# Hemodynamic Effects of Laparoscopic Insufflation at Different Pressures in Dogs Following Myocardial Ischemia

## *MYOKARDİAL İSKEMİ MODELİ OLUŞTURULAN KÖPEKLERDE DEĞİŞİK BASINÇLARDAKİ LAPAROSKOPİK İNSÜFLASYONUN HEMODİNAMİK ETKİLERİ*

Mehmet ORAL*, Ömer KURTİPEK*, İbrahim AŞIK*,
Melek TULUNAY*, Saeide DEMÎRALP*, Filiz TÜZÜNER*

* Dept. of Anesthesiology and Rcaniınation, Medical School of Ankara University, Ankara, TURKEY

**Summary**

*This study was designed to evaluate the effect pj COjpneuniaperitoiieum on hemodynamics in dogs following myocardial is -hernia. Invasive monitoring was performed in 26 adult dogs, weighing 20-25 kg. under general anesthesia. Then, the animals were allocated randomly into two main groups: Group I (control) and Group II (Ischemia). Hemodynamic measurements (MR: heart rate, MAP: mean arterial pressure, CVP: central venous pressure, MPAP: mean pulmonary' artery pressure, CO: cardiac output) and arterial blood gas determinants were obtained as baseline values. Then, the animals in control group were allocated into two subgroups; Control I (n=6) and Control II (n-6). 5 inmHg and 12 rnmHg of intraabdominal pressure (IAP) were performed, respectively. Afterwards, hemodynamic measurements were repeated 10. 20 and 30 minutes after- the peritoneal insufflation was completed. In ischemia group, median sternotomy was performed and myocardial ischemia was produced by ligating left anterior descending (LAD) coronary arfery. When the ECG revealed myocardial infarction, hemodynamic variables and arterial blood gas determinants were obtained 45 minutes after LAD was ligated as baseline values. Then, the animals in the ischemia group were allocated into two Subgroups; Ischemia-I (n=7) and lschemia-II (n=7). Animals underwent peritoneal insufflation to create 5 rnmHg in ischemia group 1 and 12 mmllg in ischemia group II. After-wards, hemodynamic measurements were obtained 10, 20 and 30 minutes after the peritoneal insufflation was completed. No significant difference was detected in cardiovascular variables in control groups, whereas significant increases were observed in the filling pressures of the heart (CVP. PCWP) and MPAP in ischemic groups (p<0.05). CO and MAP decreased in dogs following myocardial ischemia (p<0.05). and heart failure and cardiogenic shock occured following myocardial ischemia, especially in dogs with high IAP. We conclude that the cardiac functions decrease as the intraabdominal pressure oj pneumoperitoneum increases in our experimental myocardial ischemia model.*

**Key Words:** Laparoscopic insufflation. Pneumoperitoneum, Intraabdominal pressure, Hcmodynamia, Myocardial ischemia. Cardiogenic schock

T Klin J Med Res 1998, 16:76-83

**Received:** June 12, 1998

**Correspondence:** Dr.Mehmet ORAL
Uzungcmiciler sok. 30/13
06590 Icccbcci, Ankara, TURKEY

**Özet**

*Bu çalışmada myokardial iskemi oluşturulan köpeklerde karbondioksid gazı kullanılarak değişik basınç/ardaki pnömoperitoneuınun hemodinamik etkileri araştırıldı. IH - 25 kg ağırlığında 26 yetişkin köpeğe genel anestezi altında ıuvaziv monitorizasyon uygulandıktan sonra rastgele iki ana gruba ayrıldı; Kontrol ve iskemi grupları. Kontrol grubunda başlangıç hemodinamik ölçümler (Kalp atım hızı: KAH, santral venöz basınç: SVB, pıılmoner kapiller kama basıncı: PKKB, ortalama pulmoner arter basıncı: OPAB, ortalama arter basıncı: OAB, kardiak output: KO) ve kan gazları alındı. Daha sonra bu deneklere sadece peritoneal insüflasyon (sırasıyla kontrol I (n:6): 5 ınınllg ve Kontrol II (n:6): 12 nınıHg) uygulandı ve 10., 20. ve 30. dakikalarda hemodinamik ölçümler ve kan gazları tekrarlandı. iskemik grupla deneklere önce mediaıı sternotomi yapılarak sol inen koroner arterleri bağlandı ve iskemi oluştuktan (ortalama 45 dk.) sonra başlangıç hemodinamik ölçümler (KAH, SVB. PKKB. OPAB. OAB ve KO) ve kan gazları alındı ve peritoneal insüflasyon (sırasıyla iskemi I **(n**:7): 5 ınınHg ve iskemi II **(n:**7): 12 mmHg) uygulandı. Bu gruplarda iskemi oturduktan 10, 20 ve 30 dak. sonra hemodinamik ölçümler ve kan gazları tekrarlandı. **Çalışmamızdan** elde edilen sonuçlara göre; intraabdominal basınç artışının kontrol **gruplarında** önemli bir kardiovasküler değişikliğe yol açmadığı; buna karşılık iskemik kalplerde (özellikle intraabdominal basıncın daha yüksek olduğu grupta) kalbin dolma basınçlarında (SVB. PKKB) ve OPAB'da artış, kalp debisi ve OAB'de düşme ile kendini belli eden kalp yetmezliği ve kardiojenik şoka yol açtığını gösterdi (p<0.05). Bu çalışmada eksperimental myokardial iskemik modelde intra abdominal basınç artışının önemli hemodinamik instabi/iteye yol açtığı sonucuna vardık.*

**Anahtar Kelimeler:** Laparoskopik insüflasyon, Pneumoperitoneum, İntraabdominal basınç, Hemodinami, Myokard iskemisi. Kalp yetmezliği

T Klin Araştırma 1998, 16:76-83

Laparoscopic surgery has rapidly gained popularity and become a widely used technique in recent years. Potential advantages of laparoscopic procedures arc decreased cost, increased patient comfort, minimal abdominal scar, rapid postoperative recovery and short period of hospitalisation (1,2).

Although laparoscopy has been accepted a safe procedure, cardiovascular derangements were reported due to CO, pneumoperitoneum. The pathophysiologic effects of intraperitoneal $C0_2$ insufflation and high intra-abdominal pressure (1AP) on the patients' cardiopulmonary performance were studied by various investigators (1-8). As laparoscopic procedures become more universal and more complex and longer procedures such as common bile duct surgical exploration, antireflux operation, lymph node dissection, intestinal resection have been performed. This means a longer duration of $C0_2$ insufflation and the patient population may be expected to be much older and with more marginal cardiopulmonary reserve. As a consequence, prolonged $C0_2$ insufflation depresses myocardium especially in patients with limited cardiac functions.

We performed this experimental study to evaluate the hemodynamic effects of $C0_9$ pneumoperitoneum at various intra-abdominal pressures in dogs following myocardial ischemia.

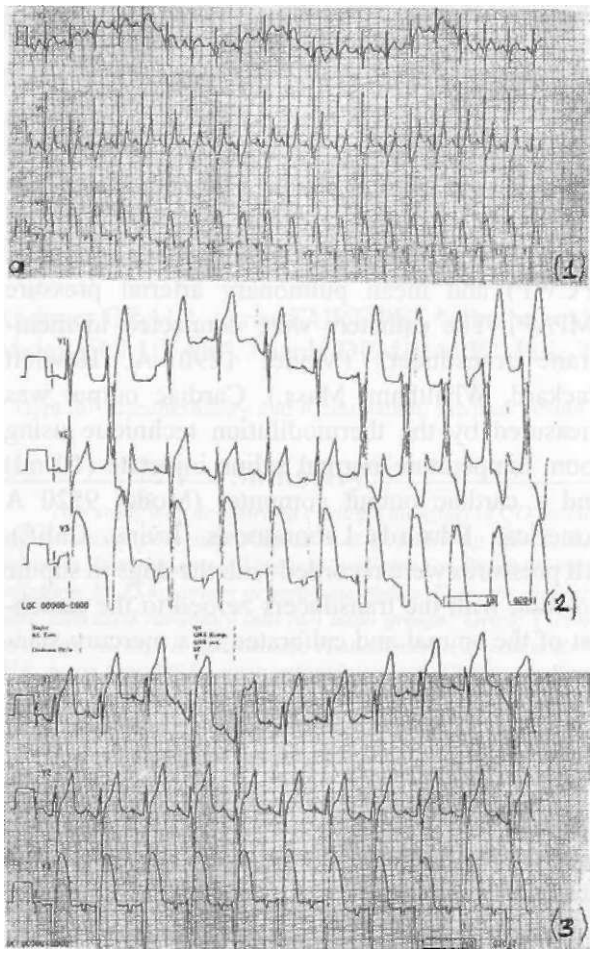
## Materials and Methods

### Animal Preparation

This study was performed in 26 adult dogs weighing 18-25 kg in animal laboratory of University of Ankara, Faculty of Medicine. After animals were sedated with an intramuscular injection of ketamine hydrochloride (10-15 mg/kg ), the animals were placed in a supine position on the operating tabic with the front and hind limbs fixed in the abduction position. Intravenous thiopcnthal (4-7 mg/kg) was given after radial venous cannulation. After endotracheal intubation, atracurium bcsylate (0.7 mg/kg) was administered and the anesthesia was maintained with halothane 1-1.5% in 50% $N_20$ + 50% $0_2$ mixture. The appropriate minute ventilation was determined by adjusting the tidal volum and respiratory rate to obtain normal arterial blood gases. The neck, abdomen and groin were shaved and draped in a sterile fashion. The right femoral artery was cannulatcd to monitor the mean arterial pressure (MAP). The right external jugular vein was surgically explored and cannulatcd with 7 F polyethylene catheter. A flow directed 5 F pulmonary arterial catheter (Baxter, American Edwards Labaratories, Irvine, Calif.) was also inserted via the internal jugular vein and floated into the pulmonary artery for measurumcnts of cardiac output (CO), pulmonary capillary wedge pressure (PCWP) and mean pulmonary arterial pressure (MPAP). The catheters were connected to membrane transducers (Model 1290 A, Hewlett Packard, Whaltham, Mass.). Cardiac output was measured by the thermodilution technique using room temperature normal saline injectate (10 ml) and a cardiac output computer (Model 9520 A American Edwards Laboratories, Irvine, Calif). A11 pressures were recorded with the dogs in supine position with the transducers zeroed to the midchest of the animal and calibrated to a mercury standard.

### Protocol

After the animals were anesthetized and frilly instrumented, a 15 minutes baseline period was observed when the animals' arterial blod gases were normalised and hemodynamic data were stabilized. The minute ventilation obtained during this baseline period was then fixed throughout the rest of the experiment. The animals were allocated randomly into two main groups. Group.I (Control) and Group II (Myocardial ischemia). Hemodynamic variables (HR: heart rate, MAP: mean arterial pressure, CVP: central venous pressure, MPAP; mean pulmonary artery pressure, PCWP: pulmonary capillary artery pressure, CO: cardiac output) and arterial blood gas determinants were obtained as baseline values. In control groups, a Vercss needle was inserted supraumblically, and placement of the needle tip in the peritoneal cavity was confirmed by the saline drop test. Insufflation of $C0_2$ was performed by an automatic insufflator (Electronic Laproflator, 26012 Storch,Tuttlingen, Germany). Then, the animals in the control group were allocated into two subgroups. Control I (C I ; n=6) and Control II (C II; n= 6). 5 and 12 mmHg of intraabdominal pressures were performed in group CI and CII, respectively. Afterwards, hemodynamic measurements were obtained at 10, 20, and 30 minutes after the peritoneal insufflation was completed. In myocar-



**Picture** 1. Electrocardiogram (ECG) (VI, V2, V3) I: Baseline, 2. Myocardial ischemia 25 th min. 3: Myocardial ischemia 45 th min.

dial ischemia group, median sternotomy was performed and myocardial ischemia was produced by ligating left anterior descending coronary artery (LAD). The sternum was then reapproximated and ECG records were obtained at regular intervals to demonstrate myocardial infarction during 45 minutes (Photograph 1). When the ECG revealed myocardial infarction, hemodynamic variables and arterial blood gas determinants were obtained 45 minutes after LAD was ligatcd as baseline values. Then, the animals in the ischemic group were allocated into two subgroups, subsequently. Ischemia I (I-I; n= 7) and ischemia II (I-II; n=7). Animals underwent peritoneal insufflation with the same method used in control groups to create 5 and 12 mmHg of intraabdominal pressures in ischemia-I and Ischcmia-II groups, respectively. Afterwards, hemodynamic measurements were obtained at 10, 20 and 30 minutes after the peritoneal insufflation was completed.

Then, the animals with myocardial ischemia were killed with pentobarbiton (60 mg/kg i.v) whereas the animals in the control group were extubated.

Arterial blood gases were analysed by a pH/blood gas analyzer (Model 170, Corning Medical, Medfield, Mass.). SVR, PVR, MAP and MPAP values were calculated by using standart formulas.

### Statistical Analysis

Data were reported as mean values ± (SEM). Analysis of variance for repeated measurements was performed to determine significant differences. Paried- t and Wilcoxon's matched pairs test was used for parametric data. A p - value below 0.05 was considered significant.

## Results

There were no significant differences in demographic characteristics between groups.

### Hemodynamic Changes

No significant differences were delected at baseline hemodynamic recordings between ischemic and control groups (Figure 1-8) ($p>0.05$). The increase in HR in myocardial ischemic groups occured after $C0_2$ insufflation at all measurement periods compared to baseline values and control groups (Figure 2) ($p<0.05$). The hemodynamic parameters after CO, insufflation did not differ significantly from baseline values in control groups (Figure 1-8) ($p<0.05$).

In myocardial ischemic group with an IAP of 12 mmHg, CVP, MPAP, and PCWP values increased significantly compared to baseline values and control groups (Figure 3,4,5) ($p<0.05$). Significant decreases were detected in MAP and CO values in myocardial ischemic groups compared to baseline values and control groups whereas SVR increased significantly compared to baseline values (Figure 1,6,7) ($p<0.05$). A significant increase was found in SVR at 10 and 20 minutes af-

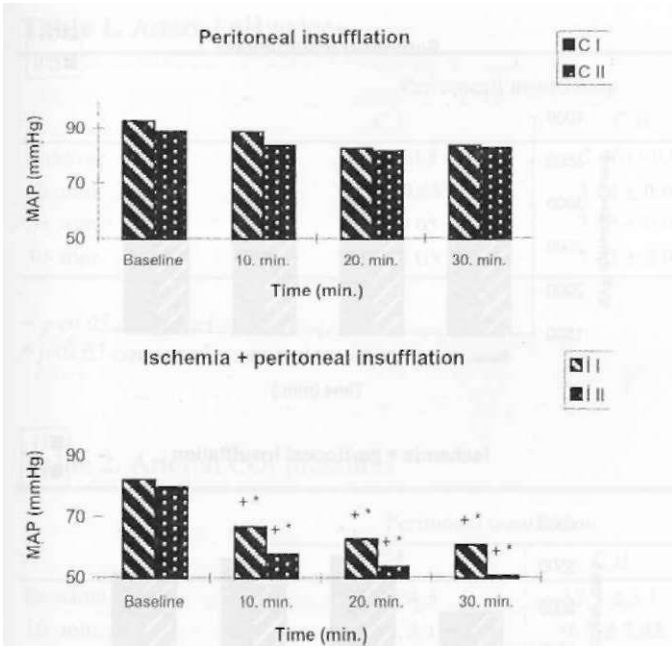



**Figure I.** Mean systemic arterial pressures (MAP).
*+ p<0.05 compared to haseline values.*
** p<0.05 compared to control group.*

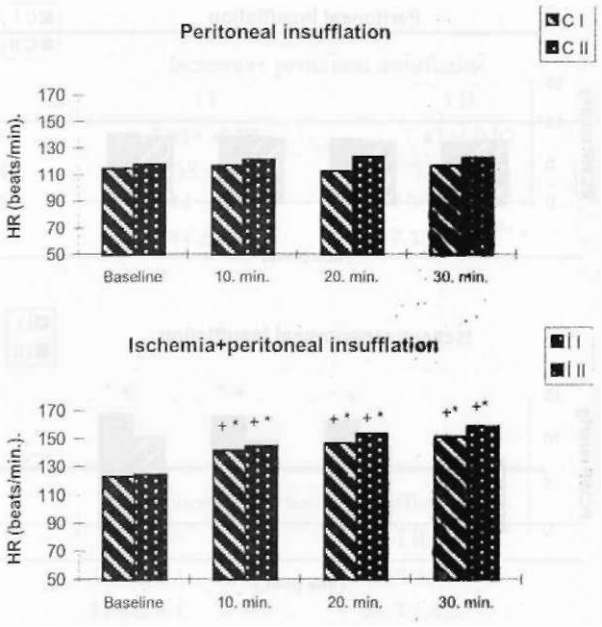



Figure **2.** Heart rate (HR) values.
*+ p<().05 compared to baseline values.*
** p<0.05 compared to control group.*

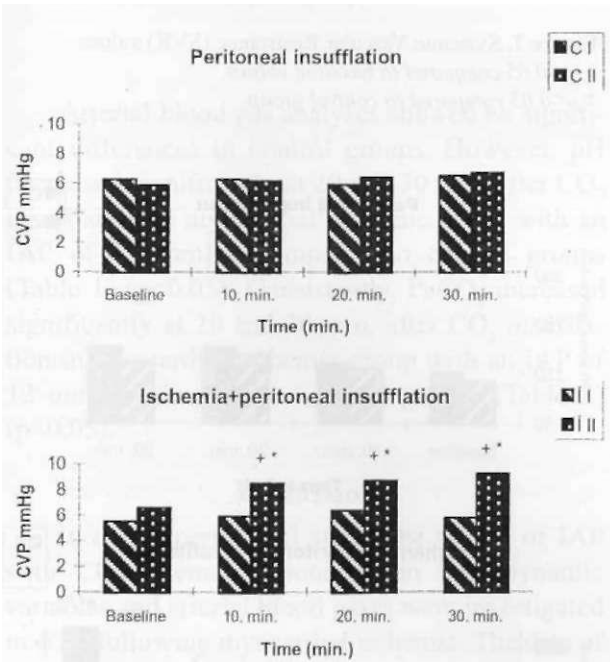



Figure 3. Central Venous Pressures (CVP).
*+ p<().05 compared lo baseline values.*
** p<0.05 compared lo control group.*

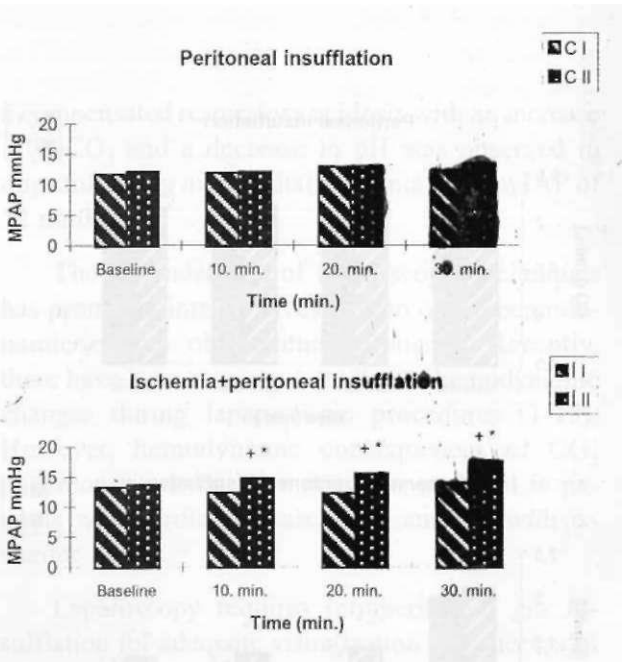



Figure 4. Mean Pulmonary Artery Pressures (MPAP).
*+ p<0.05 compared to baseline values.*
** p<0.05 compared to control group.*

ter CO-, insufflation in myocardial ischemic group with an IAP of 12 mmHg when compared to control groups (Figure 7) (p<0.05). PVR increased at 10 and 20 minutes after $CO_2$ **insufflation** in myocardial ischemic groups compared **to baseline** values and control groups (Figure 8) (p<0.05).

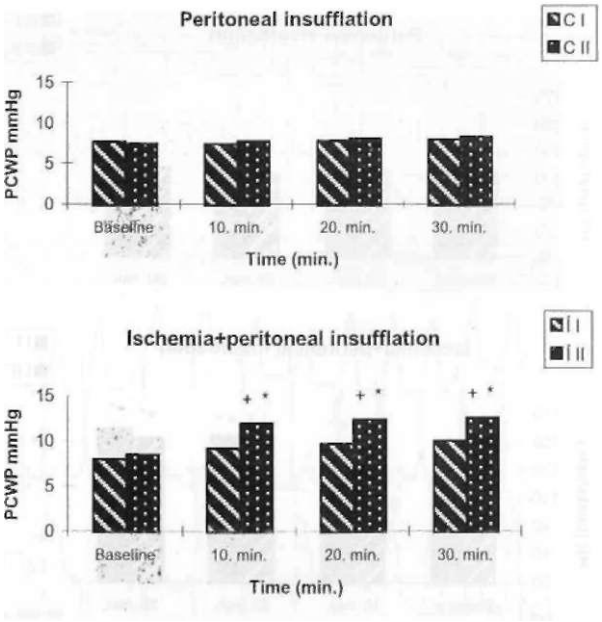



**Figure** 5. Mean pulmonary capillary wedge pressures (PCWP).
*+ p<0.05 compared to baseline values.*
** p<0.05 compared lo control group.*

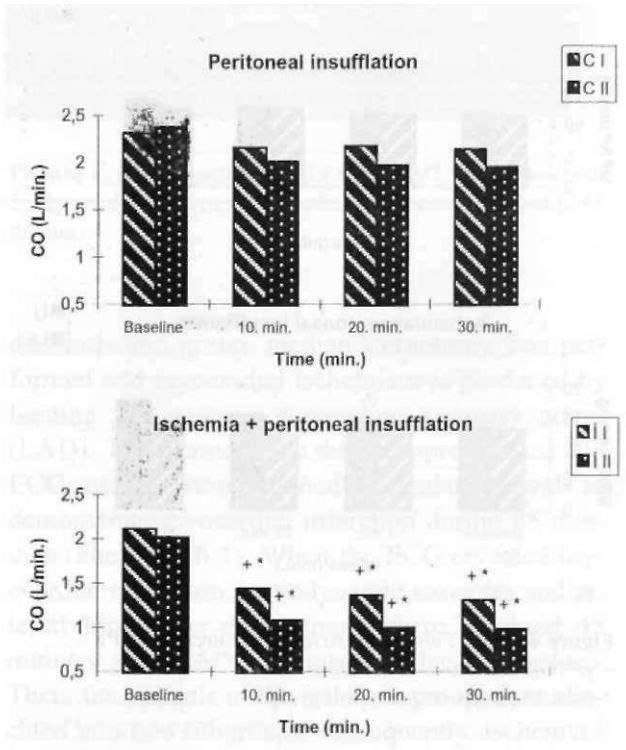



**Figure** 6. Cardiac Output (CO) values.
*+ p<0.05 compared to-baseline values.*
** p<0.05 compared to control group.*

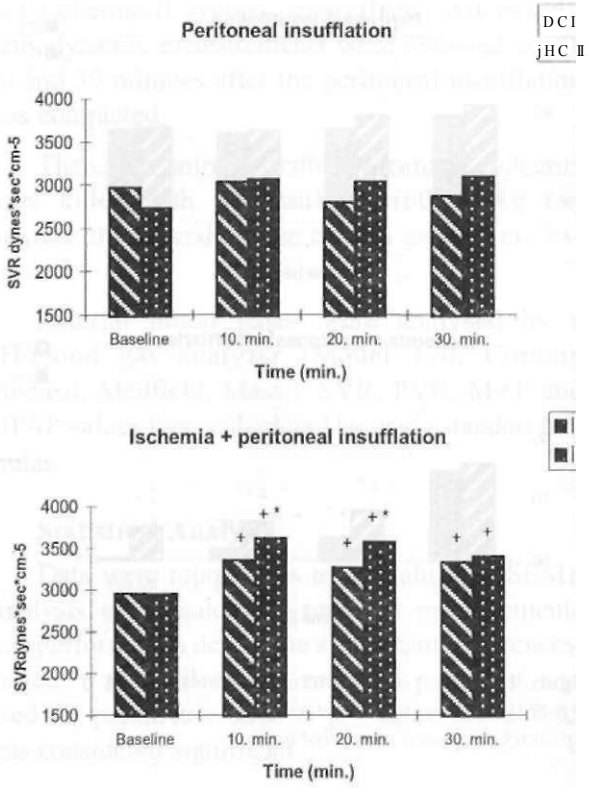



**Figure** 7. Systemic Vascular Resistance (SVR) values.
*+ p<0.05 compared to baseline values.*
** p<0.05 compared to control group.*

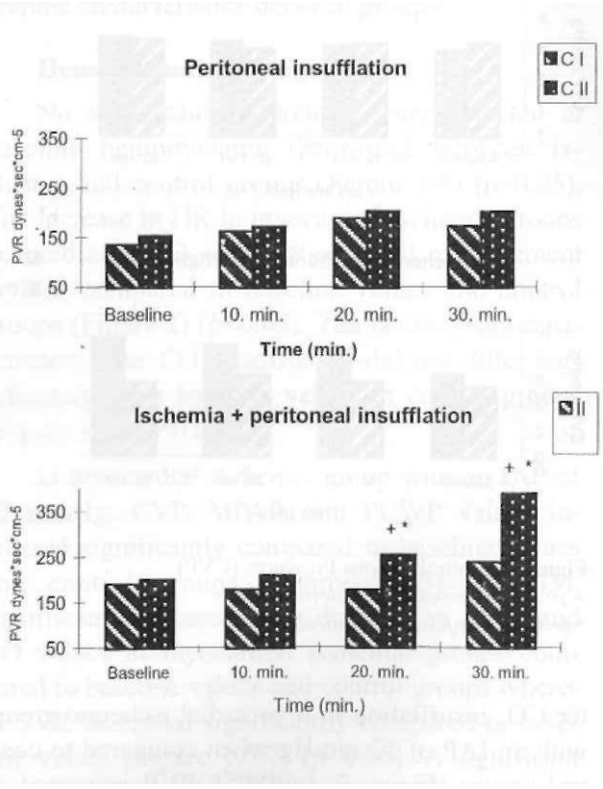


**Table 1.** Arterial pH values

| | Peritoneall insufflation | | Ischemia+ peritoneal insufflation | |
|---|---|---|---|---|
| | CI | CII | i I | in |
| Baseline | 7.44+/-0.8 | 7.46+/-0.9 | 7.41+/-0.05 | 7.47.+/-0.02 |
| 10. min. | 7.39 ± 0.08 | 7.44 ± 0.04 | 7.38 ± 1.1 | 7.39 ± 0.6 |
| 20. min. | 7.41± 0.05 | 7.42 ±0.06 | 7.44 ±0.04 | 7.35 ± 0.03 + * |
| 30. min. | 7.41+0.05 | 7.42 ±0.06 | 7.44 ±0.04 | 7.35 ± 0.03 + * |

*+ p<0.()5 compared lo baseline values*
** p<0.05 compared to control group*

**Table 2.** Arterial $CO_2$ pressures

| | Peritoneal insufflation | | Tschemia+ peritoneal insuffla | |
|---|---|---|---|---|
| • | cl | en | ïl | ilï |
| baseline | 39.7 ±4.3 | 37.3 ±3.1 | 35.4 ±2.1 | 34.5 ±1.5 |
| 10. min. | 36.4 ±3.1 | 36.7 ±3.43 | 37.8 ±4.1 | 39.7 ± 4.3 |
| 0. min. | 38.6 ±2.9 | 37.5 ±2.4 | 38.2 ±2.3 | 43.9 ±4.8 + * |
| 0. min. | 37.5 ±2.4 | 38.6 ±2.9 | 35.9 ±2.7 | 48.6 ± 3.2 + * |

*+ p<0.05 compared to baseline values*
** p<0.05 compared to control group*

Arterial blood gas analyses showed no significant differences in control groups. However, pH decreased significantly at 20 and 30 min. after $CO_2$ insufflation in myocardial ischemic group with an 1AP of 12 **iTimHg** compared to control groups (Table 1) ($p<0.05$). Consistently, $PaCO_2$ increased significantly at 20 and 30 min. after $CO_2$ insufflation in myocardial ischemic group with an IAP of 12 minHg compared to control groups (Table 2) ($p<0.05$).

## Discussion

In this experimental study, the effects of IAP with $CO_2$ pneumoperitoneiim on hemodynamic variables and arterial blood gases were investigated in dogs following myocardial ischemia. The data of this study demonstrated that the increase of IAP did not alter cardiopulmonary functions in control groups. However, cardiac filling pressures (CVP, PCWP) and MPAP increased, and CO and MAP decreased in myocardial ischemic groups, especially in dogs with an IAP of 12 muiHg. As a result of tins, heart failure and cardiogenic shock occured in dogs following myocardial ischemia. Additionally, a compensated respiratory acidosis with an increase in $PaCO_2$ and a decrease in pH was observed in dogs following myocardial ischemia with an LAP of 12 mmHg.

The expanded use of laparoscopic techniques has prompted intense investigation of the hemodynamic effects of pneumoperitoneum. Recently, there have been numerous studies of hemodynamic changes during laparoscopic procedures (1-15). However, hemodynamic consequences of $CO_2$ pneumoperitoneum have not been explored in patients with cardiac disease or in animals with ischemic hearts.

Laparoscopy requires intraperitoneal gas insufflation for adequate visualization and successful operation. However, peritoneal insufflation of $CO_2$ to create the pneumoperitoneum neccessary for laparoscopy inchices intraoperative ventilatory and hemodynamic changes (13-1 7). The position of the patient (head-down or head-up) requir-ed during these procedures also contributes to these changes (16). In the present study, the hemodynamic variables and analysis of arterial blood gases were per-

formed in supine position to avoid the effects of positioning. There are several reports that the increase of IAP above **10** mmHg to create a pneumoperitoneum is associated with a decrease of CO and an increase of **MAP,** SVR and PVR (7,11-13). The investigators indicated that the cardiovascular derangements are occured as a result of these hemodynamic changes. It is also reported that the decrease in **CO** correlates with an increase in IAP (2,13-15). In this study two different IAP was performed in animals. Although, the non significant increases of **CO** and MAP are associated with a non significant increase in SVR in control groups, significant disturbances arc characterized by an increase in cardiac filling pressures and SVR and a decrease of **CO,** especially in ischemic dogs with an IAP of **12** mmHg.

The reason that the IAP did not result any significant change in hemodynamic parameters in control groups, is probably due to relative low IAP and supine position. The decrease in CO in dogs following myocardial ischemia can be explained by increased **SVR** due to elevated intra-abdominal pressure. The mechanism that the decrease in CO in dogs produced myocardial ischemia is thought to be secondary to increased SVR and a decreased venous return from the lower extremities due to increased intraabdominal pressure. On the other hand, potential mediators such as cathecolamincs and vasopressin contribute to the increase of SVR.

In canines with normal hearts, the effects of pneumoperitoneum include an increased central venous pressure and pulmonary capillary wedge pressure with an accompanying decreased cardiac output (9,**10**,13). There are several studies indicating that the decrease in CO can be explained by hypovolemia and an increase of SVR (6,11). Additionally, duplex scanning has documented decreased lower extremity venous flow during laparoscopy (7).

In this study, cardiac filling pressures (CVP and PCWP) and MAP increased significantly in ischemic groups, especially in dogs with an IAP of 12 mmHg..The increase in CVP is thought to be secondary to an increased venous return from the lower extremities. However, despite the increase in CVP, transmural right atrium pressure (the pressure within the right atria minus the cxtracardiac pressure), which should be used rather than directly measured RAP as an indicator of venous return lo the heart in case of elevated IAP, did not change. Ivancovich el al. (13) reported that inferior vena caval flow declined with an increase of IAP 10 mmHg or more in canines with CO, or N-,0 pneumoperitoneum . He also indicated that femoral vein pressures increased roughly in parallel with the increases of IAP consequent to pooling of blood in the peripheral circulation.

The decrease in CO in ischemic groups, especially in dogs with an IAP of 12 mmHg, can be explained by a reduction in venous return and/or increased SVR. Under normal circumstances, intraperitoneal gas insufflation decrease CO. However, MAP can be maintained in the normal range with the increase of SVR. Wcstcrband el al. (2) studied the cardiovascular changes in 16 patients undergoing laparoscopic cholecystectomy with an IAP of 15 mmHg. Their results revealed a decrease of 30% in CI, 15% in MAP, and an increase of 79%, in SVRI. They also reported a myocardial infarction of the inferior part of the wall in one patient during operation and a possible high afterload was suggested for the reason of MI. Motew el al. (14) observed an elevation of blood pressure and CVP in 10 women undergoing intraperitoneal CO, insufflation up to a pressure of 20 mmHg. Further increases in intra-abdominal pressure of 30 mmHg resulted in slight depression of cardiac output and CVP.

Analysis of arterial blood gases revealed an increase in $PaC0_2$ and a decrease in pH, resulting acidemia and hypcrcapnia in the present study. Decompansated acidemia may contribute lo the decrease of CO and to the increase of PVR. However, as arterial blood gas samples in myocardial ischemia group showed compensated acidemia, this suggestion should not to be undertaken into consideration.

Using of fixed tidal volum and respiratory rate during laparoscopic surgery lead to systemic absolution of CO, and hypcrcapnia. It is well known that hypercapnia induces sympathetic activation and increases PVR (6,12,14,18). In this experimental model, we maintained a fixed minute ventilation throughout the period of insufflation to approximate the clinical model in which mechanical ventilatory impairment prevents intraoperative adjust-

ment of minute ventilation. Intraoperatively, it is imperative that end-tidal volume $CO_2$ content be monitored continuously during $CO_2$ pneumoperitoneum to allow appropriate adjustments of minute ventilation to avoid potential hypercapnia and acidemia. In the present study, an increase in $PaCO_2$ and a decrease in pH was detected in myocardial ischemic dogs with an IAP of 12 mmHg. This is probably due to the relative increase of dead spaces in lungs (high V/Q areas). This finding is of clinical importance indicating that the possibility of hypercapnia is higher in cases who have low CO when fixed minute ventilation and respiratory rate was used.

We concluded that the increase of intra-abdominal pressure with $CO_2$ insufflation induced systolic heart failure in dogs following myocardial ischemia.

## REFERENCES


1. Toiler W. Minnich M, Brotman S. Hemodynamics effects of laparoscopic cholecystectomy. The American Surgeon 1994; 60: 322-5.
2. Wcstcrband A. Water J. Amzallag M. Lebovvitz PW. Cardiovascular changes during laparoscopic cholecystectomy. Gynecology & Obstetrics. 1992; 175: 535-8.
3. Williams MD. Murr PC. Laparoscopic insufflation of abdomen depresses cardiopulmonary function. Surgical Endoscopy 1993: 7(1): 12-6.
4. Portera CA, Compton RP, David N. Benefits of pulmonary artery catheter and transesophageal echocardiography monitoring in laparoscopic cholecystectomy patients with cardiac disease. Am J Surg 1995; 169: 202-7.
5. Ho S.H., Gunther RA, Wolfe BM. Intraperitoneal carbondioxide insufflation and cardiopulmoner functions (laparoscopic cholecystectomy in pigs). Arch Surg 1992; 127: 928-33.
6. Ishizaki Y, Bandai Y, Shimomura K, Abe H, Ohtomo Y, Idezuki Y. Changes in splanchnicblood flow and cardiovascular effects following peritoneal insufflation of carbon dioxide. Surg Endosc 1993; 7(5):420-3.
7. Joris JL, Noirot D, Lcgrand M, Jacquet N, Lamy M: Hemodynamic changes during laparoscopic cholecystectomy. Anesth Analg 1993; 76:1067-71.
8. Radcmaker BMP, Odoom J, Wit L, Kalkman C. Brink SA,Ringers .l. Haemodynamic effects of pneumoperitoneum for laparascopic surgery: a comparison of ("02 with N20 insufflation. European J Anaesthesiology 1994; 11: 301-6.
9. Luz CM, Polarz H, Bohrer H, et al. Hemodynamic and respiratory effects of pneumoperitoneum and PEEP during laparoscopic pelvic lymphadenectomy in dogs. Surg Endosc 1994; 8: 25-7.
10. Kashtan J, Green J, Parsons E, Holcroft J. Hemodynamic effects of increased abdominal pressure. J Surg Res 1981; 30: 249-55.
11. Diamant M, Bcnomof J, Saidman L. Hemodynamics of increased intra-abdominal pressure. Anaesthesia 1978; 48:23-7.
12. Goodale R, Beebe D, McNcvin M. Hemodynamic, respiratory and metabolic effects of laparoscopic cholecystectomy Am J Surg 1993; 166:533-7.
13. Ivankovich AD, Miletich DJ, Albrecht RF. Hcyman HJ. Bonnet RF. Cardiovascular effects of intraperitoneal insufflation with carbon dioxide and nitrous oxide inthe dog. Anesthesiology 1975; 42: 281-7.
14. Motew M, Ivankovich AD, Bieniarz J, Albrecht RA, Zahed B, Scommegna A. Cardiovascular effects and acid-base and blood gas changes during laparoscopy. Am J Obstet Gynecology 1973; 115:1002-12.
15. Lenz RJ, Thomas TA, Wilkins DG. Cardiovascular changes during laparoscopy. Anaesthesia 1976; 31:4-12.
16. Baxter JN, Dwyer PJO. Pathophysiology of laparoscopy. Br J Surg 1995; 82: 1-2.
17. Ciofolo MJ, Clergue F, Seebacher J et al. Ventilatory effects of laparoscopy under epidural anesthesia. Anesth Analg 1990; 70:357-61.
18. Seed RF, Shakespeare TF, Muldoon MJ. Carbon dioxide homeostasis during anaesthesia for laparoscopy. Anaesthesia 1970; 25:223-31.