amplitude and duration) recorded at different time intervals

Groups	Before anesthesia	After anesthesia	Time intervals after establishment of capnoperitoneum			
			30 mins	60 mins	120 mins	24 hrs
<i>Amplitude (mV)</i>						
A	0.231 \pm 0.034	0.268 \pm 0.101	0.212 \pm 0.051	0.262 \pm 0.055	0.162 \pm 0.037	0.225 \pm 0.032
B	0.138 \pm 0.038	0.388 \pm 0.065	0.350 \pm 0.106	0.275 \pm 0.032	0.288 \pm 0.075	0.363 \pm 0.103
C	0.150 \pm 0.029	0.225 \pm 0.014	0.387 \pm 0.208	0.512 \pm 0.231	0.225 \pm 0.043	0.175 \pm 0.025
<i>Duration (seconds)</i>						
A	0.045 \pm 0.002	0.070 \pm 0.010	0.057 \pm 0.010	0.070 \pm 0.017	0.045 \pm 0.012	0.060 \pm 0.000
B	0.045 \pm 0.005	0.065 \pm 0.009	0.077 \pm 0.023	0.075 \pm 0.035	0.073 \pm 0.018	0.050 \pm 0.009
C	0.057 \pm 0.010	0.055 \pm 0.013	0.075 \pm 0.042	0.075 \pm 0.022	0.045 \pm 0.008	0.058 \pm 0.010

Table 6: Mean \pm SE of different intervals (seconds) on electrocardiograph recorded at different time intervals

Groups	Before anesthesia	After anesthesia	Time intervals after establishment of capnoperitoneum			
			30 mins	60 mins	120 mins	24 hrs
<i>RR interval</i>						
A	0.480 \pm 0.120	0.670 \pm 0.174	0.735 \pm 0.152	0.745 \pm 0.085	0.756 \pm 0.144	0.430 \pm 0.099
B	0.525 \pm 0.075	0.568 \pm 0.148	0.639 \pm 0.042	0.763 \pm 0.106	0.854 \pm 0.054	0.545 \pm 0.069
C	0.485 \pm 0.100	0.715 \pm 0.098	0.746 \pm 0.068	0.488 \pm 0.184	0.512 \pm 0.106	0.490 \pm 0.070
<i>PR interval</i>						
A	0.090 \pm 0.005	0.127 \pm 0.013	0.110 \pm 0.012	0.085 \pm 0.005	0.097 \pm 0.014	0.090 \pm 0.005
B	0.095 \pm 0.006	0.105 \pm 0.006	0.105 \pm 0.009	0.098 \pm 0.008	0.103 \pm 0.006	0.078 \pm 0.006
C	0.085 \pm 0.011	0.100 \pm 0.015	0.113 \pm 0.017	0.100 \pm 0.014	0.085 \pm 0.006	0.108 \pm 0.015
<i>ST interval</i>						
A	0.052 \pm 0.007	0.045 \pm 0.013	0.080 \pm 0.023	0.080 \pm 0.016	0.063 \pm 0.01	0.050 \pm 0.012
B	0.065 \pm 0.009	0.063 \pm 0.008	0.075 \pm 0.022	0.070 \pm 0.024	0.100 \pm 0.02	0.070 \pm 0.006
C	0.040 \pm 0.014	0.055 \pm 0.015	0.059 \pm 0.019	0.052 \pm 0.017	0.053 \pm 0.011	0.040 \pm 0.008
<i>QT interval</i>						
A	0.165 \pm 0.017	0.185 \pm 0.005	0.245 \pm 0.059	0.205 \pm 0.013	0.178 \pm 0.006	0.185 \pm 0.009
B	0.180 \pm 0.016	0.200 \pm 0.016	0.233 \pm 0.024	0.218 \pm 0.024	0.240 \pm 0.022	0.170 \pm 0.007
C	0.162 \pm 0.016	0.190 \pm 0.023	0.212 \pm 0.024	0.227 \pm 0.016	0.165 \pm 0.003	0.175 \pm 0.017

Biochemical Observations

Mean \pm SE values of AST and ALT in the animals of three groups are presented in Figures 6 and 7 respectively. AST and ALT values were within the normal range in all of the animals of three different groups throughout the observation period. Comparison among three groups revealed no significant ($p > 0.05$) changes at any time interval. Mean \pm SE values of creatinine, blood urea nitrogen and uric acid in animals of three groups are presented in Table 10. The creatinine, BUN and uric acid values in all three groups were within the normal range throughout the observation period.

Hormonal Estimation

Mean \pm SE of cortisol values recorded in animals of three different groups are presented in Figure 8. Cortisol values

in all of the animals of three groups started to increase at 30 minutes after CP and reached to peak at 120 minutes after CP, which were significantly ($p < 0.01$) higher than the base value of the respective group.

DISCUSSION

General anesthesia was achieved by inducing xylazine and ketamine combination with premedication by atropine sulphate was found sufficient to establish CP and laparoscopy in the animals of three different groups. Induction as well as recovery from general anesthesia was smooth and uneventful in all of the animals, as was also reported by Wildt and associates in 1977.¹

The establishment of CP in the animals of all three groups was easy through Verrees needle at preselected

Table 7: Mean \pm SE of PCV, Hb and TLC recorded at different time intervals

Groups	Before anesthesia	After anesthesia	Time intervals after establishment of capnoperitoneum			
			30 mins	60 mins	120 mins	24 hrs
<i>PCV (L/l)</i>						
A	0.41 \pm 0.02	0.38 \pm 0.01	0.38 \pm 0.01	0.40 \pm 0.01	0.39 \pm 0.01	0.39 \pm 0.01
B	0.41 \pm 0.01	0.41 \pm 0.01	0.40 \pm 0.01	0.41 \pm 0.01	0.41 \pm 0.01	0.43 \pm 0.01
C	0.43 \pm 0.01	0.41 \pm 0.02	0.40 \pm 0.02	0.40 \pm 0.01	0.41 \pm 0.01	0.41 \pm 0.01
<i>Hb (g/l)</i>						
A	139.83 \pm 7.42	132.33 \pm 5.16	131.33 \pm 5.37	135.50 \pm 5.27	134.00 \pm 5.42	138.83 \pm 7.38
B	136.16 \pm 4.50	133.00 \pm 4.36	131.66 \pm 4.48	132.66 \pm 4.77	134.83 \pm 4.36	137.32 \pm 6.44
C	142.33 \pm 6.23	135.83 \pm 7.00	134.83 \pm 7.55	135.50 \pm 5.39	134.66 \pm 5.48	137.33 \pm 5.50
<i>TLC ($10^9/l$)</i>						
A	8.93 \pm 0.69	9.14 \pm 0.75	9.18 \pm 0.78	9.85 \pm 0.79	9.98 \pm 0.74	9.96 \pm 0.70
B	9.41 \pm 1.19	9.30 \pm 1.15	9.74 \pm 1.17	10.07 \pm 1.36	11.56 \pm 1.22	9.83 \pm 1.21
C	9.13 \pm 1.10	9.36 \pm 1.21	9.93 \pm 1.22	11.10 \pm 1.26	12.07 \pm 1.41	9.58 \pm 1.14

Table 8: Mean \pm SE of base excess of blood (mmol/l) recorded at different time intervals

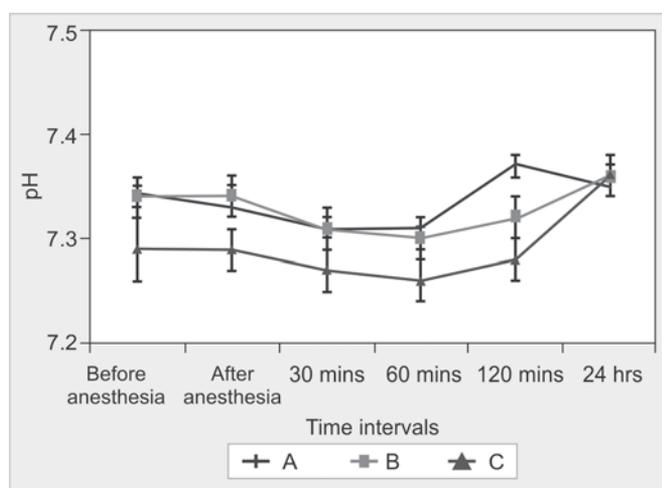
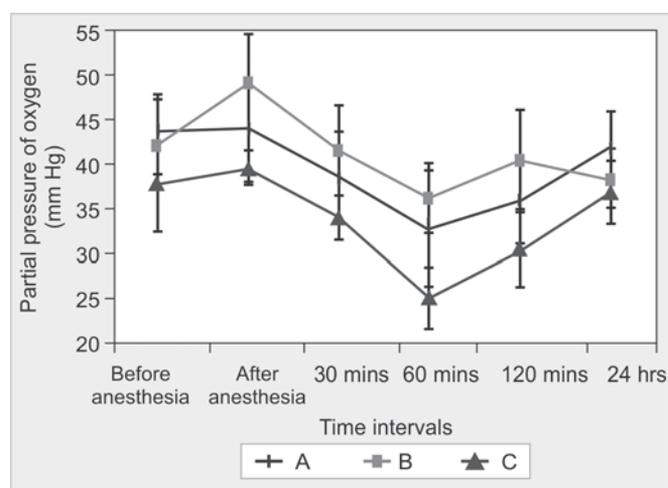
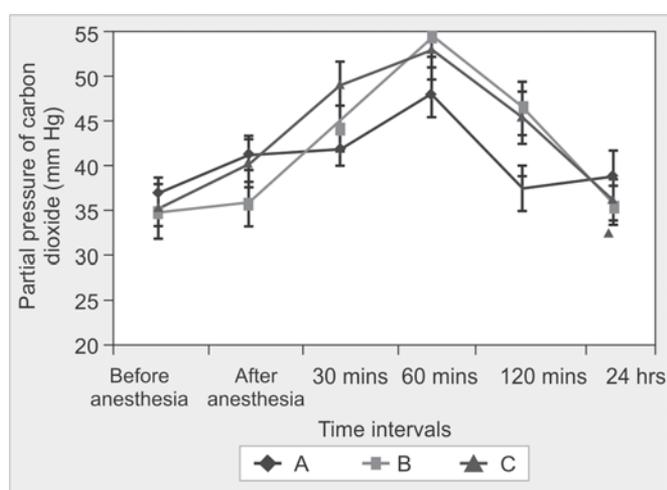
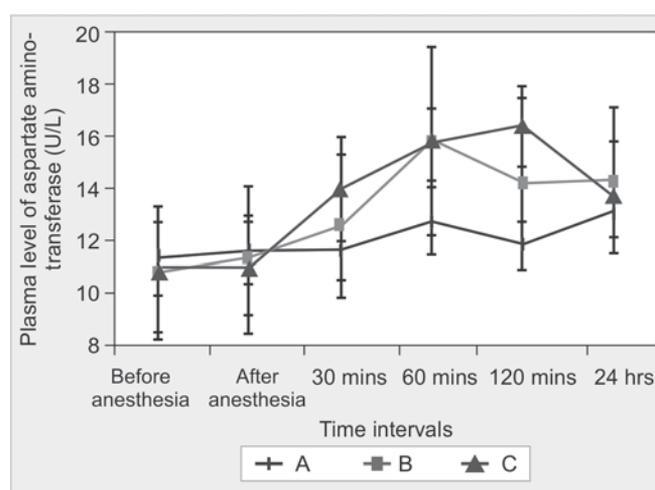
Groups	Before anesthesia	After anesthesia	Time intervals after establishment of capnoperitoneum			
			30 mins	60 mins	120 mins	24 hrs
A	-2.91 \pm 1.32	-1.98 \pm 1.20	-2.43 \pm 1.16	-1.71 \pm 1.26	-0.66 \pm 1.27	-0.31 \pm 1.10
B	-2.71 \pm 1.40	-2.61 \pm 1.12	-2.51 \pm 1.08	-1.98 \pm 1.00	-1.50 \pm 1.36	-1.56 \pm 2.06
C	-2.11 \pm 0.59	-2.38 \pm 0.51	-2.61 \pm 0.64	-1.86 \pm 0.67	-1.35 \pm 0.65	-1.68 \pm 0.66

Table 9: Mean \pm SE of sodium, potassium and chloride (mmol/l) recorded at different time intervals

Groups	Before anesthesia	After anesthesia	Time intervals after establishment of capnoperitoneum			
			30 mins	60 mins	120 mins	24 hrs
<i>Sodium</i>						
A	147.33 \pm 1.05	146.83 \pm 0.94	146.33 \pm 1.87	149.33 \pm 2.99	146.33 \pm 1.96	144.83 \pm 1.4 4
B	146.83 \pm 1.44	147.83 \pm 1.72	147.33 \pm 1.45	147.83 \pm 1.68	149.00 \pm 1.70	144.88 \pm 1.08
C	146.83 \pm 1.40	146.50 \pm 1.12	145.66 \pm 1.22	147.00 \pm 1.00	148.00 \pm 0.68	147.16 \pm 1.24
<i>Potassium</i>						
A	4.53 \pm 1.10	4.36 \pm 0.14	4.46 \pm 0.25	4.56 \pm 0.19	4.41 \pm 0.14	4.28 \pm 0.07
B	4.56 \pm 0.12	4.41 \pm 0.10	4.56 \pm 0.05	4.88 \pm 0.14	4.76 \pm 0.19	4.58 \pm 0.17
C	4.40 \pm 0.12	4.30 \pm 0.18	4.21 \pm 0.17	4.55 \pm 0.14	4.36 \pm 0.12	4.40 \pm 0.10
<i>Chloride</i>						
A	113.00 \pm 2.81	108.83 \pm 1.68	108.66 \pm 2.45	103.50 \pm 3.38	107.83 \pm 2.34	108.66 \pm 0.80
B	110.66 \pm 2.69	111.16 \pm 1.49	110.66 \pm 1.56	110.16 \pm 1.40	111.16 \pm 1.37	107.83 \pm 1.32
C	108.50 \pm 3.58	106.50 \pm 1.87	107.00 \pm 1.23	103.16 \pm 3.16	104.83 \pm 2.22	108.83 \pm 1.95

Table 10: Mean \pm SE of creatinine, blood urea nitrogen and uric acid recorded at different time intervals

Groups	Before anesthesia	After anesthesia	Time intervals after establishment of capnoperitoneum			
			30 mins	60 mins	120 mins	24 hrs
A	61.34 \pm 5.77	69.89 \pm 7.07	79.89 \pm 7.44	72.23 \pm 5.35	77.33 \pm 8.19	76.40 \pm 8.74
B	74.59 \pm 10.55	72.42 \pm 9.20	82.24 \pm 12.03	78.95 \pm 9.86	79.67 \pm 11.14	92.43 \pm 7.70
C	74.80 \pm 10.92	80.23 \pm 13.60	79.53 \pm 15.83	86.44 \pm 14.24	90.08 \pm 15.21	91.51 \pm 13.7
BUN (mmol/l)						
A	7.23 \pm 0.76	6.65 \pm 0.66	7.21 \pm 0.71	7.30 \pm 0.79	8.09 \pm 0.64	7.74 \pm 0.58
B	7.41 \pm 0.63	7.34 \pm 0.78	7.49 \pm 0.72	7.91 \pm 0.90	8.32 \pm 0.58	8.04 \pm 0.36
C	7.40 \pm 0.81	7.31 \pm 0.86	7.65 \pm 1.02	7.67 \pm 0.94	8.52 \pm 1.06	8.35 \pm 1.30
Uric acid (μmol/l)						
A	42.36 \pm 7.29	39.47 \pm 6.56	42.34 \pm 6.74	41.18 \pm 6.48	42.80 \pm 8.24	42.62 \pm 8.68
B	40.00 \pm 6.05	42.99 \pm 6.53	43.57 \pm 7.22	44.52 \pm 8.65	43.69 \pm 7.90	42.12 \pm 7.09
C	50.89 \pm 9.14	50.01 \pm 9.25	54.61 \pm 10.07	52.61 \pm 7.83	48.83 \pm 6.15	51.12 \pm 6.94

**Fig. 3:** Mean \pm SE of pH recorded in the animals of three different groups**Fig. 5:** Mean \pm SE of partial pressure of pO₂ (mm Hg) recorded in the animals of three different groups**Fig. 4:** Mean \pm SE of partial pressure of pCO₂ (mm Hg) recorded in the animals of three different groups**Fig. 6:** Mean \pm SE of plasma aspartate aminotransferase (U/L) recorded in the animals of three different groups

pressure gradient in endoflator. Injection of 5 ml of normal saline through Verres needle was found very useful⁷ to confirm the insertion of the needle within the peritoneum and thereby the chance of subcutaneous emphysema.⁸ During trocarization some complications observed in two

animals of group A. In one animal, splenic trauma due to faculty trocarization while in other animal the tip of cannula was entrapped within the mesentery. Davidson and coworkers⁹ encountered inadvertent splenic puncture and laceration due to blunt trocarization in three out of

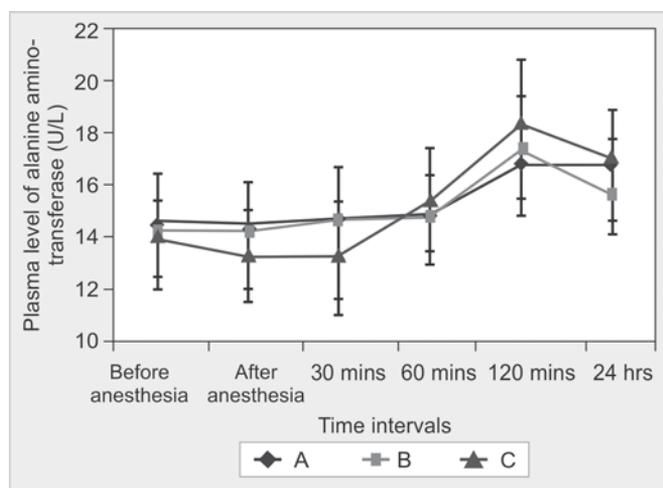


Fig. 7: Mean \pm SE of plasma alanine aminotransferase (U/L) recorded in the animals of three different groups

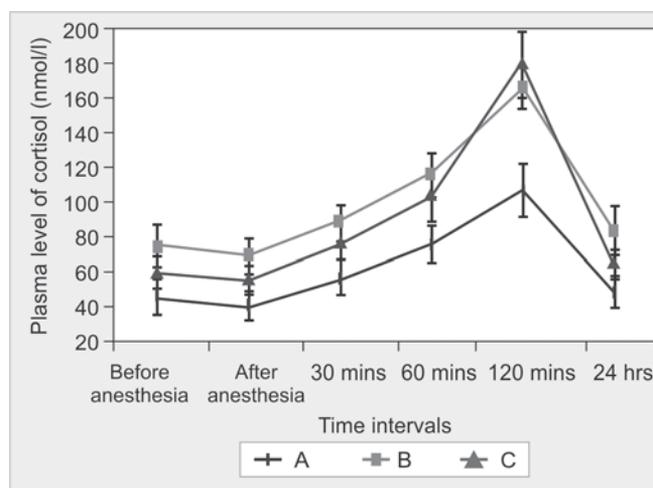


Fig. 8: Mean \pm SE of plasma cortisol (mmol/l) recorded in the animals of three different groups

16 animals during laparoscopic examination. The low insufflations pressure of CO₂ might attribute to insufficient spacing and separation of the abdominal structures from the ventral abdominal wall and led to these complications.

Visualization of the abdominal organs started from the urinary bladder which was readily and promptly visualized by its unique tortuous vasculature over the visceral surface. Identification and visualization of various internal organs like liver, spleen and pancreas, kidney, ovary and uterus during various laparoscopic surgeries have been reported.^{10,11} Evaluation of laparoscopic organ visualization at different CO₂ pressure gradient revealed marked differences among the three groups. Urinary bladder was visualized distinctly in all the animals of all three groups without any significant difference. But visualization of liver in group C differed significantly from group A. In groups B and C significantly better visualization was observed than that was in group A when other organs were evaluated.

No significant differences were found between the various groups as related to the physiologic parameters except the respiration rate. Following CP, it was increased in all groups, but it was significant in group C at 60 minutes after CP. Soon after CO₂ insufflation, CO₂ absorbed from abdominal cavity led to hypercapnia and hypercarbia which might stimulate the respiratory center and as compensation respiration rate was increased.¹² CP is associated with an increase in plasma potassium concentration,¹³ metabolic acidosis¹⁴ and hemodynamic changes;¹⁵ therefore, concomitant changes in electrocardiogram can be logically speculated. Although the initial heart rate ranged widely among the animals of three groups, it markedly decreased during post-CP period, which could be attributed to parasympathetic effect on vagus nerve owing to increased intra-abdominal pressure.⁵ Increase in R-R interval during

post-CP periods was in tune with the observation of decrease in heart rate and might be as a result of hypercarbia following CP.^{16,17} Wandering pacemakers, and atrial premature complexes were occasionally seen in this study. Wandering pacemaker a variant of sinus arrhythmia is a shift of pacemaker within the SA node and observed even in normal dogs.¹⁸ Atrial premature complexes, AV junction premature complexes, wandering pacemaker and intermittent sinus arrest seems to a normal variants and might be due to an increase in vagal tone in individual dogs on CP. The increase in amplitude of T-wave was more marked in group C at 60 minutes post-CP, and could be related to the transient hyperkalemia owing to CP.¹³ Biphasic T-wave and T-wave alternant were more marked in animals of group C. Large T-wave possibly indicated hyperkalemia and ST depression suggested myocardial ischemia.¹⁹ The ST intervals did not reveal any significant changes throughout the observation in three groups, however, ST elevation (in group A) and ST depression (in group C) were observed in some animals during post-CP and were suggestive of myocardial ischemia as a result of CP during laparoscopy.²⁰

PCV and Hb were unchanged throughout the observation period in all groups and remained within the normal range as also reported by Dellinger et al²¹ 24 hours after laparoscopy. The mean value of TLC revealed a nonsignificant increase at 60 and 120 minutes after CP in group C might be due to the effect of corticosteroid, released as a stress response of increased IP at higher CO₂ pressure gradient of group C. In this study, significant decrease of pH value was observed at 120 minutes after CP in group C might be due to hypercapnia developed as a result of increased absorption of CO₂ in blood from peritoneal cavity.⁵ Significant increase of pCO₂ in post-CP period in all the three groups might be due to compensate the respiratory acidosis developed as a result of hypercarbia.

Low insufflations pressure in group A might attributed to the unaltered plasma sodium, potassium and chloride as reported by Yavuz et al²² Furthermore, CP maintained for only 30 minutes in animals of the present study might be insufficient to inflict any changes.²³ Two cytosolic enzymes ALT and AST are mostly used to evaluate hepatic function. In this study both the ALT and AST revealed no statistically significant changes among the different groups in respect to different time intervals.

A nonsignificant increase of the mean plasma level of BUN, creatinine and uric acid was observed in post-CP period in all three groups and remained above the base value throughout the rest part of the observation period. This transient nonsignificant increase might be due to the effect of CP. In the present study, change of plasma cortisol in all groups was probably due to the effect of pneumoperitoneum rather than operative trauma. Change of plasma cortisol level had also been reported by O'Leary et al²⁴ at the time of laparoscopy. Marcovich et al²⁵ reported a higher cortisol level at 4 hours after laparoscopy in dogs. This change was reflected markedly in CP at 14 mm Hg than 6 mm Hg.

CONCLUSION

The results of this study indicated that 10 mm Hg of CO₂ pressure gradient provided optimum laparoscopic visualization of intra-abdominal organs and minimum physiological, biochemical, electrocardiographical changes and hormonal stress during laparoscopic examination in dogs.

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