





## Changes in arterial partial pressure and end-expired pressure of carbon dioxide in prepubescent and adult bitches undergoing ovariohysterectomy by videolaparoscopy or conventional laparotomy

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**ABSTRACT:** This paper aimed to determine arterial partial pressure of carbon dioxide ( $PaCO_2$ ), end-expired  $CO_2$  pressure ( $ETCO_2$ ), and the difference between arterial and end-expired  $CO_2$  pressure ( $Pa - ETCO_2$ ) in prepubescent and adult bitches undergoing videolaparoscopic or conventional ovariohysterectomy (OH). Forty bitches were randomly assigned to four groups: Conventional Adult (CA), Conventional Pediatric (CP), Videolaparoscopic Adult (VA) and Videolaparoscopic Pediatric (VP). Pulse rate (PR), respiratory rate (RR), systolic, mean, and diastolic arterial pressures (SAP, MAP, DAP),  $ETCO_2$ , peak inspiratory pressure (PIP), pH, arterial partial pressure of oxygen ( $PaO_2$ ),  $PaCO_2$ , base excess (BE) and  $HCO_3^-$  were measured. Based on the  $PaCO_2$  and  $ETCO_2$  values,  $Pa-ETCO_2$  was determined. There was no significant difference in  $PaCO_2$  between the VA ( $42.5 \pm 5.2$  to  $53.7 \pm 5.2$ ) and VP ( $48.4 \pm 5.4$  to  $55.4 \pm 5.7$ ) groups. During the postoperative period, all groups presented with hypertension. However, mild hypertension (SAP 150 to 159 mmHg) was observed in the VP group as compared to severe hypertension (SAP > 180 mmHg) in the CA group, suggesting that both the age range and videolaparoscopic OH are associated with lower levels of hypertension during the postoperative period in dogs.

**Key words:** pneumoperitoneum, videolaparoscopy, hypercapnia, dogs, pediatric.

### Variações nas pressões parciais arteriais e expiradas de dióxido de carbono em cadelas pré-púberes e adultas submetidas à ovário histerectomia vídeo laparoscópica ou convencional

**RESUMO:** O objetivo deste estudo foi determinar a pressão parcial de dióxido de carbono ( $PaCO_2$ ), pressão ao final da expiração de  $CO_2$  ( $ETCO_2$ ) e diferença artério-alveolar de  $CO_2$  ( $Pa-ETCO_2$ ) em cadelas pré-púberes e adultas submetidas à ovário-histerectomia (OH) videolaparoscópica ou convencional. Foram distribuídas 40 cadelas em quatro grupos: Convencional Adulto (CA), Convencional Pediátrico (CP), Videolaparoscópico Adulto (VA) e Videolaparoscópico Pediátrico (VP). Foram mensurados frequência de pulso (FP), frequência respiratória (FR), pressões arteriais sistólica (PAS), média (PAM) e diastólica (PAD),  $ETCO_2$ , pressão de pico inspiratória (PIP), pH, pressão parcial arterial de oxigênio ( $PaO_2$ ),  $PaCO_2$ , excesso de bases (EB) e  $HCO_3^-$ . Com base nos valores de  $PaCO_2$  e  $ETCO_2$  encontrados, foi determinada a  $Pa-ETCO_2$ . Não foram encontradas diferenças significativas nos valores de  $PaCO_2$  entre os grupos VA ( $42.5 \pm 5.2$ - $53.7 \pm 5.2$ ) e VP ( $48.4 \pm 5.4$  -  $55.4 \pm 5.7$ ). Todos os grupos apresentaram hipertensão arterial no período pós-operatório. Entretanto, o grupo VP apresentou hipertensão moderada (PAS 150-159 mmHg) em comparação ao grupo CA, que apresentou hipertensão severa (PAS > 180 mmHg), sugerindo que tanto a faixa etária, quanto a execução de OH por videolaparoscopia, estão associadas a menores taxas de hipertensão pós-operatória em cadelas.

**Palavras-chave:** pneumoperitônio, videolaparoscopia, hipercapnia, cães, pediátrico.

## INTRODUCTION

Laparoscopy allows broad and minimally invasive visualization of the abdominal cavity; additional advantages include low postoperative pain scores, shorter surgical recovery times, and lower surgical wound complication rates (MAITI et al., 2013). Carbon dioxide ( $CO_2$ ) is the gas used to induce pneumoperitoneum due to its low cost and high blood solubility; it also allows electrocoagulation and is easily eliminated through pulmonary ventilation (FUKUSHIMA

et al., 2011). However, capnopneumoperitoneum favors cranial displacement of the diaphragm and formation of pulmonary atelectasis. These changes lead to reductions of pulmonary compliance and respiratory volumes, elevation of PIP, and a worsening in pulmonary ventilation-perfusion relationship (V/Q) (IRWIN & WONG, 2014). Significant amounts of  $CO_2$  can be absorbed through the peritoneal membrane, resulting in hypercapnia and respiratory acidosis if the patient's minute volume (MV) is not increased (IRWIN & WONG, 2014). Pediatric and neonatal human patients that

experience capnopneumoperitoneum are especially sensitive to hypercapnia by absorption of CO<sub>2</sub> due to their extensive peritoneal surface (McHONEY et al., 2003). To the authors' knowledge, there are no studies about the relationship between the extent of hypercapnia and the age range of dogs undergoing videolaparoscopy.

The present study aimed to determine the variation of PaCO<sub>2</sub>, ETCO<sub>2</sub>, and Pa-ETCO<sub>2</sub> in prepubescent and adult bitches that underwent videolaparoscopic or conventional OH. The hypothesis was that in bitches that underwent videolaparoscopic OH, the PaCO<sub>2</sub> would be higher in prepubescent animals than in adult animals. A secondary objective of the study was to compare the PR and blood pressure between groups during the intra-operative and immediate postoperative periods.

## MATERIALS AND METHODS

Forty bitches with body weights between 4 and 12kg, considered healthy based on physical examination (mucous membrane color evaluation, rectal temperature, hydration score, abdominal and lymph node palpation, and cardiorespiratory auscultation), complete blood count and biochemical exams (ALT, BUN, creatinine, and albumin), abdominal ultrasonography, and chest radiography, were used in this study. Dogs were randomly and equally assigned to four groups (n=10): Conventional Pediatric (CP group), pediatric (3-7 months) bitches undergoing conventional OH; Conventional Adult (CA group), adult (1-6 years) bitches undergoing conventional OH; Videolaparoscopic Pediatric (VP group), pediatric bitches undergoing videolaparoscopic OH; and Videolaparoscopic Adult (VA group), adult bitches undergoing videolaparoscopic OH. Bitches included in pediatric groups (CP and VP) were those aged 3-7 months without a history of first estrus cycle (swelling or engorgement of the external vulva and bloody vaginal discharge). Bitches in the adult groups (CA and VA) were those aged 1 to 6 years with a previous history of first estrus cycle.

Food but not water was withheld for 12 hours. No surgery was performed in dogs presenting clinical signs of estrus in the day of surgery. Dogs received intramuscular (IM) morphine (0.3mg.kg<sup>-1</sup>) as premedication. Fifteen minutes after intramuscular (IM) morphine administration (0.3mg.kg<sup>-1</sup>), anesthesia was induced with intravenous (IV) propofol (5mg.kg<sup>-1</sup>) until tracheal intubation was possible. Anesthesia was maintained with isoflurane in 100% oxygen

(1L.min<sup>-1</sup>), delivered through a circle rebreathing system. Animals were submitted to mechanical ventilation (ORIGAMI 668 ventilator, TAKAOKA®, Sao Bernardo do Campo, Brazil) limited by pressure, with PIP ranging from 10 to 15cmH<sub>2</sub>O. The RR and PIP were adjusted to maintain the ETCO<sub>2</sub> between 35 and 45mmHg. Concentration of isoflurane delivered by the non-precision vaporizer was adjusted to maintain moderate depth of anesthesia: ventromedial rotation of the eyeball, loss of palpebral reflex, loss of jaw tone, MAP between 60 and 90mmHg. For intraoperative analgesic rescue, fentanyl (2µg.kg<sup>-1</sup>, IV) was administered in cases of PR>160bpm, and/or MAP>90mmHg. In cases of persistent hypotension (MAP<60mmHg) for more than 10 minutes, dopamine (7µg.kg<sup>-1</sup>.min<sup>-1</sup>, IV) was administered. Atropine (0.02mg.kg<sup>-1</sup>, IV) was administered in cases of PR<60bpm associated with MAP<60mmHg.

During the surgical procedure, the bitches were maintained on a thermal mattress and received lactated Ringer's solution (10mL.kg<sup>-1</sup>.h<sup>-1</sup>, IV). A lead II ECG and esophageal temperature were continuously monitored. A 22-G over-the-needle catheter was placed into the dorsal pedal artery for blood sampling, continuous monitoring of PR, and SAP, MAP, and DAP with a rigid tubular system filled with heparinized solution (5IU.mL<sup>-1</sup>). Pressure transducer was zeroed at the level of the manubrium of the sternum. A mainstream capnography sensor was positioned between the orotracheal tube and the "Y" piece of the breathing system for monitoring the ETCO<sub>2</sub>. Before each procedure, the capnography sensor was reset and calibrated according to the manufacturer's recommendations. All variables were monitored using a multi-parameter monitor (Dash, GE Healthcare®, Chicago, IL, USA). Bladder catheterization was performed and sodium ampicillin (22mg.kg<sup>-1</sup>, IV) was administered 30 minutes before beginning the surgical procedure.

Arterial blood samples were collected in heparinized syringes for blood gas evaluation, and cardio circulatory and respiratory variables were recorded at the following moments: M0, during isoflurane anesthesia, 15 minutes after initiation of mechanical ventilation and immediately before the onset of surgery (CA and CP) or before the onset of pneumoperitoneum (VA and VP); M1 and M2 of the VP and VA groups were recorded after cauterization and section of the cervix (M1) and after cauterization and section of the second ovarian arteriovenous complex (M2). In the CP and CA groups, M1 and M2 were recorded after ligation and section of the first ovarian arteriovenous complex (M1) and

after ligation and section of the cervix (M2). Time points M3, M4, M5, and M6 were recorded every 15 minutes after extubation until 60 minutes. Arterial blood samples were analyzed immediately using a portable analyzer (i-STAT, Abbot Laboratories, Abbott Park, IL, USA) and EG7+ model cartridges. Based on the values of PaCO<sub>2</sub> and ETCO<sub>2</sub>, Pa-ETCO<sub>2</sub> was calculated.

In dogs that underwent laparotomy, removal of the uterus and ovaries was performed using the modified three tweezers technique. In the groups that underwent videolaparoscopic OH, the technique was performed through three access portals with 5-mm diameters (Ø). Pneumoperitoneum was maintained with a flow of 3.5 L.min<sup>-1</sup> and 6 mmHg pressure. All dogs were administered tramadol (3mg.kg<sup>-1</sup>, IM), meloxicam (0.2mg.kg<sup>-1</sup>, IV), and dipyrone (25mg.kg<sup>-1</sup>, IV) immediately prior to closure of the skin. After the end of the surgical procedure, isoflurane was discontinued and the bitches were allowed to recover. 100% oxygen was supplied until extubation (return of cough reflex). Analgesic rescue with morphine (0.3mg.kg<sup>-1</sup>, IM) was provided if animals presented clinical signs of pain (vocalization, reluctance to move, reaction to palpation of the surgical wound, or aggression) during immediate anesthesia recovery.

Unless otherwise expressed, data are presented as mean ± standard deviation. Weight and surgery time were compared between groups using analysis of variance (ANOVA) and a Tukey's test (symmetrical distribution). For comparisons between

groups in age and volume of CO<sub>2</sub> (asymmetric distribution), a Kruskal-Wallis and Dunn test were performed. For simultaneous intra and intergroup comparisons, the generalized estimating equations (GEE) model was applied. The least significant difference (LSD) test was applied when there was a significant effect of group, time, or interaction (group×time) for ETCO<sub>2</sub>, PaCO<sub>2</sub>, Pa-ETCO<sub>2</sub>, RR, PIP, pH, HCO<sub>3</sub><sup>-</sup>, PaO<sub>2</sub>, PR, SAP, MAP, or DAP data. A p-value <0.05 was considered significant. All analyses were performed using SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA).

## RESULTS

Thirty-nine bitches completed the study. One animal in the CA group experienced cardiac arrest during the manipulation of the first ovary. The patient responded adequately to resuscitation maneuvers and was discharged after 24 hours. Data from this dog were excluded from statistical analysis. There was no significant difference in weight between the groups. There was no difference in age between the VA and VP groups, or between the CA and CP groups. There was also no significant difference between the CO<sub>2</sub> volume used in the VA and VP groups (Table 1).

Intraoperative analgesic rescue with fentanyl was administered to 8 animals in the VP group and 7 in the VA group immediately after pneumoperitoneum (before M1). Other 6 animals

Table 1 - Demographic data of the 39 bitches included in the study distributed in the CA (Conventional Adult), CP (Conventional Pediatric), VA (Videolaparoscopic Adult), and VP (Videolaparoscopic Pediatric) groups.

Variable*	CA (n=9)	CP (n=10)	VA (n=10)	VP (n=10)	Pvalue
Age (months)	27 (12 -60)	5 (5 - 7)	24 (12 - 54)	5 (3 - 7)	-
Weight (kg)	6.9 ±2.1	6.9 ±2.6	6.2 ±1.1	8.4 ±2.1	0.127
Duration of surgery (min)	64 ±12 <sup>a</sup>	61 ±10 <sup>a</sup>	119 ±17 <sup>b</sup>	108 ±22 <sup>b</sup>	<0.001
CO <sub>2</sub> volume (L)	--	--	58.5 (25 - 161)	38 (25.7 - 103)	0.315
DogBreeds	Crossbreed (n=3)	Crossbreed (n=5)	Crossbreed (n=6)	Crossbreed (n=7)	
	Pug (n=2)		Maltese (n=1)		
	Teckel (n=1)	Fox (n=2)	West Highland White Terrier (n=1)	Fox (n=1)	
	Spitz (n=1)	Teckel (n=1)	LhasaApso (n=1)	Labrador (n=1)	
	Shih-tzu (n=1)	Pug (n=1)	Shih-tzu (n=1)	Teckel (n=1)	
	Pinscher (n=1)	Shih-tzu (n=1)			

\*Described by mean ± standard deviation or median (minimum-maximum); <sup>a, b</sup> Equal letters do not differ by the Tukey test at 5% significance.



in the CA group and 7 in the CP group were given analgesic rescue during manipulation of the first ovarian arteriovenous complex (before recording variables at M1). Atropine was administered to 3 animals in the CA group and dopamine was administered to 1 animal each in the CA and VP groups. Four dogs in the CA group and 2 dogs in the VP group received analgesic rescue once in the immediate postoperative period. The number of dogs administered rescue analgesia intraoperatively and postoperatively did not differ between groups.

Duration of surgery was significantly higher in the VA and VP groups than in the CA and CP groups ( $P < 0.001$ ). There was a significant increase of  $\text{ETCO}_2$  at M1 and M2 compared to M0 in the VA group, and at M2 compared to M0 in the VP group ( $P < 0.001$ ). Values for  $\text{PaCO}_2$  increased significantly at M1 and M2 in the VA and VP groups compared to M0 ( $P < 0.001$ ). Significantly higher PIP and RR were required intraoperatively in the VA and VP groups compared to the CA and CP groups ( $P < 0.001$ ). From M3 to M6, all groups had significantly higher values of RR than at M0 ( $P < 0.001$ ). From M3 to M6,  $\text{PaCO}_2$  values were significantly lower than at M0 in the CA, CP, and VP groups ( $P < 0.001$ ). There was no significant difference in  $\text{Pa-ETCO}_2$  among the groups or over time (Table 2).

Mean values for  $\text{PaO}_2$  were within the expected range for dogs according to the inspired oxygen fraction ( $>90\%$  at M1 and M2; 21% from M3 to M6; data not shown). Arterial pH values remained below the reference values for dogs throughout the evaluation period. All animals developed respiratory acidosis intraoperatively due to  $\text{PaCO}_2$  increase, and metabolic acidosis due to BE and  $\text{HCO}_3^-$  decreases during the postoperative period (Table 2).

There was no significant difference in PR between groups or compared to M0 during the intraoperative period (M1 and M2). At selected time points from M3 to M6, PR increased significantly in all groups compared to M0, with a trend towards higher values in the prepubescent (CP and VP) groups. Arterial blood pressures were higher in the CA and CP groups than in the VA and VP groups during the intraoperative period; significant differences in MAP and DAP were observed at M1. Higher SAP, MAP and DAP values were observed in all groups during the postoperative period as compared to M0. The highest values were observed in the CA group and the lowest values were observed in the VP group, with significant differences in MAP and DAP between groups at specific moments (Table 3).

## DISCUSSION

The main findings of the present study were: a) age (CP and VP groups *versus* CA and VA groups) did not influence  $\text{PaCO}_2$  or  $\text{Pa-ETCO}_2$  values in bitches undergoing conventional or videolaparoscopic OH; and b) videolaparoscopic OH (VA and VP groups *versus* CA and CP groups), despite resulting in longer surgical times, seemed to cause a lower pressure response to surgical stimulation and a lower frequency of postoperative hypertension, notably in prepubescent bitches (VP group).

The increases in  $\text{ETCO}_2$  and  $\text{PaCO}_2$  values at M1 and M2 in the VA and VP groups are likely to have resulted from peritoneal  $\text{CO}_2$  absorption from capnoperitoneum (IRWIN & WONG, 2014). In the same time points, it is suggested that higher intraoperative values of PIP and RR were required in VA and VP due to cranial displacement of the diaphragm resulting from pneumoperitoneum, which in turn decreases pulmonary compliance and total lung volume (IRWIN & WONG, 2014).

The hypothesis of the study was rejected as there was no significant difference in  $\text{PaCO}_2$  between the VA and VP groups. It is possible that the absence of a significant difference of  $\text{CO}_2$  absorption between the VP and VA groups was due to the age range of patients in the VP group (3 to 7 months). In this age range, the peritoneal surface-to-body mass ratio is closer to that reported in adult animals (TRANQUILLI et al., 2007). Our results might have been different if the bitches were younger than 3 months, but it is not common in clinical practice to perform OH on animals at such an early age.

At time point M0, mean  $\text{Pa-ETCO}_2$  values in all groups (8.3-11.0 mmHg) were above the physiological range for dogs (2-5 mmHg) anesthetized under spontaneous ventilation or positive pressure ventilation (HIGHTOWER et al., 1980). The high values of  $\text{Pa-ETCO}_2$  possibly resulted from atelectasis. High  $\text{O}_2$ -inspired fractions may have resulted in rapid reabsorption of gases from alveoli and alveolar collapse (DANTZKER et al., 1975). Despite mean values of  $\text{Pa-ETCO}_2$  were high at M0, there was no significant change in any of the groups intraoperatively. Absence of an increase in  $\text{Pa-ETCO}_2$  at M1 and M2 in the VA and VP groups suggested that the low inflation pressures used (6 mmHg) to maintain pneumoperitoneum did not worsen any impairment of the V/Q ratio induced by high inspired oxygen fraction (MAITI et al., 2013).

Table 2 - Comparison between CA (Conventional Adult), CP (Conventional Pediatric), VA (Videolaparoscopic Adult), and VP (Videolaparoscopic Pediatric) groups and time points of variables end-expired pressure of carbon dioxide (ETCO<sub>2</sub>), arterial partial pressure of CO<sub>2</sub> (PaCO<sub>2</sub>), difference between arterial and end-expired pressure of CO<sub>2</sub> (Pa-ETCO<sub>2</sub>), respiratory rate (RR), peak inspiratory pressure (PIP), pH, and HCO<sub>3</sub><sup>-</sup>

Variable*	CA (n=9)	CP (n=10)	VA (n=10)	VP (n=10)	-----P value-----		
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Group	Time	Group x Time
<b>ETCO<sub>2</sub> (mmHg)</b>					0.122	<0.001	<0.001
M0	37.3 ±6.58 <sup>ab</sup>	40.8 ±4.1 <sup>b</sup>	32.9 ±6.3 <sup>a</sup>	37.4 ± 4.9 <sup>ab</sup>			
M1	39.4 ±6.42 <sup>a</sup>	41.7 ±3.6 <sup>a</sup>	43.9 ±3.2 <sup>*a</sup>	44.4 ± 3.9 <sup>*a</sup>			
M2	40.4 ±4.25 <sup>a</sup>	42.8 ±3.3 <sup>a</sup>	43.6 ±4.0 <sup>*a</sup>	44.2 ±4.2 <sup>*a</sup>			
<b>PaCO<sub>2</sub>(mmHg)</b>					0.871	<0.001	<0.001
M0	47.7 ±6.2 <sup>ab</sup>	49.1 ±4.7 <sup>b</sup>	42.5 ±5.2 <sup>a</sup>	48.4 ±5.4 <sup>ab</sup>			
M1	51.7 ±7.9 <sup>a</sup>	50.2 ±3.9 <sup>a</sup>	52.7 ±4.3 <sup>*a</sup>	55.4 ±5.7 <sup>*a</sup>			
M2	51.8 ±8.3 <sup>a</sup>	50.7 ±3.0 <sup>a</sup>	53.7 ±5.2 <sup>*a</sup>	54.7 ±4.0 <sup>*a</sup>			
M3	41.2 ±3.7 <sup>*a</sup>	41.3 ±3.0 <sup>*a</sup>	39.0 ±4.7 <sup>a</sup>	37.6 ±3.6 <sup>*a</sup>			
M4	39.6 ±4.1 <sup>*a</sup>	41.3 ±3.4 <sup>*a</sup>	39.6 ±4.0 <sup>a</sup>	36.3 ±5.1 <sup>*a</sup>			
M5	39.7 ±3.0 <sup>*a</sup>	39.0 ±2.4 <sup>*a</sup>	38.9 ±3.9 <sup>a</sup>	38.1 ±3.2 <sup>*a</sup>			
M6	38.5 ±2.9 <sup>*a</sup>	37.2 ±2.8 <sup>*a</sup>	38.9 ±3.9 <sup>a</sup>	37.4 ±2.2 <sup>*a</sup>			
<b>Pa-ETCO<sub>2</sub></b>					0.062	0.979	0.870
M0	10.4 ±3.7 <sup>a</sup>	8.3 ±2.5 <sup>a</sup>	9.6 ±2.5 <sup>a</sup>	11.0 ±7.1 <sup>a</sup>			
M1	12.2 ±9.1 <sup>a</sup>	8.4 ±3.7 <sup>a</sup>	8.8 ±4.7 <sup>a</sup>	11.0 ±7.2 <sup>a</sup>			
M2	11.4 ±7.5 <sup>a</sup>	7.9 ±3.7 <sup>a</sup>	10.0 ±7.2 <sup>a</sup>	10.5 ±5.8 <sup>a</sup>			
<b>PIP (cmH<sub>2</sub>O)</b>					< 0.001	<0.001	<0.001
M0	10 ±0.7 <sup>a</sup>	10, ±0.0 <sup>a</sup>	10±0.6 <sup>a</sup>	10 ±1.3 <sup>a</sup>			
M1	10 ±1.1 <sup>a</sup>	10 ±0.9 <sup>a</sup>	13 ±2.4 <sup>*b</sup>	14 ±1.1 <sup>*b</sup>			
M2	10 ±1.7 <sup>a</sup>	10 ±0.9 <sup>a</sup>	13 ±2.6 <sup>*b</sup>	14 ±1.0 <sup>*b</sup>			
<b>RR (breaths min<sup>-1</sup>)</b>					0.266	<0.001	<0.001
M0	10 ±2.1 <sup>a</sup>	12 ±1.8 <sup>a</sup>	9 ±3.9 <sup>a</sup>	12 ±3.7 <sup>a</sup>			
M1	10 ±2.2 <sup>a</sup>	13 ±2.8 <sup>ab</sup>	15 ±3.1 <sup>*b</sup>	16 ±5.5 <sup>*b</sup>			
M2	11 ±1.8 <sup>a</sup>	13 ±2.3 <sup>ab</sup>	16 ±5.1 <sup>*b</sup>	18 ±5.0 <sup>*b</sup>			
M3	73 ±62.6 <sup>*a</sup>	35 ±24.4 <sup>*a</sup>	75 ±51.4 <sup>*a</sup>	75 ±44.3 <sup>*a</sup>			
M4	87 ±72.1 <sup>*a</sup>	41 ±34.3 <sup>a</sup>	82 ±53.0 <sup>*a</sup>	81 ±57.3 <sup>*a</sup>			
M5	83 ±67.5 <sup>*a</sup>	45 ±42.1 <sup>a</sup>	77 ±50.3 <sup>*a</sup>	71 ±42.3 <sup>*a</sup>			
M6	81 ±62.0 <sup>*a</sup>	70 ±58.0 <sup>*a</sup>	63 ±41.3 <sup>*a</sup>	79 ±46.2 <sup>*a</sup>			
<b>pH</b>					0.131	<0.001	<0.001
M0	7.30 ±0.05 <sup>ab</sup>	7.30 ±0.03 <sup>ab</sup>	7.34±0.03 <sup>b</sup>	7.30 ±0.03 <sup>a</sup>			
M1	7.26 ±0.05 <sup>ab</sup>	7.29 ±0.03 <sup>b</sup>	7.24±0.02 <sup>*a</sup>	7.23 ±0.03 <sup>*a</sup>			
M2	7.24 ±0,06 <sup>a</sup>	7.26 ±0.03 <sup>*a</sup>	7.23 ±0.03 <sup>*a</sup>	7.23 ±0.02 <sup>*a</sup>			
M3	7.28 ±0.03 <sup>a</sup>	7.30 ±0.03 <sup>a</sup>	7.28 ±0.04 <sup>*a</sup>	7.31 ±0.03 <sup>a</sup>			
M4	7.28 ±0.03 <sup>a</sup>	7.30 ±0.03 <sup>a</sup>	7.28 ±0.04 <sup>*a</sup>	7.32 ±0.05 <sup>a</sup>			
M5	7.29 ±0.03 <sup>a</sup>	7.32 ±0.03 <sup>a</sup>	7.32 ±0.05 <sup>*a</sup>	7.31 ±0.02 <sup>a</sup>			
M6	7.30 ±0,03 <sup>a</sup>	7.32 ±0.03 <sup>a</sup>	7.28 ±0.04 <sup>*a</sup>	7.32 ±0.02 <sup>a</sup>			
<b>HCO<sub>3</sub><sup>-</sup>(mEq/L)</b>					0.326	<0.001	<0.001
M0	23.6 ±1.8 <sup>a</sup>	24.3 ±2.1 <sup>a</sup>	23.1 ±1.7 <sup>a</sup>	23.8 ±1.7 <sup>a</sup>			
M1	23.3 ±2.6 <sup>a</sup>	24.3 ±1.7 <sup>a</sup>	22.8 ±1.0 <sup>a</sup>	23.5 ±2.5 <sup>a</sup>			
M2	22.5 ±2.4 <sup>a</sup>	23.3 ±1.8 <sup>*a</sup>	22.7 ±0.9 <sup>a</sup>	23.2 ±1.5 <sup>a</sup>			
M3	19.4 ±1.6 <sup>*a</sup>	20.6 ±2.0 <sup>*a</sup>	18.5 ±1.9 <sup>*a</sup>	19.2 ±1.1 <sup>*a</sup>			
M4	18.8 ±1.1 <sup>*a</sup>	20.9 ±2.3 <sup>*a</sup>	18.9 ±2.1 <sup>*a</sup>	18.8 ±1.1 <sup>*a</sup>			
M5	19.3 ±2.1 <sup>*a</sup>	20.2 ±2.3 <sup>*a</sup>	18.8 ±2.6 <sup>*a</sup>	19.5 ±1.6 <sup>*a</sup>			
M6	19.0 ±2.2 <sup>*a</sup>	19.4 ±2.7 <sup>*a</sup>	18.9 ±2.6 <sup>*a</sup>	19.5 ±1.2 <sup>*a</sup>			

\*Described by mean ± standard deviation or median (minimum-maximum); <sup>a, b</sup> Equal letters do not differ by the Tukey test at 5% significance.

Table 3 – Comparison between CA (Conventional Adult), CP (Conventional Pediatric), VA (Videolaparoscopic Adult), and VP (Videolaparoscopic Pediatric) groups and time points of variables pulse rate (PR), systolic arterial pressure (SAP), mean arterial pressure (MAP), and diastolic (DAP).

Variable*	CA (n=9)	CP (n=10)	VA (n=10)	VP (n=10)	-----P value-----		
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Group	Time	Group x Time
PR (beats.min <sup>-1</sup> )					0.003	<0.001	<0.001
M0	97.6 ±21.1 <sup>a</sup>	105.2 ±23.9 <sup>a</sup>	95.3 ±10.9 <sup>a</sup>	108.1 ±21.3 <sup>a</sup>			
M1	107.8 ±22.8 <sup>a</sup>	109.5 ±14.2 <sup>a</sup>	101.6 ±12.6 <sup>a</sup>	108.9 ±18.0 <sup>a</sup>			
M2	95.3 ±24.2 <sup>a</sup>	105.3 ±10.4 <sup>a</sup>	105.8 ±12.0 <sup>a</sup>	114.3 ±13.3 <sup>a</sup>			
M3	135.9 ±22.2 <sup>a</sup>	138.8 ±29.2 <sup>a</sup>	112.7 ±19.8 <sup>a</sup>	143.7 ±21.9 <sup>a</sup>			
M4	122.8 ±20.2 <sup>a</sup>	130.3 ±15.9 <sup>ab</sup>	113.0 ±19.8 <sup>a</sup>	146.3 ±16.7 <sup>ab</sup>			
M5	119.4 ±13.3 <sup>a</sup>	135.7 ±29.3 <sup>ab</sup>	116.0 ±32.4 <sup>ab</sup>	145.4 ±12.0 <sup>ab</sup>			
M6	124.9 ±11.2 <sup>a</sup>	133.9 ±21.2 <sup>a</sup>	111.7 ±23.8 <sup>a</sup>	135.4 ±24.9 <sup>a</sup>			
SAP (mmHg)					0.137	<0.001	<0.001
M0	112.2 ±14.6 <sup>a</sup>	109.6 ±21.2 <sup>a</sup>	105.0 ±17.0 <sup>a</sup>	116.2 ±25.7 <sup>a</sup>			
M1	140.4 ±25.5 <sup>a</sup>	132.9 ±18.2 <sup>a</sup>	120.5 ±13.6 <sup>a</sup>	127.1 ±22.2 <sup>a</sup>			
M2	128.9 ±27.0 <sup>a</sup>	128.9 ±16.4 <sup>a</sup>	115.7 ±17.9 <sup>a</sup>	112.3 ±20.0 <sup>a</sup>			
M3	174.0 ±20.4 <sup>a</sup>	153.7 ±29.8 <sup>a</sup>	177.9 ±28.4 <sup>a</sup>	157.9 ±20.9 <sup>a</sup>			
M4	173.4 ±20.0 <sup>a</sup>	173.7 ±20.2 <sup>a</sup>	155.9 ±33.5 <sup>a</sup>	157.7 ±26.4 <sup>a</sup>			
M5	183.1 ±26.3 <sup>a</sup>	176.0 ±21.2 <sup>a</sup>	161.3 ±41.1 <sup>a</sup>	160.4 ±28.6 <sup>a</sup>			
M6	184.6 ±26.7 <sup>a</sup>	176.7 ±19.7 <sup>a</sup>	160.4 ±32.5 <sup>a</sup>	164.1 ±27.2 <sup>a</sup>			
MAP (mmHg)					<0.001	<0.001	<0.001
M0	68.6 ±10.6 <sup>a</sup>	70.9 ±16.5 <sup>a</sup>	67.2 ±8.0 <sup>a</sup>	66.7 ±7.4 <sup>a</sup>			
M1	110.4 ±22.0 <sup>a</sup>	99.3 ±14.2 <sup>a</sup>	83.2 ±7.3 <sup>ab</sup>	85.8 ±15.2 <sup>ab</sup>			
M2	90.3 ±27.2 <sup>a</sup>	93.2 ±10.7 <sup>a</sup>	72.2 ±23.1 <sup>a</sup>	78.8 ±16.5 <sup>a</sup>			
M3	139.7 ±18.5 <sup>a</sup>	119.3 ±12.8 <sup>abc</sup>	128.1 ±21.7 <sup>abcd</sup>	108.1 ±14.8 <sup>abd</sup>			
M4	136.1 ±15.0 <sup>a</sup>	124.2 ±10.5 <sup>ac</sup>	109.7 ±19.8 <sup>bc</sup>	107.6 ±13.9 <sup>ab</sup>			
M5	135.7 ±19.2 <sup>a</sup>	119.4 ±10.9 <sup>ab</sup>	112.2 ±18.5 <sup>ab</sup>	106.4 ±17.6 <sup>ab</sup>			
M6	140.8 ±27.3 <sup>a</sup>	120.4 ±10.5 <sup>a</sup>	115.0 ±19.6 <sup>a</sup>	112.0 ±25.2 <sup>a</sup>			
DAP (mmHg)					<0.001	<0.001	<0.001
M0	52.9 ±8.0 <sup>a</sup>	55.0 ±13.8 <sup>a</sup>	56.8 ±10.5 <sup>a</sup>	50.1 ±4.2 <sup>a</sup>			
M1	91.6 ±20.2 <sup>a</sup>	83.9 ±14.3 <sup>a</sup>	69.4 ±8.7 <sup>ab</sup>	63.0 ±10.2 <sup>ab</sup>			
M2	77.4 ±26.9 <sup>a</sup>	77.6 ±8.0 <sup>a</sup>	68.2 ±12.0 <sup>a</sup>	64.3 ±14.6 <sup>a</sup>			
M3	120.4 ±29.4 <sup>a</sup>	99.0 ±12.9 <sup>a</sup>	101.6 ±18.3 <sup>a</sup>	80.8 ±10.2 <sup>ab</sup>			
M4	105.9 ±23.0 <sup>a</sup>	99.1 ±11.7 <sup>a</sup>	89.4 ±14.9 <sup>a</sup>	79.8 ±12.1 <sup>a</sup>			
M5	109.9 ±34.0 <sup>ab</sup>	98.8 ±13.9 <sup>ab</sup>	90.4 ±12.7 <sup>ab</sup>	78.6 ±13.9 <sup>a</sup>			
M6	111.9 ±37.8 <sup>a</sup>	94.2 ±6.7 <sup>a</sup>	94.7 ± 14.0 <sup>a</sup>	75.6 ± 13.7 <sup>ab</sup>			

\*Described by mean ± standard deviation or median (minimum-maximum); <sup>a, b, c, d</sup> Equal letters do not differ by the Tukey test at 5% significance.

It has been reported in anesthetized dogs that increasing the traction force of the ovary and ovarian ligament resulted in progressively increases in the intensity of the noxious stimulus (BOSCAN et al., 2011). In the present study, the lower values of MAP and DAP observed in the VA and VP groups at M1 and M2 suggested the occurrence of lower nociceptive stimulation during OH in these groups (DEVITT et al., 2005). These findings may have resulted from minimal traction forces of the ovarian ligament required during videolaparoscopic surgery. Due to particularities of

each surgical technique, time points M1 and M2 were associated to different noxious stimuli in the CA and CP groups (ligation and section of the first ovarian arteriovenous complex followed by ligation and section of the cervix) as compared to the VA and VP groups (manipulation of the uterine cervix followed by the ovarian arteriovenous complex). Although, this design might have biased the results of this study, the authors considered unlikely that this was the determining factor for the higher MAP and DAP values recorded in the CA and CP groups

because the highest MAP values in all groups were observed at M1, regardless of the structure being manipulated.

During the postoperative period (M3 to M6), all groups presented hypertension ( $SAP \geq 150$  mmHg). However, mild hypertension ( $SAP 150-159$  mmHg) was observed in the VP group as compared to severe hypertension ( $SAP > 180$  mmHg) in the CA group (BROWN et al., 2007). These findings indicated that both the age range (KUSTRITZ, 2014) and the use of videolaparoscopic surgery (FERANTI et al., 2016) are associated with lower levels of hypertension during the postoperative period in dogs undergoing OH. High blood pressure may result from acute pain (MURREL, 2008). Nevertheless, all animals in this study received analgesics considered adequate for the management of pain associated to OH in dogs (FERANTI et al., 2016). Only 6 out of 40 animals presented with clinical signs of postoperative pain and were administered rescue analgesia.

## CONCLUSION

Pediatric bitches submitted to laparoscopic OH with 6 mmHg inflation pressure of  $CO_2$  do not develop higher  $ETCO_2$ ,  $PaCO_2$ , or  $Pa-ETCO_2$  values than adult bitches undergoing the same surgical procedure. Higher PIP values are required to maintain normocapnia in bitches undergoing laparoscopic OH compared to conventional OH. Laparoscopic OH in pediatric bitches appeared to result in lower blood pressure increases in response to surgical stimulation and lower levels of postoperative arterial hypertension as compared to conventional OH in adult bitches.

## BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

This study was approved by the by the Ethics Committee for Animal Use (CEUA) of Universidade Federal do Rio Grande do Sul (UFRGS), (protocol number 26609).

## DECLARATION OF CONFLICTING OF INTERESTS

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## AUTHORS' CONTRIBUTIONS

LBQ, ERM and CACB conceived and designed experiments. LBQ, GMS, FRS, LMF, VSM, METRT, GFLD e DCC performed the experiments, SFV carried out the lab analyses. LBQ, CACB and ERM prepared the draft of the manuscript. All authors critically revised the manuscript and approved of the final version.

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