Retroperitoneal Laparoscopy in Dogs: Access Technique, Working Space, and Surgical Anatomy

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Submitted March 2016
Accepted September 2016

DOI:10.1111/vsu.12571

Objective: To develop and describe a laparoscopic retroperitoneal access technique, investigate working space establishment, and describe the surgical anatomy in the retroperitoneal space as an initial step for clinical application of retroperitoneal laparoscopy in dogs.
Study Design: Cadaveric and experimental study.
Animals: Cadaveric (n=8) and healthy (n=6) adult dogs.
Methods: The retroperitoneal access technique was developed in 3 cadavers based on the human technique and transperitoneal observation. Its application and working space establishment with carbon dioxide (CO_2) insufflation alone was evaluated in 5 cadavers by observing with a transperitoneal telescope and in 6 live dogs by repeated computed tomography (CT) scans at pressure of 0, 5, 10, and 15 mmHg. Recordings of retroperitoneoscopy as well as working space volume and linear dimensions measured on CT images were analyzed.
Results: Retroperitoneal access and working space establishment with CO_2 insufflation alone were successfully performed in all 6 live dogs. The only complication observed was in 1 dog that developed subclinical pneumomediastinum. As pressure increased, working space was established from the ipsilateral to the contralateral side, and peritoneal tearing eventually developed. Working space volume increased significantly from 5 mmHg and linear dimensions increased significantly from 0 to 10 mmHg. With pneumo-retroperitoneum above 5 mmHg, retroperitoneal organs, including kidneys and adrenal glands, were easily visualized.
Conclusion: The retroperitoneal access technique and working space establishment with CO_2 insufflation starting with 5 mmHg and increasing to 10 mmHg provided adequate working space and visualization of retroperitoneal organs, which may allow direct access for retroperitoneal laparoscopy in dogs.

In minimally invasive procedures, gaining appropriate access to the closed abdominal or thoracic cavity and establishing a proper working space for visualization and instrument manipulation are important initial steps to enable the surgeon to work efficiently. Retroperitoneal laparoscopy—direct access to the retroperitoneal space—is an attractive alternative to transperitoneal techniques for surgeries involving the retroperitoneal organs. In human medicine, retroperitoneal laparoscopic surgeries have been developed since the early 1990s and have become a standard procedure.[1–5]

The advantage of retroperitoneal laparoscopy is direct access to retroperitoneal organs without retraction of intra-abdominal organs, which allows surgeons to save time by avoiding adhesions from previous abdominal surgery.[1–5] Disadvantages mostly involve technical aspects, such as spatial limitations and unfamiliar anatomic landmarks that require the acquisition of new skills by surgeons. In addition, intra-abdominal exploration and the removal of large tumors are not possible. These limitations warrant appropriate patient selection.[1–5] Recent meta-analyses in people comparing transperitoneal and retroperitoneal approaches for nephrectomy and adrenalectomy found that the overall clinical outcomes were similar,[1–5] and that retroperitoneoscopic nephrectomy was superior to transperitoneal nephrectomy in operation time, blood loss, and hospitalization.[1,2] In addition, although there were no statistical differences between the 2 approaches for laparoscopic adrenalectomy,[3–5] some authors considered that retroperitoneoscopic adrenalectomy, if performed by experienced surgeons in selected patients, was superior.[3,5]

In small animals, most laparoscopic techniques including retroperitoneal organ surgeries have been performed using a transperitoneal technique.[6] Therefore, the evaluation of retroperitoneal laparoscopy in veterinary patients is warranted, considering the promising benefits in people. To the authors' knowledge, the only study describing retroperitoneoscopy in dogs was performed by medical doctors in 1979 as a technical feasibility study for clinical application in people.[7] In this study, the retroperitoneal space of 13 dogs was insufflated with nitrous oxide (N_2O) at 25–30 mmHg

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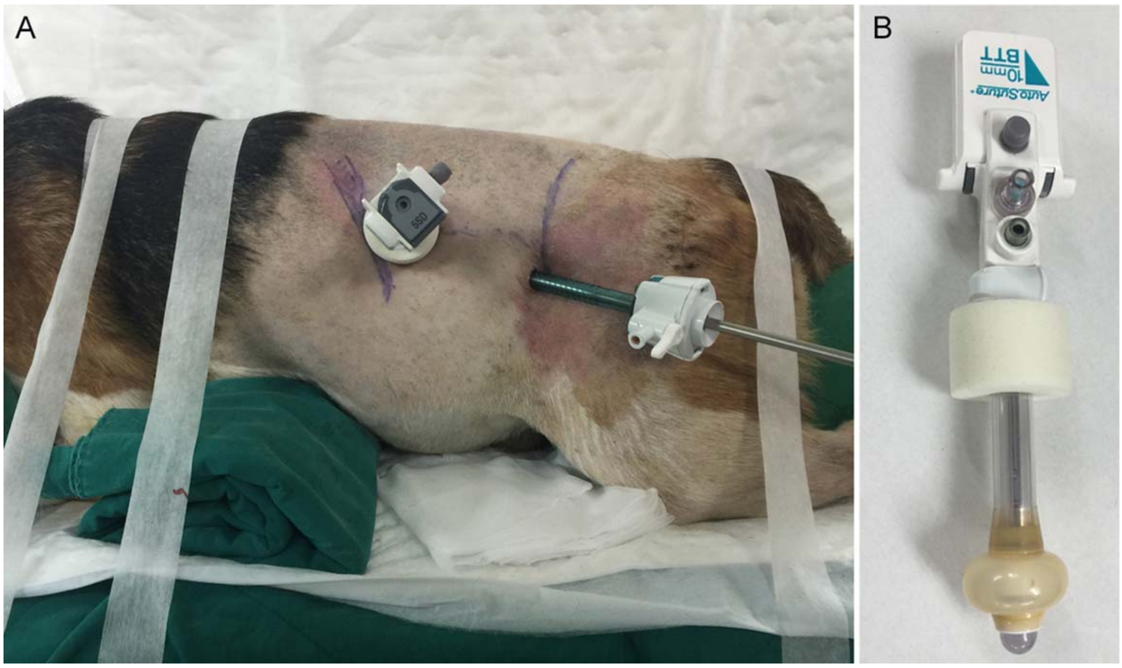

Figure 1 (A) A transperitoneal trocar was inserted cranial to the iliac crest for anatomic observation of the visceral peritoneum and retroperitoneal organs during the cadaveric study. A retroperitoneal trocar was placed at the level of the 2nd lumbar vertebrae on the right side and 3rd lumbar vertebrae on the left side in the cadaveric study. The most important landmark for this access is a transverse process of the vertebrae. (B) The 10 mm blunt-tip trocar with an inflatable balloon and an adjustable sleeve used for introduction into the retroperitoneal access site.

pressure through a 20 gauge spinal needle placed presacrally. Then, a renal biopsy using a single port was performed. The study showed that retroperitoneoscopy is feasible in dogs; however, the procedure was not designed or evaluated in the perspective of clinical application in veterinary patients.

The aim of this study was to develop and describe a retroperitoneal access technique, to investigate the establishment of working space, and to describe the surgical anatomy in the retroperitoneal space in dogs as an initial step for future clinical applications. We hypothesized that the retroperitoneal space could be accessed safely with an open-access technique on both sides and that adequate working space could be established with carbon dioxide (CO_2) insufflation alone at low pressure levels, providing direct access to retroperitoneal organs, especially the adrenal glands and the dorsal part of the kidneys.

MATERIALS AND METHODS

This study was approved by the Institutional Animal Care and Use Committee.

Pilot Study

Cadavers of intact male beagle dogs that had been euthanatized for purposes unrelated to this study (n=8) and had been previously frozen at −18°C were used. These dogs had no history of abdominal surgery and were of similar body size with a body condition score (BCS) of 4–5.[8] A 5 mm disposable trocar (Kii Shielded Bladed Access System, Applied Medical, Rancho Santa Margarita, CA) was placed in the peritoneal space cranially at the cranial margin of the iliac crest on each side and a 5 mm 0° telescope (Karl Stortz, Tuttlingen, Germany) was inserted for anatomic observation of the visceral peritoneum and retroperitoneal organs during the study (Fig 1A). The peritoneal space was insufflated with 5 mmHg pressure of CO_2 for visualization. The access technique for retroperitoneoscopy was established on the basis of the human technique[9] in the first 3 cadavers. In people, with the patient in the prone position to allow the ventral abdominal wall to hang with the abdomen suspended to facilitate gravitational displacement of the abdominal viscera, an incision is made just below the tip of the 12th rib—a landmark to locate the kidneys—and subsequent blunt and sharp dissection of the abdominal wall is performed to reach the retroperitoneal space. According to transperitoneal observation, the visceral peritoneum around the renal region extended particularly far in a ventral direction by suspended kidneys, farther than the other organs closely attached to the dorsal region of the abdomen. The visceral peritoneum was attached laterally to the abdominal wall between the dorsal and ventral margins of the kidneys, closer to the dorsal margin. The transverse process of a lumbar vertebrae was considered a palpable anatomic landmark to identify the upper margin of the kidney.

The developed technique was applied in the next 5 cadavers. The retroperitoneal space was approached in 3 cadavers from the right side and 2 cadavers from the left side. Cadavers were selected blindly and operated on by 1 surgeon (JMJ). Cadavers were positioned in sternal recumbency with the abdomen suspended to facilitate gravitational displacement of the abdominal viscera.[10] By placing cushions under the dog to elevate the chest and pelvic area, the abdomen was not in contact with the surgical table.[10] To access the renal region, a 1.5 cm vertical incision was created with a #15 scalpel blade starting from the point where the transverse process of the 3rd lumbar vertebra on the left side and the 2nd lumbar vertebra on the right side was palpated. The site of entry was expanded by blunt dissection with Metzenbaum scissors and digital palpation of the lateral margin of the transverse process was used to guide the scissors in the plane of the abdominal wall layers (oblique muscles, fatty tissues, and deeply lying transverse abdominal muscle), as described by Johnston et al.[11] The retroperitoneal space was entered with the Metzenbaum scissors by penetrating the deepest division of the thoracolumbar fascia. The soft fatty tissue around the kidney was felt upon entry, confirming that the retroperitoneal space had been entered successfully. Subsequently, a 10 mm blunt trocar with an inflatable balloon and an adjustable sleeve (Covidien, Dublin, Ireland) was introduced into the incision site (Fig 1B) and a 5 mm 0° telescope (Karl Stortz) was inserted into the access port to ensure that the tip of the trocar was within the retroperitoneal space. A 0° telescope was selected to provide the simplest spatial orientation similar to that of normal vision, considering unfamiliar orientation was one of technical challenges in people. The balloon was inflated to prevent leakage of CO_2, and the retroperitoneal space was established with CO_2 insufflation with an electronic CO_2 insufflator (Karl Stortz) starting with a pressure of 5 mmHg and increasing in 5 mmHg increments. Visualization was subjectively evaluated with the telescope using both the transperitoneal and retroperitoneal trocars.

Experimental CT Study

Six clinically healthy intact male beagle dogs were studied (approximate age, 3 years; mean body weight, 10.5 kg; range, 7.5–12.7; BCS, 4–6 out of 9).[8] Food was withheld from the dogs for 12 hours in preparation for anesthesia. An intravenous catheter was placed in the cephalic vein, dogs were premedicated with acepromazine (0.01 mg/kg IV), and anesthesia was induced with alfaxalone (5 mg/kg IV to effect) and maintained with isoflurane in oxygen. Compound sodium lactate solution (5 mL/kg/h) was administered intravenously. Urinary catheterization was performed to keep the bladder empty during scanning. Anesthetized dogs were positioned in sternal recumbency with a commercial patient positioning kit (Vacu-positioner kit, Shor-line, Kansas, MO) and secured with adhesive tape. Computed tomography (CT) was performed with a single-slice helical CT scanner (GE CT/e, General Electronic Medical Systems, Yokogawa, Japan). Scans were performed from the diaphragm to ischial tuberosities in a cranial to caudal direction with a 3 mm slice thickness. After the initial scanning as a baseline for comparison with subsequent scanning, the retroperitoneal space was approached aseptically with the above-described technique. Dogs were randomized to groups of left-sided (n=3) or right-sided (n=3) approaches. The working space was established with CO_2 insufflation by increasing the pressure within the retroperitoneal space from 0 mmHg to 5, 10, and 15 mmHg at a rate of 1 L/min. Scanning was carried out at each pressure level unless pneumoperitoneum occurred secondary to a peritoneal tear, at which point further CO_2 insufflation and scanning were aborted to prevent possible complications.

During the study, basic anesthetic monitoring was performed, including measurement of heart rate, respiratory rate, oxygen saturation as measured by pulse oximetry, noninvasive blood pressure, end-tidal CO_2, and body temperature using a multi-parameter monitor (Datex-Ohmeda S/5, GE Healthcare, Madison, WI). At each new pressure level, further scanning was paused for 5 minutes for stabilization of end-tidal CO_2 and monitoring of possible changes affected by pneumoretroperitoneum. At the study end, the trocar was removed and the port site closed with simple interrupted sutures with 3-0 polydioxanone and 4-0 polyamide in the fascia of the thoracolumbar region and the skin, respectively. The trocar site was infiltrated with a mixture of 2% lidocaine and 0.25% bupivacaine (50:50) and the dog was allowed to recover from general anesthesia. Postoperatively, dogs were administered a carprofen (4.4 mg/kg once daily for 5 days) and monitored for pain using a visual analog scale (VAS)[12] and major or minor complications associated with access and pneumo-retroperitoneum by physical examination and visual observation for 2 weeks.

Outcome Measures

All CT images were imported to OsiriX software (ver. 7.03 for Mac OS, http://www.osirix-viewer.com, Swiss, PIXEMEO) for analysis.[13] Two different measures of working space were analyzed: pneumo-retroperitoneum volumes and working space linear dimensions. For CT volumetry, regions of CO_2 in the retroperitoneal space were detected semiautomatically with the definition of appropriate thresholds on all transverse images (Fig 2). The total volume, including ipsilateral and contralateral sides, and the ipsilateral volume based on the mid-sagittal plane as the medial border were measured. Inadvertently selected gas regions in the intestines were excluded with visual inspection before volume computation.[14,15] Maximum linear dimensions (maximum dorsoventral diameter [height] and maximum transverse diameter [width]) were measured on transverse images at the levels of the 2nd to 4th lumbar vertebrae—a potential working region in adrenalectomy or nephrectomy (Fig 3). Measurements were performed separately for the left and right retroperitoneal spaces based on the mid-sagittal plane as the medial border, because retroperitoneoscopic procedures would be performed in the left or right side of the space individually. Additionally, maximum linear dimensions (maximum dorsoventral diameter [height] and maximum craniocaudal diameter [width]) were measured in a para-sagittal plane of the ipsilateral side on multiplanar reconstruction. Finally,

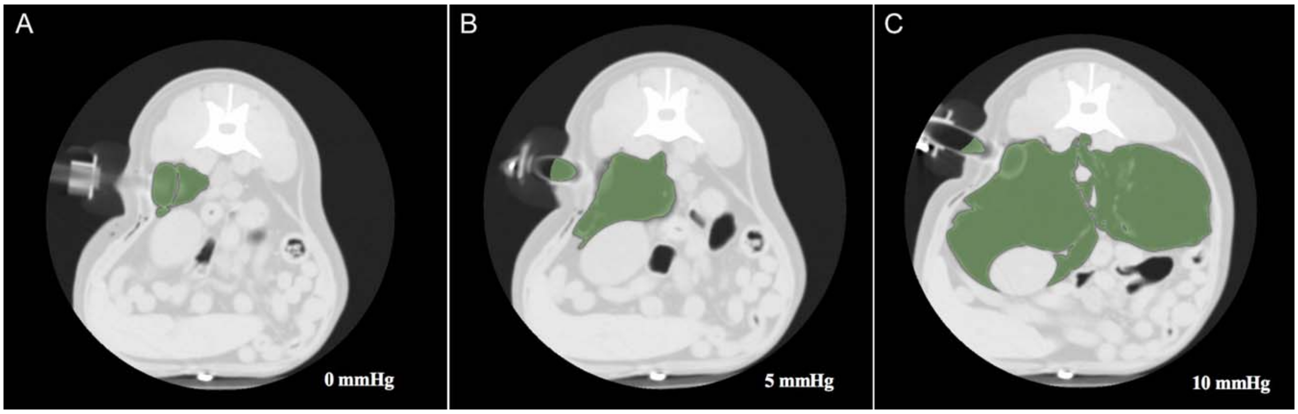

Figure 2 Transverse computed tomography images at (A) 0 mmHg, (B) 5 mmHg, and (C) 10 mmHg CO_2 insufflation, demonstrating the region of CO_2 pneumo-retroperitoneum selected in OsiriX. The detected areas on all transverse images were integrated to a total volume of CO_2 pneumo-retroperitoneum. The retroperitoneal working space in dogs was established from ipsilateral to contralateral side as insufflation pressure was increased, which led to peritoneal tearing to communicate with peritoneal space.

abdominal height and width were measured in the transverse plane at the level of the 2nd lumbar vertebra to identify abdominal distention secondary to expansion of the retroperitoneal space. For all measurements associated with the lumbar vertebrae, the images visualizing the most lateral margin of the transverse process—an important palpable anatomic landmark—were selected.

Retroperitoneal Space Observation

Subjective evaluation of the retroperitoneal working space and organs within it was performed non-blindly with images and videos from cadaveric and CT studies. The observations were compared with CT scans to complement the evaluation.

Statistical Analysis

All statistical analyses were performed using commercial software (STATA/MP 14.1, StatCorp LP, College Station, TX). The effect of the approach side (left, right) on the responses (volume, working space linear dimensions) was assessed using repeated-measures 1-way ANOVA. The side of the approach did not have a significant effect and was not included in any further analysis. Repeated-measures 1-way ANOVA was used to assess the effect of pressure on volume, with the model including the 0, 5, 10, and 15 mmHg pressures. The effect of pressure on working space linear dimensions was evaluated using the same model. Abdominal diameter at the 2nd lumbar level with increasing pressure

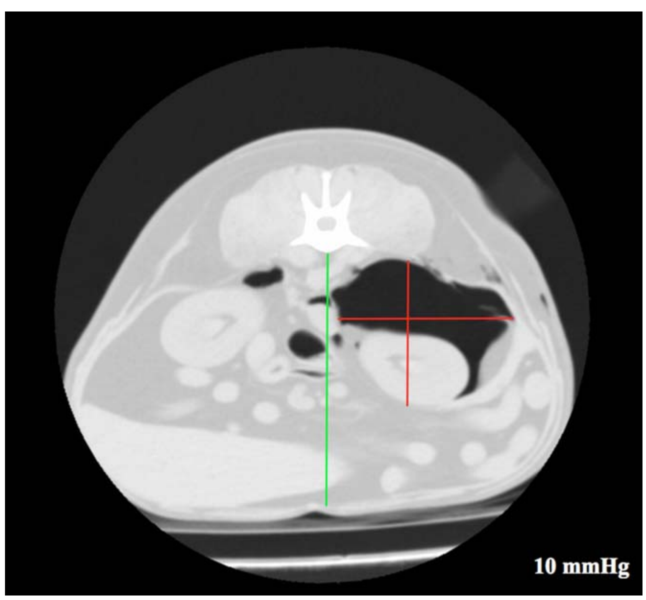

Figure 3 Transverse computed tomography image at the level of the 2nd lumbar vertebra for 10 mmHg CO_2 insufflation pressure. The trocar was placed with the right approach. Maximum linear dimensions (maximum dorsoventral diameter and maximum transverse diameter [red lines]) were measured separately on left and right sides based on the mid-sagittal plane as the medial border (green line).

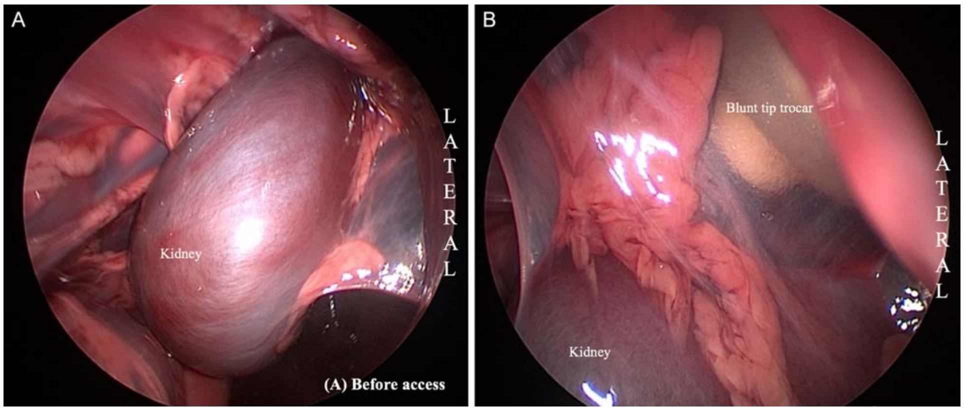

Figure 4 Transperitoneal caudocranial images obtained in a canine cadaver (A) before and (B) after retroperitoneal access from the right side. The kidney is displaced medioventrally by trocar placement.

was assessed using the same repeated-measures 1-way ANOVA. All post hoc comparisons were made with a Bonferroni correction. $P<.05$ was considered statistically significant.

RESULTS

Pilot Study

The retroperitoneal space was successfully accessed in all 5 cadavers while placing a trocar dorsolateral to the kidney and displacing it in a medioventral direction (Fig 4). In 4 cadavers, adequate retroperitoneal working space was established with CO_2 insufflation from 5 mmHg pressure, expanded further at 10 mmHg pressure, and communicated to the peritoneal space due to peritoneal tearing at 15 mmHg. Pneumoperitoneum at 5 mmHg pressure was observed in 1 cadaver, which was the result of iatrogenic peritoneal injury during the access. Early technical issues included peritoneal injury and subcutaneous emphysema during access, which were addressed. Peritoneal tearing led to peritoneal insufflation, narrowing of the retroperitoneal space, and abdominal distension.

Experimental CT Study

Retroperitoneal access and working space establishment were performed successfully in all 6 dogs. During the approach, hemorrhage was minimal and easily controlled with brief pressure. No subcutaneous emphysema was observed. At 15 mmHg pressure, peritoneal tearing occurred in 4 dogs. However, the other 2 dogs displayed no complications at a pressure of 15 mmHg. Between the dogs with and without peritoneal tearing, the BCS was higher in dogs without peritoneal tearing (5–6/9 vs. 4/9), though the procedures were not different. All dogs were stable during the study with no changes in anesthetic monitoring recognized at each new pressure level. Dogs recovered from general anesthesia uneventfully and walked actively within 30 minutes with no visual pain responses. During the 2 weeks postoperatively, pain was well-controlled and prolonged pain medication was not required. The VAS was very low (0-1) and decreased to 0. All dogs were clinically healthy and did not show any major or minor complications associated with access and pneumo-retroperitoneum.

Working Space Establishment

The CT images of all dogs showed common patterns of working space establishment. At 0 mmHg (Fig 2A), retroperitoneal working space was established around the trocar. As the pressure increased to 5 mmHg (Fig 2B), the working space expanded radially then extended craniocaudally from the diaphragm to the anus. The working space was limited to the ipsilateral side in 4 dogs, but it did start to extend across the mid-sagittal plane in 2 dogs. With further increase in pressure to 10 mmHg (Fig 2C), it expanded contralaterally, then led to peritoneal tearing at 15 mmHg. The degree and speed of this pattern in association with the pressure varied among individual dogs. In 1 dog, pneumomediastinum was identified on transverse images at 10 mmHg.

The relationship of pressure and working space volume (Table 1) showed that working space volume on both sides and the ipsilateral side alone increased significantly from 5 to 10 mmHg and 10 to 15 mmHg. On the other hand, workspace linear dimensions (Table 2) were increased significantly from 0 to 5 mmHg and 5 to 10 mmHg on parasagittal images and transverse images at the 2nd to 4th lumbar vertebrae, except linear height on transverse images at the second lumbar vertebra from 0 to 5 mmHg. The establishment of retroperitoneal space from 5 to 10, and 10 to 15 mmHg resulted in significant changes in abdominal height at the second lumbar vertebra (Table 3). However, abdominal width increased significantly only from 5 to 10 mmHg.

Retroperitoneal Space Observation

Without insufflation, entry to and visibility of the retroperitoneal space was obscured by the loose connective tissue mesh mixed with fat tissue (Fig 5A). This tissue was easily pushed aside with the telescope and CO_2 insufflation, leading to

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Table 1 Relationship between pressure and working space volume (mean±SD) in dogs undergoing retroperitoneal laparoscopy

Insufflation pressure (mmHg)	# Dogs	Volume (mL)			
		Ipsilateral	*P*-value	Both sides	*P*-value
0	6	15.1 ± 3.4	–	15.1 ± 3.4	–
5	6	91.6 ± 51.9	.110	99.1 ± 62.3	.990
10	6	269.2 ± 95.0*	<.001	501.2 ± 225.1*	.001
15	2	407.5 ± 41.3*	.009	824.6 ± 56.5*	.020

*Values significantly increased compared to others within the same column when pressure increased by 5 mmHg.

identification of the retroperitoneal organs (Fig 5B). During working space establishment, the kidney displaced ventrally and the great vessels pushed medially. Therefore, relative to the entry site, the dorsal plane of the displaced kidney was observed ventrally, the pulsating abdominal aorta and caudal vena cava were found in front of the trocar and the renal vessels crossed vertically to connect to the kidney.

The adrenal glands could also be identified and were located cranial to the renal vessels and closely ventral to the aorta or caudal vena cava, which were consistently found on CT scans at 0, 5, and 10 mmHg in all dogs. Additionally, the phrenicoabdominal vein was located craniodorsally to the adrenal glands. Relative to the trocar, the adrenal glands were located craniomedially.

DISCUSSION

In our study, a retroperitoneal access technique was developed and the retroperitoneal space was successfully entered and subsequent working space established with low-pressure CO_2 insufflation alone in all 6 dogs on both right and left sides without any complications. As pressure increased, working space established from the ipsilateral to contralateral side and peritoneal tearing eventually developed. Working space volume increased significantly from 5 mmHg and linear dimensions increased significantly from 0 to 10 mmHg. Further, surgical anatomy of retroperitoneal organs within the working space was visualized, which may allow direct access with appropriate instrumentation for retroperitoneal laparoscopy in dogs.

The initial consideration for the retroperitoneal approach is reliable anatomic landmarks to identify the proper entry site dorsal to the lateral peritoneal reflection. Current access techniques in people use the tip of the 12th rib as a key anatomic landmark[9,16] based on the fact that it consistently lies within both kidney regions and is posterior to the peritoneal fold.[16,17] In our pilot study, the potential region of retroperitoneal approach in dogs was considered to lie between the dorsal wall of the abdomen and the dorsal margin of the kidneys. Unfortunately, there were no palpable anatomic structures or reliable and constantly applicable visual landmarks associated with the upper margin of the kidneys. Therefore, the access site of this technique was designed using the transverse process of a lumbar vertebra as a palpable anatomic landmark to identify the upper margin of entry.

An open-entry technique, currently standard for the retroperitoneal approach in people,[9,16,18,19] was adopted in our study. Without reliable anatomic landmarks delineating the lateral peritoneal fold in dogs, developing a reliable and safe blind Veress needle placement technique in dogs was considered implausible in our study. Fortunately, a study of conventional open adrenalectomy using the retroperitoneal approach[11] describes surgical access to the retroperitoneal space with finger insertion, which is similar to the human

Table 2 Relationship between pressure and working space linear dimensions (mean±SD) on the ipsilateral side as measured on transverse images and parasagittal images in dogs undergoing retroperitoneal laparoscopy

	Lumbar level	Pressure (mmHg)							
		0	*P*-value	5	*P*-value	10	*P*-value	15	*P*-value
Measured on transverse images									
Height (mm)	2	6.2 ± 9.1	–	23.0 ± 23.7	.581	63.4 ± 11.1*	.007	67.2 ± 1.2	.990
	3	12.0 ± 10.0	–	35.4 ± 13.5*	.005	61.7 ± 13.2*	.002	66.8 ± 3.5	.476
	4	7.4 ±5.8	–	39.1 ± 16.6*	<.001	56.7 ± 14.0*	.034	67.4 ± 3.8	.249
Width (mm)	2	4.6 ±5.3	–	29.3 ± 20.7*	.030	60.4 ± 10.0*	.006	77.4 ± 1.7	.990
	3	16.2 ± 14.6	–	42.4 ± 10.1*	.019	66.0 ± 12.9*	.038	84.0 ± 1.2	.990
	4	12.8 ± 10.5	–	41.7 ± 11.3*	<.001	65.0 ± 12.4*	.001	82.4 ± 0.6	.670
Measured in a parasagittal plane									
Height (mm)		14.5 ± 4.4	–	37.7 ± 10.7*	.004	58.0 ± 18.2*	.010	66.2 ± 0.7	.108
Width (mm)		36.9 ± 13.0	–	105.4 ± 29.0*	<.001	158.7 ± 25.8*	.003	157.2 ± 10.5	.990

*Values significantly increased compared to others within the same row when pressure increased by 5 mmHg.

Table 3 Abdominal diameter (cm) at 2nd lumbar vertebra (mean±SD) in dogs undergoing retroperitoneal laparoscopy

Abdominal diameter (cm)	Pressure (mmHg)							
	0	*P*-value	5	*P*-value	10	*P*-value	15	*P*-value
Height	15.0 ± 0.7	–	15.0 ± 0.8	.990	15.7 ± 0.9*	.001	16.1 ± 0.6*	.001
Width	15.4 ± 3.3	–	15.6 ± 3.2	.990	16.3 ± 3.1*	.021	19.4 ± 0.7	.405

*Values significantly increased compared to others within the same row when pressure increased by 5 mmHg.

retroperitoneal access technique.[9,18] This was applicable to the present technique using the transverse process of a lumbar vertebra as an anatomic landmark.

After addressing early stage technical issues in our pilot study, none of the 6 dogs in our in vivo study showed any complications of access. A major concern of the open-entry technique is gas leakage from the trocar access site, resulting in retroperitoneal space collapse, subsequent loss of effective working space, and subcutaneous emphysema.[16] To overcome this, most human surgeons use a blunt-tip trocar in retroperitoneal laparoscopy,[9,19] which was also used in our study.

In the early phases of retroperitoneal laparoscopy in people, the most important issue that prevented its development was the inadequate creation of working space.[20] Because of the dense connective tissue in the retroperitoneal space in people, CO_2 insufflation alone is not enough to establish a working space.[20] Fortunately, our study showed that CO_2 insufflation alone was sufficient to establish working space in dogs. By increasing the CO_2 insufflation pressure, the working space was extended not only ipsilaterally, but also contralaterally in all dogs. Further, the entire space was over-expanded at 15 mmHg, resulting in peritoneal tearing in all cadavers and 4 live dogs. To the authors' knowledge, this pattern of working space development has not been described in the human literature. These findings may be explained by anatomic differences in the retroperitoneal space of dogs,[21] which is filled with loose connective tissue mesh without compartmentalization as found in people.

During working space establishment, abdominal distention was not perceived until peritoneal tearing occurred and the changes in abdominal diameter measured on CT were mild, even though it was statistically significant. This suggests that retroperitoneal working space is established by reducing intraperitoneal space with mild abdominal wall distension. Therefore, the contents of the abdomen, such as intestinal gas or feces and abdominal fat, would affect retroperitoneal space establishment. This may support that sternal recumbency without abdominal support is beneficial for retroperitoneal working space establishment, as reported in people.[9,18,22]

In our study, organ displacement in the retroperitoneal working space in dogs was similar to that in people. Pneumo-retroperitoneum acted like a natural retractor by displacing the kidney ventrally, exposing the renal hilum, great vessels, and adrenal glands, which would provide direct access for retroperitoneal laparoscopy in dogs. Further, the adrenal glands could be identified using the vasculature (renal vessels, abdominal aorta, and caudal vena cava) as anatomic landmarks. This can be explained by the fact that the left adrenal gland is more closely related in position to the abdominal aorta than the left kidney and that the capsule of the right adrenal gland is closely associated with the caudal vena cava.[23] In human retroperitoneal adrenalectomy, the first step after entry is finding the cranial pole of a kidney, which can lead to the adrenal glands.[9,18] Therefore, locating retroperitoneal vasculature could be considered an initial step in retroperitoneal adrenalectomy in dogs.

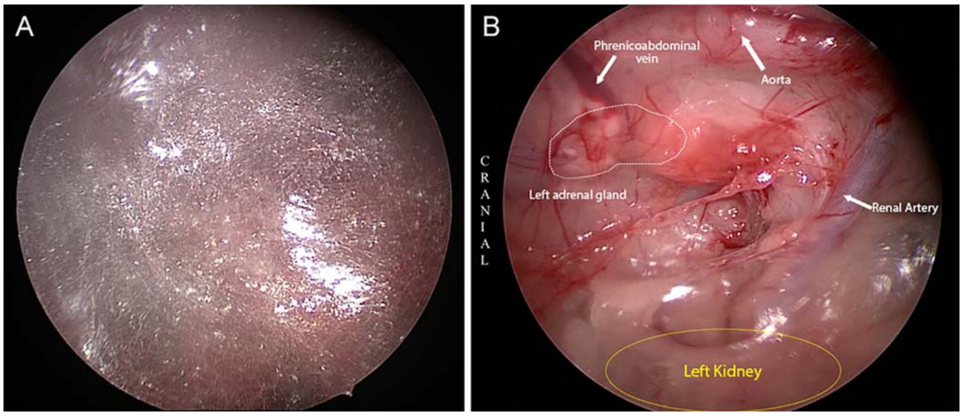

Figure 5 Telescopic view from a left-sided retroperitoneal trocar in a lateromedial direction. (A) Loose connective tissue mesh is seen upon entry before insufflation. (B) Surgical anatomy of retroperitoneal organs in the established working space.

The degree of fat deposition in the retroperitoneal space was an important factor affecting the quality of visualization. Although the adrenals were visible at a pressure of 5 mmHg in all dogs, full visualization as described above was obtained at different pressure levels from 5 to 15 mmHg in different dogs, with greater visualization obtained by increasing the insufflation pressure. In our opinion, 5 mmHg of insufflation pressure with an understanding of the anatomic relationship and manipulation with instrumentation would be sufficient to visualize the adrenals for surgical procedures.

Retroperitoneal laparoscopy only requires establishment of a working space on one side. Further, the pressure required to establish adequate working space linear dimensions representing the actual surgical field of the kidneys and adrenal glands could be valid information. From 0 to 10 mmHg, working space was established limited to the ipsilateral side. The working space volume significantly increased from 5 mmHg and linear dimensions significantly increased from 0 to 10 mmHg. These findings suggest that working space creation should start with a pressure of 5 mmHg and that pressure may be increased gradually to 10 mmHg if necessary.

Interestingly, peritoneal tearing was not observed in a previous canine study[7] even though a higher pressure (25–30 mmHg) was maintained than in our study at the same infusion rate. These differences could be explained by use of different gas types, higher range of body weight (15–60 kg), different breeds with different conformation, and/or unknown BCSs.

All dogs were stable and clinically healthy during and after the procedure. Subclinical pneumomediastinum was found in 1 dog on CT images at 10 mmHg. In people, pneumothorax and pneumomediastinum are potential complications of pneumo-retroperitoneum[24]; however, pneumomediastinum is rarely of clinical consequence and resolves spontaneously in dogs.[25]

This study has several limitations. Firstly, subclinical effects were not evaluated. Despite the findings that all dogs were stable during the study and suggested pressures were relatively low, pneumo-retroperitoneum would have had a silent effect on hemodynamics, CO_2 absorption, and organ perfusion, specifically the kidneys and adrenals. Before clinical application in dogs with retroperitoneal disease, thorough evaluation is warranted. Secondly, instrumentation or any surgical procedure were not performed, as it was not feasible in our repeated CT study design. Further, there are no established standards for measurement methods or clinical relevance in working space studies. Therefore, the findings in our study warrants the individual interpretation of surgeons to fill the gap between working space establishment and surgical procedures. In our opinion, the working space linear dimensions measured in a parasagittal plane at 5–10 mmHg might suggest that both triangulation and a single incision laparoscopic surgery (SILS) approach could be feasible, especially a SILS approach. Thirdly, the number of dogs was small and the body weight and BCS varied. The degree and speed of working space establishment pattern and quality of visualization were different among individual dogs. In our opinion, body fat disposition, specifically retroperitoneal fat, may be a factor affecting these differences. In clinical procedures, obese dogs might require adjustment from that suggested in our study. To completely evaluate these factors and the safety of this approach, a large number of dogs or more strictly controlled dogs are needed for advanced statistical analysis. Fourthly, the standardization of insufflator running duration and randomization of insufflation pressure were not applied. The variation in the duration of the insufflator run and the accumulated volume might have affected the working space establishment with different pressure effect. However, from our pilot study, randomization was not considered applicable to the retroperitoneal space in the repeated-measure design. Further, the variation of the duration of the insufflator run was not avoidable due to the technical issues including CT scanner and retroperitoneal observation time. Fifthly, intra- and inter-observer variability measurements were not performed for measurement of CT images. Sixthly, only sternal recumbency was studied. Thus, the optimal position for retroperitoneal laparoscopy in dogs was not evaluated. In people, retroperitoneal laparoscopy is performed in the lateral or posterior position depending on the patient, surgical procedure, and surgeon preference.[16] Finally, only Beagles were studied and our findings might not be representative for other breeds.

In summary, the retroperitoneal access technique was reliable for visualization. Working space establishment with CO_2 insufflation starting with 5 mmHg and increasing to 10 mmHg would provide adequate visualization of the retroperitoneal organs and may allow direct access by appropriate instrumentation. Before use of retroperitoneal laparoscopy for clinical cases, the subclinical effects as well as additional port placement sites and subsequent surgical procedures (or single port procedures) should be studied to refine the technique.

DISCLOSURE

The authors declare no conflicts of interest related to this report.

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