Ciência Rural, Santa Maria, v.53:9, e20210902, 2023
http://doi.org/10.1590/0103-8478cr20210902
ISSNe 1678-4596
CLINIC AND SURGERY

Laparoscopic adrenalectomy: comparison between pneumoperitoneum and the use of a laparoscopic lift device in dog cadavers

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ABSTRACT: This study evaluated the feasibility of abdominal liftfor laparoscopic adrenalectomy and compared it with the conventional laparoscopic technique using pneumoperitoneum with medicinal CO_2 in dog cadavers. The total surgical time (TST), adrenalectomy time (AT), and gland integrity after removal were evaluated. Thirty-eight adrenalectomies were performed in 19 cadavers. Regardless of the antimere, the TST was significantly lower in the CO_2 procedures than in the lift laparoscopy procedures (P=0.001). When comparing the techniques between antimeres, the TST was significantly higher on the left side with lift laparoscopy than with CO_2 (P=0.015) and similar between the techniques on the right side of the animals (P=0.086). In the comparison of AT, regardless of the execution side, no differences were observed between the techniques (P=0.05). The same was observed when AT was evaluated separately using antimeres (P=0.902). Of the 38 adrenals evaluated, 92.1% were removed in a single block, and 32.29% had a superficial lesion in the capsule. There was no difference between the groups in the removal capacity in a single block (P=0.340) and capsule integrity (P=0.287). Abdominal lift for laparoscopic adrenalectomy is a feasible technique in dog cadavers; however, it requires a longer surgical time than the conventional technique. The traction force used to elevate the abdominal wall must be evaluated.
Key words: video-surgery, capnopneumoperitoneum, gasless, adrenal gland, canines.

Adrenalectomia laparoscópica: comparação entre o pneumoperitônio e o uso de dispositivo para liftlaparoscopy em cadáveres de cães

RESUMO: O presente trabalho teve como objetivo avaliar a exequibilidade da adrenalectomia laparoscópica utilizando dispositivo de elevação da parede abdominal via *liftlaparoscopy* e comparar com a técnica laparoscópica convencional utilizando pneumoperitônio com CO_2 medicinal em cadáveres de cães. Para isso, avaliou-se tempo cirúrgico total (TCT), tempo de adrenalectomia (TA) e integridade das glândulas após remoção. Foram realizadas 38 adrenalectomias em 19 cadáveres. Independentemente do antímero, o TCT foi significativamente menor nos procedimentos com CO_2 do que com *liftlaparoscopy* (P=0,001). Na comparação das técnicas entre antímeros, o TCT foi significativamente maior no lado esquerdo com *liftlaparoscopy* do que com CO_2 (P = 0,015) e semelhante entre as técnicas no lado direito dos animais (P=0,086). Já na comparação do TA, independente do lado de execução, não foram observadas diferenças entre os métodos (P=0,05). O mesmo foi observado quando o TA foi avaliado separadamente por antímero (P=0,902). Das 38 adrenais avaliadas, 92,1% foram removidas em um único bloco e destas, 32,29% apresentaram lesão superficial na cápsula. Não houve diferença entre grupos para capacidade de remoção em um único bloco (P=0,340) e da integridade da cápsula (P=0,287). A adrenalectomia laparoscópica por elevação da parede abdominal é factível de ser realizada em cadáveres de cães, entretanto, demanda maior tempo cirúrgico quando comparada à técnica convencional. Além disso, a força de tração empregada para elevar a parede abdominal necessita ser avaliada.
Palavras-chave: videocirurgia, capno-pneumoperitônio, *gasless*, glândula adrenal, caninos.

INTRODUCTION

Adrenalectomy is the treatment of choice for most canine adrenal tumors (BARRERA et al., 2013; NELSON & COUTO, 2015). The open technique is the most frequently used in veterinary medicine, with the reported complications including hemorrhage, pancreatitis, wound infections, delayed closure, and thromboembolism (SCHWARTZ et al., 2008; FOSSUM, 2014). Procedures performed on the right side are more challenging because the right adrenal gland is located between the kidney, caudate process of the liver, and vena cava (EVANS & DE LAHUNTA, 2010). Therefore, different approaches have been studied, including the intercostal incision approach (ANDRADE et al., 2014). Laparoscopic

Received 12.22.21 Approved 10.08.22 Returned by the author 12.20.22
CR-2021-0902.R1
Editors: Rudi Weiblen Daniel Curvello de Mendonça Muller

adrenalectomy may offer advantages such as fewer surgical incision complications, reduced morbidity, greater postoperative comfort, better organ visualization, and shorter hospital stay (ZOGRAFOS et al., 2006). Anatomical knowledge and mastery of the celiotomy technique are essential for the success of the laparoscopic procedure since conversion to the open technique may be necessary (MAYHEW & KIRPENSTEIJN, 2015). Carbon dioxide (CO_2) is used to inflate the peritoneal cavity and create a working space in conventional laparoscopic surgery, and its usehas been shown to be safe in most healthy patients. However, some studies have indicated that increased intra-abdominal pressure can cause hemodynamic and pulmonary complications, such as increased heart rate and systemic vascular resistance, increased arterial and venous pressure, and decreased lung compliance (FRANSSON et al., 2014; DUQUE & MORENO, 2015). In gasless or lift laparoscopy, the working space is provided by passively filling the abdomen with ambient air (FRANSSON et al., 2014). This is an alternative that minimizes the complications resulting from the use of CO_2. Different devices have been developed to elevate the abdominal wall (CHEN et al., 2017; BRUN et al., 2021). The most commonly used model in veterinary medicine is composed of a circular portion placed inside the abdomen and a rod suspended by a hook, thus elevating the abdominal wall (FRANSSON, 2014; FRANSSON et al., 2014; GNANARAJ & RHODES, 2015). This method has been criticized for providing less workspace than CO_2 pneumoperitoneum, potentially leading to longer operative times (FRANSSON & RAGLE, 2011; FRANSSON et al., 2014; CHEN et al., 2017). A prototype of a multidirectional traction device was recently patented and has already been shown to be viable for laparoscopic diaphragmatic hernia repair in dog cadavers (BRUN et al., 2021).

This study evaluated the feasibility of laparoscopic adrenalectomy using an abdominal wall elevator device via lift laparoscopy and to compare it with the conventional laparoscopic technique using pneumoperitoneum with medicinal CO_2 in dog cadavers.

MATERIALS AND METHODS

Twenty dog cadavers weighing 5–35 kg of different breeds and both sexes, with no history of trauma or recent abdominal surgery, were selected. The cadavers were kept frozen, and 12 to 24 h before the procedure, they were immersed in water at room temperature for thawing. Subsequently, they were dried, weighed, and a wide shaving of the abdominal wall was performed. All cadavers underwent right and left adrenalectomy, with the workspace generated by CO_2 insufflation using an electronic insufflator (model 26430020, Storz®) or a circular device to elevate the abdominal wall. The procedures were homogeneously distributed according to the method of abdominal wall elevation, order of execution, and antimere and defined by drawing lots immediately before surgery. Based on the laparoscopic approach and procedure, the following groups were defined: CO_2 left side group (CO_2L), CO_2 right side group (CO_2R), left side lift laparoscopy (LIFTL), and right-lift laparoscopy side group (LIFTR).

Each cadaver underwent adrenalectomyeither by CO_2 insufflation or lift laparoscopy, varying only on the procedure side. In both techniques, the cadaver was positioned in lateral recumbency with elevation of the thoracolumbar region by arranging fold-field cloths placed below the flank region of the animal. The surgical team was positioned in front of the animal's abdomen, and the video-surgery tower faced the animal's back (Figure 1-A).

In the CO_2L and CO_2R groups, a permanent trocar (Edlo®, 10 mm) was inserted lateral to the umbilicus using the modified Hasson technique (open technique). Through this, a 2.5 $L.min^{-1}$ flow was established to maintainan 8 mmHg pressure pneumoperitoneum. Then, a 10 mm optic and 0º field view (Storz®) was inserted through the same portal. Two other permanent trocars (Edlo®, 5 mm) were placed in the subcostal region and iliac fossa under direct visualization, forming a semicircle (Figure 1-B). When necessary, a fourth trocar was inserted at the adjacent kidney level. The adrenal gland was identified, and dissection was performed using Kelly and Maryland video laparoscopic forceps (Edlo®, 30 cm) (Figures 2-B and 2-C). The phrenic-abdominal vessels were primarily dissected, isolated, and subjected to hemostasis by electrocoagulation using laparoscopic bipolar forceps (Edlo®, model HF-120, WEM) at 15 W power (Figure 2-D) and sectioned with Metzenbaum scissors between the hemostasis points (Figure 2-E). Blunt dissection of the adrenal gland was continued using Kelly forceps and adjacent tissue cauterization before sectioning. After the gland was completely released (Figure 2-F), it was removed by direct grasping and traction and exteriorized by enlarging the orifice of one of the portals without packaging it in an extractor bag. There were two sizes of steel abdominal wall lifting devices available, and the surgical team chose the most suitable device for each animal in accordance with previous studies (FRANSSON & RAGLE, 2011) (Figure 1-C). The

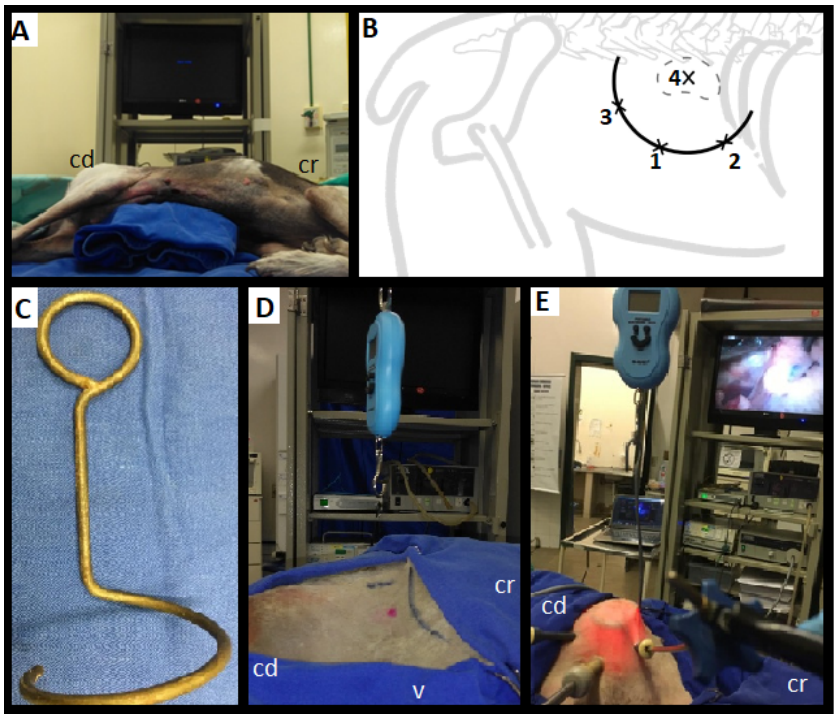

Figure 1 - (A) Position of the animal in lateral decubitus with elevation of the thoracolumbar region for performing right laparoscopic adrenalectomy in a dog cadaver. (B) Schematic drawing demonstrating the kidney location (dashed) and insertion position of the trocars in the paralumbar fossa for performing right-sidedlaparoscopic adrenalectomy (1: laparoscope; 2-4: instruments). Device model for abdominal wall elevation during the adrenalectomies. (D) Dog corpse in left lateral recumbency. The larger blue line indicates the demarcation of the last rib, the smaller blue line indicates the transverse process of the lumbar vertebrae, and the red dot indicates the insertion site of the hook in the cranial portion of the paralumbar fossa. (E) Device positioned on the dog cadaver providing the creation of the workspace, connected to the suspended scale used to measure its traction force. cr=cranial; cd=caudal; v=ventral. Credits: (A,C,D,E) theauthor, 2019. (B) Pela´ EZET al., 2008.

diameter of the smaller hook was 3 mm, and the radius of the inner circle of the suspension was 2.75 cm. The largest hook had a diameter of 5 mm and an inner circle radius of 4.5 cm. Both of the hooks were 20 cm tall. The smaller hook was used for dogs weighing less than 15 kg, and the larger hook for dogs over this weight. The device was inserted cranially into the paralumbar fossa and caudal to the last rib (Figure 1-D). After the skin incision, the abdominal wall was suspended using three Halsted forceps in triangulation, and the abdominal cavity wasaccessed through a stab incision with a scalpel.The abdominal wall lifting device was inserted and attached to a scale suspended above the animal to create an intra-abdominal workspace. The device was elevated until an adequate field of view was obtained, maintaining contact between the cadaver and the procedure table (Figure 1-E).The first trocar was inserted for optic introduction and internal inspection of the abdominal cavity. The device was located to certify that it was inside the abdominal cavity and to rule out iatrogenic events during its introduction and manipulation (Figure 2-A). The adrenal glands were removed in the same manner as in the CO_2L and CO_2R groups. The muscular and skin incisions were sutured in a sultan pattern with 2-0 monofilament nylon and in an isolated pattern with 3-0 monofilament nylon. All adrenal glands were immersed in a 10% buffered formalin solution to properly identify the vials and sent to the Pathology Department to assess their integrity. Information regarding body weight and sex were also recorded. From the fourth procedure performed by lift laparoscopy, traction force was measured using a digital scale (model BM-A06, MAX). The

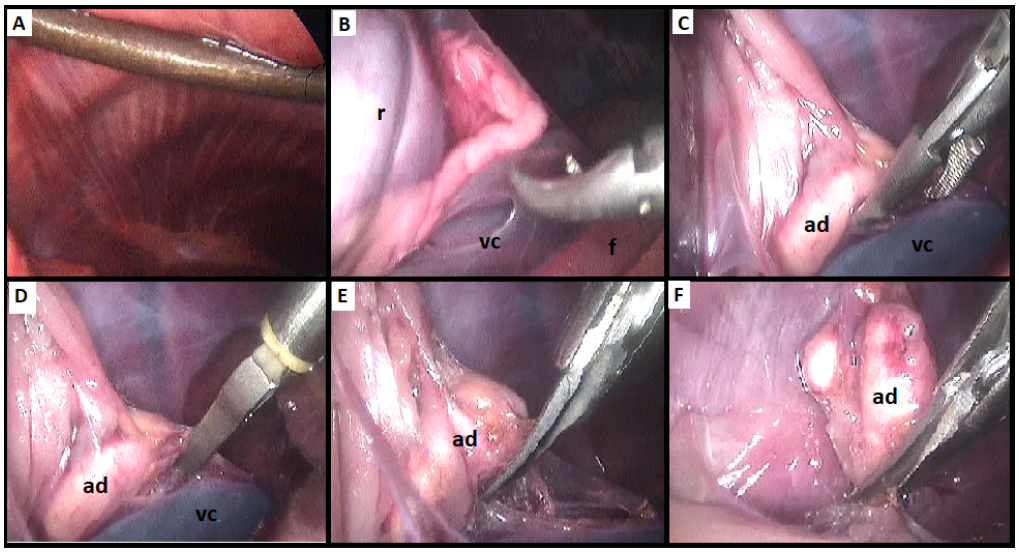

Figure 2 - Internal view of the abdominal cavity during right adrenalectomy by lift laparoscopy in a dog cadaver. (A) Internal location of part of the device promoting workspace. (B) Dissection of the region between the right kidney (r), caudal vena cava (vc), and liver (f) to expose the right adrenal gland and rupture of the hepatorenal ligament. (C) Identification and dissection of the adrenal gland (ad). (D) Hemostasis of the phrenic-abdominal vessels using laparoscopic bipolar forceps. (E) Phrenic-abdominal vessels resection. (F) Complete release of the adrenal gland from the adjacent tissue. Credits: The author, 2019.

times recorded were the total surgical time (TST), time between the first skin incision until the end of the last suture, and adrenalectomy time (AT) – time between the beginning of the adrenal dissection until removal from the abdominal cavity. All procedures were performed by the same surgeon. The procedures were recorded to determine the time and evaluate the surgeries. Data were analyzed using SPSS version 20.0. The symmetry of the variables was evaluated using the Kolmogorov-Smirnov test. Variables were described using the mean and standard deviation when symmetrical and the median, minimum, and maximum when asymmetrical. The times between techniques and sides were compared using a generalized estimation equation model. A significance level of 5% was considered statistically significant.

RESULTS

Thirty-eight laparoscopic adrenalectomies were performed on 19 (12 males and seven females) dog cadavers of different breeds, weighing between 5.6 and 27.2 kg (14.42 ± 6.65 kg). One cadaver was excluded from the study because of advanced autolysis.Thirty-sixprocedures (4.74%) were easily performed with the placement of the three portals. In two surgeries in the same animal (CO_2R and LIFTL), a fourth portal was required to move the kidney caudally.There were no differences between the groups (CO_2R, CO_2L, LIFTR, and LIFTL) (P=0.902) or time (TST and AT) (P=0.829) (Table 1). There was no significant difference between the abdominal wall retraction methods (CO_2R and CO_2L *vs* LIFTR and LIFTL) in relation to AT, regardless of the side performed (P=0.05). The effect of antimer-operation (CO_2R and LIFTR *vs* CO_2L and LIFTL) under AT also showed no significant difference (P=0.902). Comparing the techniques within each side, AT showed no significant difference between the CO_2R and LIFTR groups (P=0.189) or between the LIFTR and LIFTL groups (P=0.590). There was also no difference between the LIFTR and LIFTL groups (P=797) or between the CO_2R and CO_2L groups (P=0.650). Regardless of the side (CO_2R and CO_2L *vs* LIFTR and LIFTL), procedures with CO_2 insufflation (CO_2R and CO_2L) showed significantly lower TSTthan lift laparoscopy procedures (LIFTR and LIFTL) (P=0.001). There was no difference in the TST values between the sides, regardless of the technique employed (CO_2R and CO_2L *vs* LIFTR and LIFTL) (P=0.596). When comparing the techniques within each side, TST was significantly higher in LIFTL than in CO_2L (P=0.015) and statistically the same between LIFTR and CO_2R

Table 1 - Comparison of adrenalectomy time (AT) and total surgery time (TST) between conventional laparoscopic access with CO_2 insufflation – right and left sides (CO_2R and CO_2L groups, respectively) and lift laparoscopic – right and left sides (LIFTR and LIFTL groups, respectively) in laparoscopic adrenalectomy on dog cadavers.

	CO_2R	LIFTR	CO_2L	LIFTL	p-value
AT	22.75 ± 9.40	28.73 ± 11.36	24.66 ±9.93	27.36 ±13.11	0.902
TST	51.27 ±19.10	62.69 ±10.77	47.68 ±7.87	62.01 ±17.80	0.829

Data are presented using the mean, standard deviation, and p-value obtained through the generalized estimating equation.

(P=0.086). Comparing the sides within the techniques, there was no difference between the TST values of LIFTR and LIFTL (P=0.915) or CO_2R and CO_2L (P=0.566). All samples were identified as adrenal tissue through microscopic evaluation. Thirty-fiveadrenal glands were removed in a single block (92.1%), of which 12 (34.29%) had superficial lesions in the capsule. The frequency of preserved capsule (P=0.340) and gland integrity (P=0.287) was the same for all groups.The traction force used in the LIFTR and LIFTL groups was measured in 16 animals, and the percentage of weight/strength in relation to animal weight was calculated. The mean and standard deviation were 18.5 ± 10.45%. In the LIFTR and LIFTL groups, iatrogenic events occurred in five procedures (26.32%) during hook introduction: three cases of omentum apprehension, one of intestinal apprehension, and one of placement of the device in the retroperitoneal space. Thawing the dog cadavers 12 to 24 h before the procedure allowed for laparoscopic adrenalectomy.

DISCUSSION

The abdominal wall elevation device allowed the creation of an adequate working space for performing laparoscopic adrenalectomy in a manner similar to CO_2 insufflation on both sides of the cadavers, with the advantage of maintaining an isobaric pneumoperitoneum in relation to the operating room. The position of the cadaverson the operating table with elevation of the thoracolumbar region and the trocar position facilitated the performance of the procedures, regardless of the weight, sex, or group. Lateral decubitus with slight elevation of the lumbar region is the most frequent position indicated for laparoscopic adrenalectomy because of the better field of view and ease of the open paracostal approach if emergency conversion is required (MAYHEW et al., 2014; MAYHEW & KIRPENSTEIJN, 2015; TAYLOR & MONNET, 2021). Studies in dogs positioned in sternal recumbency, with elevation of the thoracic and pelvic regions, have reported good access to the adrenal glands. In one study, nine adrenal tumors were successfully removed (NAAN et al., 2013), and in another, eight adrenalectomies were performed in healthy beagles using a single-port retroperitoneal approach (KO et al., 2018). In one cadaver, a fourth portal was needed on both sides (LIFTL and CO_2R) to draw the kidney caudally without a significant increase in surgical time. A fourth portal should be considered in patients with adrenal tumors when the gland dimensions are larger than those found in the models used in the present study. In another study, three portals equally arranged were sufficient to perform nine adrenalectomies (NAAN et al., 2013). The need for a fourth portal was reported in a dog that underwent videolaparoscopic excision of a right adrenal tumor (SOUZA et al., 2016). Based on the complications arising from the blind insertion of the abdominal wall elevation device, the surgical team considered it necessary to modify the laparoscopic lift technique. Placement of the first portal using the open technique and introduction of the optic prior to the hook would be more indicated as it allows visual monitoring of the device insertion into the abdomen. In one previous study in dog cadavers, no lesions were reported in the abdominal organs, but the device was inserted in the linea alba (FRANSSON & RAGLE, 2011). The TST was higher in lift laparoscopy procedures owing to device placement, as the AT was similar on both sides. In a previous study, there was no difference between the surgical times of ovariohysterectomy performed using CO_2 insufflation and the lift laparoscopy technique. The force that is adequate for performing procedures using lift laparoscopy is not well-defined. In this study, the device was empirically pulled to the point that surgeons considered suitable for performing the procedure. Adequate visualization and working space have been reported in dog cadavers with a pulling force of 20% body weight in the umbilical region (KENNEDY et al., 2015). The increase in lift forces provided a greater volume of workspace; however, the pressure on tissues in direct contact with the lifting device also increases,

causing tissue trauma and discomfort (FRANSSON et al., 2014). Studies in live animals are needed to define and standardize the minimum traction force required to perform different procedures and assess pain associated with lift laparoscopy. It is possible that the development of other configurations of lifting devices can help expand the workspace with larger areas of traction force distribution and reduction of possible traumas. In addition, in patients with tissue fragility, lift laparoscopy can be a limiting factor owing to the risk of skin and even muscle rupture when subjected to traction (HERRTAGE & RAMSEY, 2015). The difficulty in accessing the gland and manipulating the surgical instruments was similar for both adrenalectomy techniques. The right gland was more difficult to access than the contralateral gland, regardless of the technique used. In many procedures, the left adrenal gland is visualized immediately after endoscope insertion, requiring only ventral retraction of the spleen in some animals. The hepatorenal ligament was sectioned on the right side, the right lateral hepatic lobe was pulled cranially, and the kidney was retracted caudally. Proximity to the caudal vena cava requires caution during adrenal dissection and cauterization of phrenic-abdominal vessels. The AT was similar on both sides, but it is expected that when applied in clinical cases, the surgical time of procedures on the right side will be longer. Four left-sided and three right-sided adrenalectomies have been reported in dogs, with a mean total operative time of 99 min (range:90-110 min) and 133 min (range:120-150 min), respectively (PELÁEZ et al., 2008). The lesions detected in the adrenal glands in this study occurred during dissection. In a report of seven laparoscopic adrenalectomies in dogs, there was a rupture of the gland in the first two procedures, in which the surgeons chose to open a small window in the capsule and suction the necrotic and tumor fluid from its interior to prevent further ruptures (PELÁEZ et al., 2008). This maneuver may be necessary in clinical adrenalectomies; however, capsule rupture should be avoided as much as possible in cases of malignant neoplasms. In these cases, after dissection of the adrenal gland, exteriorizing it from the cavity through a recovery bag or a surgical glove finger is recommended to prevent the implantation of tumor cells in the abdominal wall (NAAN et al., 2013). This maneuver was not performed in this study because we used cadavers, and there was no interference in comparing the two techniques.

CONCLUSION

Laparoscopic adrenalectomy by abdominal wall elevation is feasible in dog cadavers; however, it requires a longer surgical time than the conventional technique. Additionally, the traction force used to elevate the abdominal wall must be evaluated.

ACKNOWLEDGMENTS

The authors would like to thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for their financial support. In addition, the HCV-UFRGS provided both equipment and infrastructure.The authors would like to thank Editage (www.editage.com) for English language editing.

AUTHORS' CONTRIBUTIONS

All the authors contributed to the design and writing of the manuscript, critically reviewed the manuscript, and approved the final version.

BIOETHICS AND BIOSECURITY COMMITTEE APPROVAL

We, the authors of the manuscript entitled "Laparoscopic adrenalectomy: comparison between pneumoperitoneum and the use of a laparoscopic lift device in dog cadavers," declare, for all due proposes, that the project that gave rise to the data presented was not submitted for evaluation to the Ethics Committee of the Federal University of Rio Grande do Sul, but we are aware of the resolutions of the Conselho Nacional de Experimentação Animal (CONCEA) in case of animal experimentation (http://www.mct.gov.br/index.php/content/view/310553.html). The authors assume full responsibility for the data presented and are available to answer any questions.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflicts of interest. The sponsors had no role in the study design, data analysis or interpretation, manuscript writing, or decision to publish the results.

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