Influence of body weight and body conformation on the pressure-volume curve during capnoperitoneum in dogs

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OBJECTIVE

To evaluate the pressure-volume relationship during capnoperitoneum in dogs and effects of body weight and body conformation.

ANIMALS

86 dogs scheduled for routine laparoscopy.

PROCEDURES

Dogs were allocated into 3 groups on the basis of body weight. Body measurements, body condition score, and body conformation indices were calculated. Carbon dioxide was insufflated into the abdomen with a syringe, and pressure was measured at the laparoscopic cannula. Volume and pressure data were processed, and the yield point, defined by use of a cutoff volume (COV) and cutoff pressure (COP), was calculated.

RESULTS

20 dogs were excluded because of recording errors, air leakage attributable to surgical flaws, or trocar defects. For the remaining 66 dogs, the pressure-volume curve was linear-like until the yield point was reached, and then it became visibly exponential. Mean ± SD COP was 5.99 ± 0.805 mm Hg. No correlation was detected between yield point, body variables, or body weight. Mean COV was 1,196.2 ± 697.9 mL (65.15 ± 20.83 mL of CO_2/kg), and COV was correlated significantly with body weight and one of the body condition indices but not with other variables.

CONCLUSION AND CLINICAL RELEVANCE

In this study, there was a similar COP for all dogs of all sizes. In addition, results suggested that increasing the abdominal pressure after the yield point was reached did not contribute to a substantial increase in working space in the abdomen. No correlation was found between yield point, body variables, and body weight. (*Am J Vet Res* 2017;78:631–637)

During the interim since the first minimally invasive cholecystectomy was performed,[1,2] laparoscopic procedures have become state-of-the-art options for various surgical procedures in human and veterinary medicine.[3] Shorter postoperative recovery time, reduced postoperative pain,[4] and fewer disturbances in wound healing[5,6] are only some of the advantages for laparoscopic surgery,[7] compared with results for open surgery.

The abdomen usually is insufflated with CO_2 during laparoscopic procedures, which results in capnoperitoneum. Although insufflators usually deliver CO_2 intra-abdominally until a predetermined IAP has been reached, the working space created in the abdomen during laparoscopy depends mainly on the volume of CO_2 that can be injected and not on the IAP that has been attained per se. Guidelines for human medicine[8,9] recommend that a safe value for IAP is ≤ 15 mm Hg. Although similar IAP recommendations have been adopted for veterinary surgery,[10,11] specific guidelines that take into account the wide variety of sizes and shapes in small animal patients are lacking.[12] Furthermore, deleterious complications of high IAPs have been described in human and veterinary medicine.[13–15] These complications include subcutaneous or mediastinal emphysema, pneumothorax, cardiac arrhythmias followed by hypotension, and hypoxemia leading to organ failure attributable to IAP-induced hypovolemia, and they should be avoided.

Although experienced surgeons with advanced surgical skills may be able to perform surgical procedures in abdominal cavities at low IAPs or may additionally or even solely use the abdominal wall lift method,[16,17] most surgeons increase the IAP to obtain more working space. Lack of working space in the abdominal cavity can hamper the surgical view and force surgeons to convert to open laparotomy. Therefore, obtaining adequate working space at a limited IAP is of utmost importance.

It has been suggested that even standard IAPs may cause complications in small dogs,[3,10,11] similar to

ABREVIATIONS

BCI	Body conformation index
BCS	Body condition score
COP	Cutoff pressure
COV	Cutoff volume
IAP	Intra-abdominal pressure

complications reported in pediatric surgery.[18] Thus, it can be suspected that the same IAP might provide insufficient working space in larger animals.

In humans, the relationship between IAP and volume of CO_2 injected was evaluated in obese patients, and the effects of various patient positions on intra-abdominal space were also evaluated.[19] That study[19] indicated that patients in the beach-chair position (semisitting) had significantly higher intra-abdominal volume than did patients in supine or reverse Trendelenburg positions, whereas the IAP was not significantly different among these positions.

Despite its relevance to the creation of safety guidelines for use in laparoscopic surgery, the pressure-volume curve has not been studied in companion animals, to our knowledge. Therefore, the objective of the study reported here was to evaluate the pressure-volume curve for dogs of various breeds and BCSs during capnoperitoneum. One hypothesis was that the volume of CO_2 insufflated would have a linear relationship with IAP until, at a given IAP threshold, a yield point would be reached, above which further insufflation would cause an exponential increase in IAP. A second hypothesis was that the yield point would be influenced by a dog's body weight, BCIs, and BCS.

Materials and Methods

Animals

The prospective study population consisted of 86 dogs admitted to the Clinic for Small Animal Surgery of the Veterinary University of Vienna between October 2013 and May 2014 for routine diagnostic or therapeutic laparoscopy. Patients admitted for elective laparoscopic ovariectomy, ovariohysterectomy, biopsy, cryptorchid castration, gastropexy, and laparoscopic exploration were included. Unstable patients not amenable to sustaining capnoperitoneum or dogs with preoperative or intraoperative abnormalities of the abdomen (eg, uterine abnormalities, herniations, large intra-abdominal masses, ascites, and massive adhesions attributable to previous surgery) were excluded. All owners provided informed consent. The study was discussed and approved by the institutional ethics committee in accordance with Good Scientific Practice guidelines and national legislation (approval No. 23/03/97/2012).

Group allocations and body measurements

Dogs were allocated into 3 weight groups (< 11 kg, 11 to 30 kg, and > 30 kg). Dogs were further categorized on the basis of BCS (scale, 1 [extremely thin] to 9 [extremely obese])[20] and BCIs.[21]

Trunk circumferences, body height, and body length were measured in nonsedated dogs in a standing position **(Figure 1)**. Circumference of the thorax (C1) was measured at the caudal angle of the dorsal margin of the scapulae, whereas circumference of the middle aspect of the trunk (C2) and caudal aspect of the abdomen (C3) was measured at the xiphoid process and tuber coxae, respectively.[22] Two height measurements were obtained at a right angle to the floor. Height was measured from the floor to the cranial angle of the dorsal border of the scapulae (H1) and from the floor to the cranial dorsal iliac spine of the tuber sacrum (H2).[22] Length (L1) was defined as the distance between H1 and H2. In addition, length of the thoracic cavity (L2) was defined as the distance between H1 and the xiphoid process, and length of the abdominal cavity (L3) was defined as the distance between the xiphoid process and H2. These measurements did not comprise the natural anatomic limits of the thorax and abdominal cavity, and they were used as comparable reference measurements for index calculation only.

Five BCIs were created to provide proportions for comparison among dogs of various sizes. The BCIs consisted of mathematical combinations of the aforementioned measurements, as follows: BCI 1 = L1/H2; BCI 2 = C2/C3; BCI 3 = (L1/H2) + (C2/C3); BCI 4 = (L1/H1) + (C1/C3); and BCI 5 = (L1/H1) + (C2/C3).

Anesthesia

Food was withheld from each dog for 8 hours before anesthesia. A standard anesthesia protocol (American Society of Anesthesiologists) for patients undergoing laparoscopy was used. Premedication consisted of IM administration of methadone (0.1 to 0.2 mg/kg) and acepromazine maleate (0.01 to

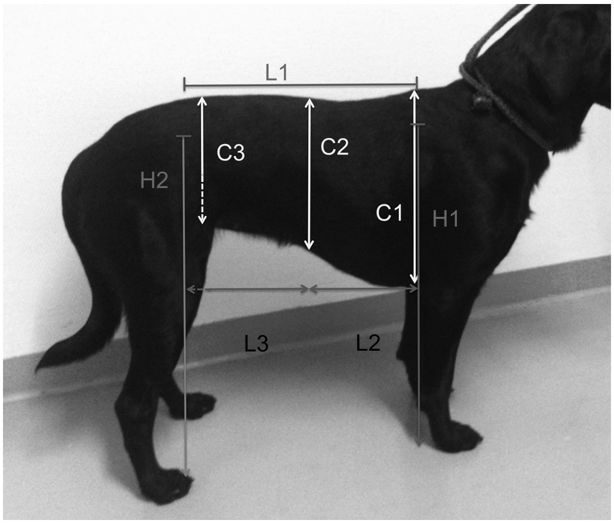

Figure 1—Photograph of a representative dog and measurements obtained for conformation analysis. C1 = Circumference of the thorax. C2 = Circumference of the middle aspect of the trunk, measured at the xiphoid process. C3 = Circumference of the caudal aspect of the abdomen measured at the tuber coxae. H1 = Height measured at the cranial angle of the dorsal border of the scapulae. H2 = Height measured at the cranial dorsal iliac spine of the tuber sacrum. L1 = Length. L2 = Length of the thoracic cavity. L3 = Length of the abdominal cavity. These measurements did not comprise the natural anatomic limits of the thorax and abdominal cavity, and they were used as comparable reference measurements for index calculation only.

0.02 mg/kg). Anesthesia was induced by IV injection of propofol (to effect) and maintained by administration of isoflurane in oxygen. For analgesic purposes, a constant rate infusion of fentanyl (0.02 mg/kg/h) was administered to each dog. All patients were ventilated with volume-controlled ventilation at a breathing rate of 14 breaths/min (with possible modifications to maintain normocapnia) and tidal volume of 12 mL/kg. Maximal pulmonary pressure during abdominal insufflation was 15 cm H_2O.

Laparoscopic procedures

The bladder of each anesthetized dog was emptied by manual expression. Dogs were clipped of hair and aseptically prepared for surgery and then placed in dorsal recumbency on a horizontal table. A modified Hasson technique with a blunt balloon trocar[a] was used to make the initial entry into the abdominal cavity. A 1.5-cm skin incision was made caudal to the umbilicus. The linea alba was identified, and 2 traction sutures[b] were placed in the fascia of the rectus abdominis muscle. The muscular layer was incised, and the peritoneum was identified and punctured. The blunt trocar tip was moistened with saline (0.9% NaCl) solution and introduced into the abdominal cavity. The balloon of the trocar was inflated with 10 mL of air, and the trocar was pulled outward until contact between the balloon and the peritoneum lining the inner abdominal wall was felt. The gel cushion on the outer part of the cannula was then lowered until it adhered tightly to the skin, and then it was affixed in position with the locking device. Traction sutures were inserted on each side of the cannula to ensure maximal tightness. The trocar was then removed, which left the cannula in place. One finger was removed from a size 6 latex glove and pulled over the dorsal opening of the cannula to prevent leakage from the cannula valve.

The lateral plug valve of the cannula was then connected via flexible silicon tubes and a 3-way stopcock to a pressure-measuring transducer[c] that had been precalibrated to atmospheric pressure by use of a water column scale **(Figure 2)**. The transducer was connected via three 3-way stopcocks to a syringe (50 mL,[d] 125 mL,[e] and 250 mL,[e] depending on the size of the dog [a 250-mL syringe[e] was modified and calibrated to create the 125-mL syringe]). All dogs > 10 kg were insufflated with the 250-mL syringe. Each syringe was also connected (via a 3-way stopcock) to a laparoscopic insufflator.[f] The pressure-measuring transducer[c] was linked to a computer[g] loaded with a commercial software program.[h] The transducer[c] transformed pressure values into acoustic values and transmitted them through a serial interface[c] to the computer,[g] where they were transformed back into pressure values and recorded by pressure-recording software.[i]

Baseline IAP was measured and recorded with the stopcock closed toward the syringe and insufflator (the second stopcock was closed toward the water scale, and the other stopcock was opened toward the cannula and the dog throughout the entire measurement; Figure 2). The insufflator was then used to fill the syringe with CO_2 (stopcock toward the dog and pressure-recording transducer remained closed). The stopcock was closed toward the insufflator and opened between the syringe and dog, and CO_2 insufflation was performed by emptying the volume of the syringe (4 dogs with a single 50-mL syringe, 22 dogs with a single 125-mL syringe, 57 dogs with a single 250-mL syringe, 1 dog with a combination of a 125- and a 250-mL syringe, and 2 dogs [> 60 kg] with two 250-mL syringes). The stopcock was then closed to interrupt the connection toward the syringe and insufflator to ensure correct measurements.

There was a pause (lag phase) of ≥ 15 seconds between successive CO_2 insufflations, except for the first dog (lag phase of only 5 seconds) and dogs 2 through 8 (lag phase of 10 seconds). Each insufflation procedure was repeated incrementally until the IAP exceeded 15 mm Hg.

When the IAP exceeded 15 mm Hg, the cannula was disconnected from the transducer and syringe and directly connected to the insufflator, and CO_2 was allowed to exit the abdominal cavity until the IAP decreased to 8 mm Hg. The elective surgical procedure then was performed in a routine manner.

Throughout the procedures, insufflation was interrupted when signs of adverse effects of capnoperitoneum were detected by the anesthetist. Dogs for which there were technical problems, method or measurement errors (eg, CO_2 leakage), or recording problems were excluded from the study.

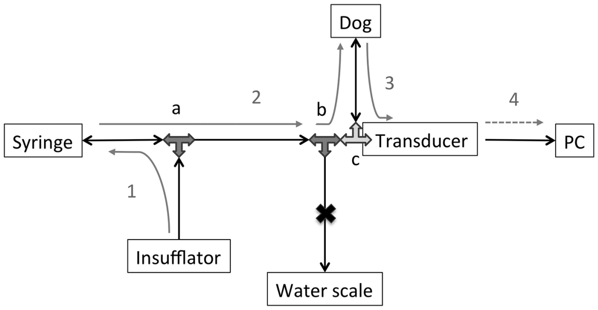

Figure 2—Schematic depiction of airflow through flexible silicon tubes and a cannula inserted into each dog for laparoscopic surgery. 1 = Activation of the insufflator, which fills the syringe with CO_2. The insufflation system is closed (stopcock a) toward the dog and pressure-recording transducer. 2 = Stopcock a is closed toward the insufflator and opened toward the dog. Stopcocks b and c are opened toward the syringe and dog and closed toward the water scale during the procedure. Stopcock c is incorporated into the transducer device. The CO_2 in the syringe is emptied into the abdomen. After the syringe is empty, stopcock a is immediately closed. 3 = The transducer receives pressure measurements from the abdomen. 4 = The transducer transmits the pressure measurements to pressure-recording software in the personal computer (PC).

Analysis of pressure data

Recorded IAP data were converted into text files and processed with a motion analysis program.[j] The program created a graph that revealed the stepwise increase in the IAP, which was initiated by an extremely high pressure peak attributable to insufflation via syringe injection of CO_2 **(Figure 3)**. Each increment represented a pressure reading resulting from injection of the predetermined CO_2 volume. The pressure plateau between 2 insufflations corresponded to the lag phase. The smaller pressure elevations during the lag phase represented peaks attributable to the volume-controlled ventilation. A low-pass filter (frequency, 0.2 Hz) was used to reduce the influence of the volume-controlled ventilation. To eliminate insufflation disturbances in the collection of IAP data, there was a minimal interval of 1 second after every insufflation peak before each measurement interval. After the 1-second interval, pressure data for the following 5 seconds were used for further evaluation, which resulted in 50 measurement points/lag phase. By use of these 50 pressure values, a mean IAP value was calculated for each lag phase.

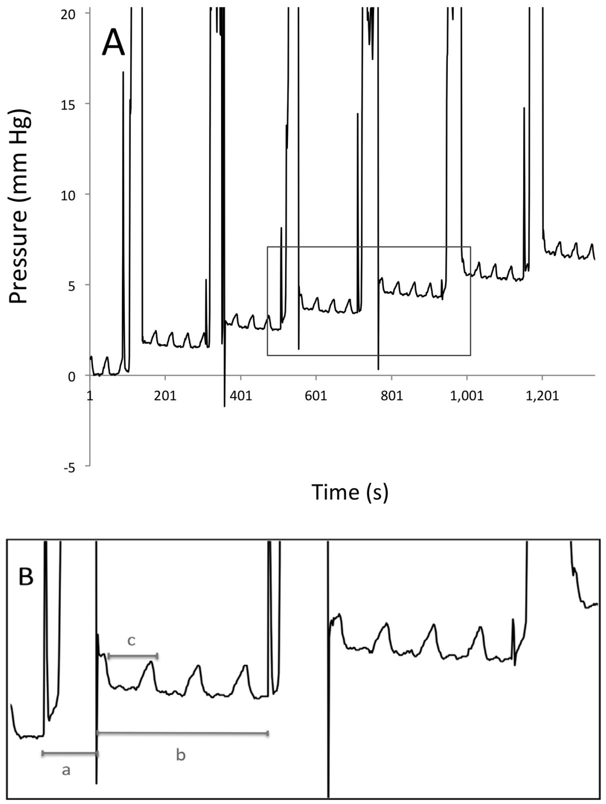

Figure 3—Representative pressure curve generated during data processing by a motion analysis program (A) and an enlargement of a portion of the pressure curve (B). In panel A, notice the stepwise increases in pressure attributable to successive injections of predetermined volumes of CO_2. In panel B, the pressure curve is initiated by an extremely high pressure peak attributable to insufflation of CO_2 (insufflation phase [a]). There is a pressure plateau between 2 insufflations (lag phase [b]). Data were collected during the measurement phase (c).

Mean IAP values were plotted against their corresponding volume values **(Figure 4)**. Analysis of the data resulted in the exponential function $y = e^x$, where y is IAP, e is a mathematical constant (Euler number), and x is the volume of CO_2.

Determination of the yield point at which further insufflation would result in an exponential increase in IAP was one of the study objectives. The IAP threshold at which the yield point was reached was defined as the COP, and the corresponding volume was defined as the COV.

To determine COP, a capacitor discharging function evaluation was used, as has been described for spirometry curve analysis.[23] The slope between the last 2 measured points on the exponential curve was calculated and inserted into the following tangential function to identify the COP and COV points: $\int(p) = kV + d$, where p is the IAP, k is the slope between the last 2 measured points, V is volume, and d is the intercept of the y-axis. Volume was calculated as $V = -d/k$; as a consequence of $\int(p) = 0$, volume was equivalent to the COV.

The nearest volume value to the calculated COV was identified in the data, and its corresponding mean IAP value was chosen as the COP value (Figure 4).

Statistical analysis

Statistical analysis was performed by use of available software.[k] All applicable test assumptions were met. The Kolmogorov-Smirnov test was used to evaluate the data distribution; data were normally distributed. Correlation evaluation between mean COP and mean COV values was performed by use of Pearson or Spearman correlation for categorical parameters. An ANOVA with Bonferroni α correction as a post hoc procedure was used to evaluate the difference between body weight groups for the calculated BCI, mean COV, and COP data. Results were reported as mean ± SD. Values of $P < 0.05$ were considered significant.

Results

Of 86 dogs originally enrolled in the study, 20 were excluded because of recording errors, air leakage attributable to surgical flaws, or trocar defects. None of the patients was excluded because of anesthetic complications caused by capnoperitoneum. Thus, data for 66 animals (64 females and 2 males) were used in the study (21 dogs that weighed < 11 kg, 38 dogs that weighed 11 to 30 kg, and 7 dogs that weighed > 30 kg). Dogs weighing < 11 kg comprised 8 mixed-breed dogs, 4 Pugs, 2 Parson Jack Russell Terriers, and 1 each of Chihuahua, Cocker Spaniel, Dachshund, French Bulldog, Havenese, Maltese, and West Highland White Terrier. Dogs weighing 11 to 30 kg comprised 14 mixed-breed dogs, 6 Labrador Retrievers, 3 Border Collies, 3 Boxers, 2 American Staffordshire Terriers, and 1 each of Bearded Collie, Dutch Shepherd Dog, Elo, English Bulldog, Entlebucher Mountain Dog, German Shepherd Dog, Golden

Retriever, Irish Terrier, Magyar Viszla, and Small Munsterlander. Dogs weighing > 30 kg comprised 1 mixed-breed dog and 1 each of German Shepherd Dog, German Shorthair Pointer, Golden Retriever, Great Dane, Labrador Retriever, and Leonberger.

After the procedures were performed on the first 10 dogs, only 125- or 250-mL syringes were used for insufflation because use of the 50-mL syringe resulted in an unnecessarily prolonged insufflation time. Plotting of the volume-pressure relationship resulted in an exponential curve for all dogs in the study. There was an obvious steep increase in pressure after a certain pressure point was reached. The injected volume differed significantly ($P < 0.001$) among the 3 weight groups, but pressure did not differ significantly ($P = 0.316$) among the 3 weight groups.

Mean ± SD COV was 1,196.2 ± 697.9 mL (range, 164.6 to 4,104.8 mL), which equated to 65.2 ± 20.8 mL of CO_2/kg (range, 22.0 to 107.8 mL of CO_2/kg; **Table 1**). Mean COP was 5.99 ± 0.81 mm Hg (range, 4.04 to 8.52 mm Hg). Results of an ANOVA confirmed that there were significant differences among the 3 weight groups for COV but not for COP.

A significant correlation was detected between COV and body weight and COV and BCI 1, but not between COV and BCS or the other BCIs. None of the variables were correlated with COP. Significant correlations were also detected between body weight and BCI 1 ($r = -0.414$; $P = 0.001$) and between body weight and BCI 4 ($r = -0.247$; $P = 0.046$)

Discussion

Analysis of results for the present study revealed a linear-like relationship between the volume of CO_2 injected and the IAP until a given threshold at a yield point (mean ± SD COP, 5.99 ± 0.805 mm Hg; range, 4.04 to 8.52 mm Hg) was reached. Further insufflation of volume increments resulted in a more pronounced increase in IAP.

The pressure-volume curve has been evaluated by use of pigs.[24,25] However, those studies did not include investigation of the COP. Investigators in another study[12] compared abdominal distension in cats by measuring circumferential diameter, height, and width at various IAPs; the authors also assessed the increase in working space

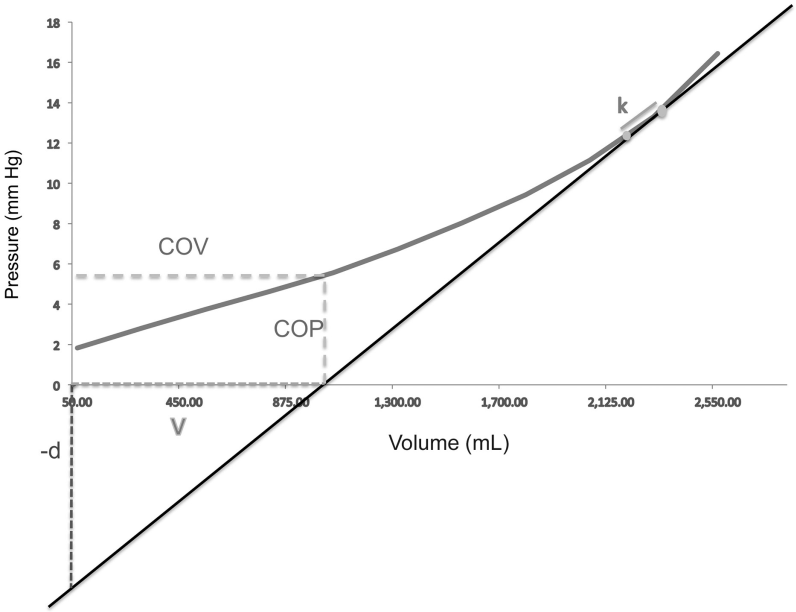

Figure 4—Representative graph of a volume-pressure curve with the exponential function $y = e^x$, where y is the IAP, e is a mathematical constant (Euler number), and x is the volume of CO_2. A black line passes tangentially through the last 2 measurement values (circles); slope of that line between the last 2 measurement points (gray bar) and y-axis values are derived from the following tangential formula: $\int(p) = kV + d$, where p is the IAP, k is the slope between the last 2 measured points, V is volume, and d is the intercept of the y-axis. The slope between the last 2 measurement points was inserted into the tangential function (gray line) to identify the COP and COV points. The intercept of the black line and x-axis corresponds to the V = COV value. The COP was derived from the corresponding COV.

Table 1—Mean or mean ± SD and range values for COV and COP for 66 dogs after insufflation of CO_2 during laparoscopic elective surgery.

Variable	Body weight (kg)	n	Mean	Range
COV (mL of CO_2/kg)*	< 11	21	77.4	22.0–107.8
	11–30	38	59.2	15.4–107.6
	> 30	7	61.0	44.8–68.8
	Total	**66**	**65.2**	**22.0–107.8**
COV (mL of CO_2)†	< 11	21	583.0 ± 197.2	164.7–987.8
	11–30	38	1,292.0 ± 413.8	429.4–2,691.0
	> 30	7	2,515.0 ± 829.9	1,532.8–4,104.8
	Total	**66**	**1,196.2 ± 697.9**	**164.6–4,104.8**
COP (mm Hg)	< 11	21	6.15 ± 0.97	4.23–8.52
	11–30	38	5.86 ± 0.78	2.53–7.29
	> 30	7	6.22 ± 0.66	4.96–6.78
	Total	**66**	**5.99 ± 0.81**	**4.04–8.52**

†Value differs significantly ($P < 0.004$; †$P < 0.001$) among body weight groups.

by subjective analysis of still images and video recordings. A large gain in working space was observed between 4 and 8 mm Hg, and a smaller gain was observed between 8 and 15 mm Hg. Although this is in accordance with findings for the study reported here, intra-abdominal volume measurement was not evaluated in that study.[12] For the present study, increases in pressure above the mean ± SD COP of 5.99 ± 0.805 mm Hg resulted in gains in intra-abdominal volume that were increasingly smaller in relation to the increase in IAP.

We hypothesized that the COP would be influenced by patient body weight and BCIs; however, this was not proven in the present study. The COP values in this study remained far below the current recommended maximal guidelines for laparoscopic surgery in small animals.[3,10,11] On the basis of this result, one should question whether the previously recommended IAP values for small animal laparoscopy should be revised. In addition, results for the present study clearly indicated that neither body weight nor conformation indices influenced the COP. This finding was of utmost importance because it has been recommended[11,26] that the IAP be minimized in smaller animals, and many surgeons tend to work with higher pressures in larger animals because of the lack of guidelines. Therefore, these results suggested that, at least in dogs, there is little benefit in increasing the IAP above the COP independent of body weight and BCIs.

To evaluate the influence of body conformation, BCIs were calculated by use of body measurements. Additional BCS variables were also evaluated, thus eliminating possible interference of the measurements attributable to body fat accumulation or muscle mass. Even though morphometric measurements used in the study reported here were slightly restricted because errors in detecting bony prominences can occur in overweight patients, results for the present study clearly indicated that neither body mass nor body circumferences influenced the COP.

In the study reported here, a modified Hasson entry technique with a balloon trocar–cannula was used to ensure tight contact between the cannula and abdominal wall, which thus limited the risk of leakage. Although investigators of previous studies[12,25] delivered a specific volume of CO_2 into the abdomen, insufflators usually deliver volumes at a minimum of 1-L increments. In contrast, the syringe method[27] used in the present study enabled precise measurement of the injected volume and collection of a sufficient number of data points. It would not have been possible to record low IAP values in small and midsized dogs with the use of only a standard insufflator instead of an additional transducer. In addition, accuracy of the volume and pressure measurements displayed for insufflators has been challenged.[9,12] This was the reason the IAP was measured by use of a direct connection to the abdomen in the present study.

Data for the study reported here indicated an extremely small but continuous decrease of IAP during each additional CO_2 increment. One reason could have been a small amount of leakage around the cannula or at the connections between the cannula, transducer, and syringe. Another explanation could have been adaptation of the abdominal wall attributable to increased compliance after injection of a given volume of CO_2. Increased compliance of the abdominal wall has been detected in another study.[24] In fact, it has been suggested[28] that stretching the abdomen before surgery by injecting a high volume of CO_2 very quickly and then deflating the abdomen before the surgical procedures can increase overall abdominal compliance and increase the working space at lower IAPs. It should be mentioned that when the IAP exceeds 10 mm Hg, it typically will decrease for 1 to 2 seconds and adapt shortly thereafter to a constant value. Whether this reflects the natural behavior of the abdominal wall at higher IAPs is not known.

Differences in abdominal compliance among animals have been suggested for cats.[12,26] In the present study, the number of dogs of each breed was too small to enable statistical analysis. Additional studies involving homogenous groups or breeds would be necessary to evaluate such influences on COV or COP.

Another important factor was the composition of the study population with regard to age and medical status because most of the dogs included in this study were healthy (American Society of Anesthesiologists grade 1 or 2) patients undergoing elective surgery. The influence of age or underlying diseases on the pressure-volume curve was not evaluated in this study.

Findings for the present study indicated that increasing the IAP after the COP has been reached results in minimal gains in volume and working space. This should help surgeons avoid the use of an unnecessarily high IAP during laparoscopic surgery and limit adverse effects of capnoperitoneum. Results of this study could serve as a foundation for evaluation of factors that might aid in increasing working space in the abdominal cavity without increasing the IAP.

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Footnotes

a. Kii balloon blunt tip system, 12 X 100 mm, Applied Medical, Rancho Santa Margarita, Calif.
b. Biosyn 2-0, Covidien Animal Health, Plymouth, Minn.

c. TruWave disposable pressure transducer serial interface RS232, Edwards Lifesciences Corp, Irvine, Calif.
d. Original Perfusorpritze, 50 mL, No. 8728844F, B. Braun Vet Care GmbH, Kronberg, Germany.
e. Drenching syringe, 250 mL, No. 54217, Ukal Elevage, Eschbach, France.
f. Endo-Arthroflator insufflator, Karl-Storz Tuttlingen, Germany.
g. Lenovo ThinkPad X131e with Radeon HD graphics, 1.7 GHz, Lenovo, Morrisville, NC.
h. Windows 7 Professional, version 6.1, Microsoft Corp, Redmond, Wash.
i. Buzzer Datalogger, version 2.00 alpha, Universiätsklinik für Anästhesie und Intensivmedizin, Innsbruck, Austria.
j. SIMI Motion 3D, Simi Reality Motion Systems GmbH, Unterschleißheim, Germany.
k. SPSS, version 14.0, SPSS Inc, Chicago, Ill.

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