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Surgery

Topographic laparoscopy for buffaloes in the quadruped position

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ABSTRACT. This study aimed to describe the anatomical topography of the abdominal cavity of buffaloes in the quadruped position to establish the best endosurgical access and vantage points and identify possible limitations. Laparoscopies were performed on 10 healthy female buffaloes obtained from the Universidade Federal Rural da Amazônia to explore possible access points to the abdomen. Techniques for assessing and possibly observing certain organs and structures through the left and right flanks of 10 animals have been described. In five animals, access was created through the right side of the last intercostal space to allow more cranial access to the abdominal cavity. Despite the presence of the rumen, access through the left flank allowed the visualization of the structures of the gastrointestinal tract and the genitourinary system. With access through the right flank, however, imaging was hampered by the presence of the greater omentum and its deep and superficial walls, which prevented the progression of the endoscope. Access through the last right intercostal space allowed the visualization of the cranial structures of the abdominal cavity, such as the caudate process, right lobe of the liver, right kidney, and pancreas. Laparoscopic access through the left flank and the last intercostal space in healthy buffaloes in the quadruped position is feasible, and it is promising for the exploration, diagnosis, and treatment of various disorders in buffaloes.

KEY WORDS: *Bubalus bubalis*, endosurgery, minimally invasive technique, ruminant surgery

Laparoscopy is a minimally invasive technique that allows the visualization of the abdominal cavity for diagnostic, therapeutic, and prognostic purposes [20, 21]. This technique causes less trauma to the animals than conventional laparotomy [1, 21].This study aimed to provide an accurate and detailed description of the topographic anatomy of buffaloes in the quadruped position to guide optimal laparoscopic approaches and identify the advantages and possible complications resulting from this technique.

Endosurgery reduces the risks associated with the exposure of the animal and thereby decreases the risk of mortality. This is especially important for animals of high zootechnical value. Reduced exposure also increases the chances of a successful diagnosis and cure. Although more expensive than conventional surgery, endosurgery is valuable when working with high-production animals [9].

Laparoscopy was first used in large animals to document the ovulation cycle of mares in 1975 [12]. The development of veterinary laparoscopy is directly correlated with the development of laparoscopy techniques for human patients [12]. Several of the possible procedures that are used to assist reproduction are reliant on endosurgical techniques [8]. Endosurgical techniques for different animals are continually being developed, with new studies exploring optimal access points, positioning, equipment, and specific instruments. New laparoscopic methods for horses and ruminants are of particular interest and form the focus of several of these studies [21, 22, 24]. Few surgical techniques have been described or used for Water Buffaloes (*Bubalus bubalis*) [5, 18]. The few reports that are available in the literature have mainly focused on laparoscopies performed for reproductive purposes in this species. However, none have explored the optimal access points or differences in the outcomes related to anatomical peculiarities such as skin thickness [5]. Laparoscopic methods can provide several clinical, surgical, and reproductive benefits for these animals, particularly with respect to the diagnosis and treatment of reproductive problems.

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MATERIALS AND METHODS

The study was approved by the Ethics and Animal Experimentation Committee of the Federal University of Pará (CEUA/UFPA 4141181219).

Animals

This study used 10 healthy Murrah–Mediterranean crossbred water buffaloes that were reared at the Biotério Eva Daher Abufaiad Milk Bubalinoculture Unit of the Federal Rural University of the Amazon. The animals had an average age of 4.5 years and an average weight of 449.8 kg, and they were raised in a continuous grazing system with water and mineral supplementation *ad libitum*.

Anesthesia was administered with 0.2 mg/kg of 2% lidocaine hydrochloride (Xylestesin 2%, Cristália, São Paulo, Brazil) and 0.125 mg/kg of levobupivacaine (Novabupi 0.5%, Cristália), administered epidurally to the 10 buffaloes following 48 hr of fasting. Before this and under anesthesia, the animals were placed in a trunk maintaining them in a quadrupedal position, and their rectums were emptied by palpation. The sacrococcygeal region was cleaned with soap and water and degreased with alcohol and 2% iodine (Riodeine 2%, Rioquímica, São Paulo, Brazil).

The epidural anesthesia technique used in this study was based on the reference for the sacrococcygeal region of the animal, and a viable intervertebral space for the introduction of the Tuohy needle and the epidural catheter was sought. The operative fields, comprising the left flank, right flank, and the last right intercostal space, were sterilized and anesthetized with infiltrative blocks of 10 ml of local anesthetic (lidocaine) in the region where the skin would be incised for each laparoscopy port site.

Exploratory laparoscopy

The following equipment and laparoscopic video instruments were used: electronic CO_2 insufflator (Access 40, Dyonics, Michigan,USA), light source (Led Light Source, GDI, Ribeirão Preto, São Paulo, Brazil), lighting cable (Fiber optic 495 light cable, Karl Storz SE & Co, Germany), microcamera with processor (Combo Endosurgery system, GDI,), rigid 10 mm endoscope with 0° diameter (Ø) and a 33 cm long viewing angle (Rigid endoscope, Karl Storz SE & Co, Tuttlingen, Germany), monitor (AG Neovo 22, Neovo, Taipé, Taiwan), Zscan recorder (image capture software, Zscan, Brazil), and 5 and 10 mm trocars (Rigid trocars, Bhio Supply, Sapucaia do Sul, Rio Grande do Sul, Brazil). All the materials were disinfected by submerging them in a 2% glutaraldehyde solution (Glutacin, Cinord, Serrana, São Paulo, Brazil) for 45 min and rinsing with a sterile 0.9% sodium chloride solution (Eurofarma, São Paulo, Brazil). The microcamera was connected to a rigid 10 mm Ø endoscope, and the fiber optic cable was covered with a sterile videoendoscopic plastic cover.

Surgeries were initially performed on the left side and, subsequently, on the right side. The first port was made on the left flank, at the center of a triangle formed by the limits of the thigh tuberosity, the transverse apophysis of the lumbar vertebrae, and the thirteenth rib. A small incision was made in the animal’s skin, and the 10-mm permanent trocar was inserted with care to prevent iatrogenic perforations. As soon as the abdominal cavity was visible through the rigid endoscope, the region was insufflated with CO_2, using a 15 mmHg intra-abdominal pressure and 5 l/min insufflation speed. This process was repeated on the right side; however, in addition to the flank port, an intercostal port, of 20–30 cm in the dorsoventral direction, was added between the twelfth and thirteenth ribs.

Postoperative

At the end of the surgical procedure, some of the CO_2 present in the abdominal cavity was released by opening the cannula safety valve. All the trocars were removed with rotating movements that promoted the approximation of the muscle layers. The skin incision was closed with two horizontal mattress sutures using nylon 0 (nylon, monofilament black 0, Shalon, Sertix, Rio de Janeiro, Brazil).

For analgesic and anti-inflammatory therapy, all animals received intramuscular injections of flunixin meglumine (Niglumine, Ceva Hertape, São Paulo, Brazil; 1 mg/kg) during the immediate postoperative period and every 12 hr for the first 48 hr. For antimicrobial therapy, 20% oxytetracycline hydrochloride (Oxitape, Ceva Hertape) was administered intramuscularly at a dose of 20 mg/kg. The surgical wound was dressed with an ointment (Uguento, Vansil, São Paulo, Brazil) until the stitches were removed 10 days after the operation.

The animals were confined to their respective pens until they were observed to interact with the others, after which they were released back into the pasture. Roaming animals that presented with ataxia or any other sign of altered behavior were retained in stalls, and follow-ups continued. They were released once they showed signs of recovery.

Data

The following were considered during endoscopic observation: identification of the organ or structure, the visualized segment, and the possible resulting changes. These data were distributed according to the approached area, with the abdomen subdivided into cranial and caudal regions for each access port.

RESULTS

Intracavitary exploration on the left flank (Table 1) began once the pneumoperitoneum was obtained. The dorsal rumen sac was easily located, and we obtained the image (Fig. 1C) of its left longitudinal groove from a dorsal point of view with the dorsal sac ventrally. Following the entire length of the rumen sac to the caudal end allowed the visualization of the rectum, descending colon, and uterus (Fig. 1B).

With rectal palpation, it was possible to view the left and right ovaries in some animals (Fig. 1D). It was also possible to access the bladder, although this was more difficult. The caudal vena cava was occasionally observed when the endoscope was positioned dorsally.

In the cranial portion, it was possible to identify the nephrosplenic space and its structures, such as the ligament and spleen. Some animals had fibrin in the spleen and an aspect of adherence to the nephrosplenic space (Fig. 1A). Peritoneal liquid content with a reddish appearance and occasionally with the presence of fibrin was found in most buffaloes, making it impossible to explore the ventral region.

In the case of the right flank (Table 1), the fixed portion of the greater omentum prevented the visualization and exploration of the abdominal cavity (Fig. 2A). In addition, the thick structure and complicated penetration of the right flank hampered the movement of the endoscope. However, it was occasionally possible to visualize the descending duodenum in smaller and heavier animals.

It was possible to identify more structures with the intercostal access port on the right side, although movement was slightly restricted by the bone structures (Table 1). Better visibility was achieved with the intercostal access port than with the right flank access port. The caudal lobe of the liver was observed soon after the endoscope was inserted into this field (Fig. 2B). Cranially, a progressive space between the liver and the abdominal wall was formed due to pneumoperitoneum, thereby facilitating the exploration of the area and allowing the visualization of the right hepatic lobe. In some buffaloes, fibrin and hemorrhagic spots were observed on the liver, with some even exhibiting small adhesions (Fig. 2D). A section of the descending duodenum was visualized cranially, and the pancreas and the cranial part of the duodenum were accessed caudally (Fig. 2E), in some animals (Fig. 2C). The right kidney in the retroperitoneal space was only visualized in one animal (Fig. 2F).

DISCUSSION

Several laparoscopic procedures can be applied to ruminants [20]. This includes reproductive manipulation techniques, such as artificial insemination and embryo transfer; therapeutic and diagnostic techniques, such as biopsies of the liver, kidney, intestines, pancreas, ovaries, and other organs; diagnosis of conditions such as traumatic reticuloperitonitis, post-surgical adhesions, and abomasal ulcers; and various other interventions such as bladder and umbilical structure resection, and assessing the performance

Table 1. Number of video-laparoscopic views of the structures located in the access to the left and right sides of the buffaloes according to the laparoscopic procedure in the quadruped position

Structure proposed for laparoscopic visualization	Total of animals (%)	Type of access
Kidneys	10	Penultimate intercostal space
Spleen	100	Left flank
Nephrosplenic ligament	100	Left flank
Reticulum	0	None
Liver	100	Penultimate intercostal space
Cranial rumen	100	Left flank
Caudal rumen	100	Left flank
Omasum	0	None
Abomasum	0	None
Bladder	80	Left flank
Uterus	100	Left flank
Ovaries	100	Left flank
Rectum	100	Left flank
Descending colon	100	Left flank
Caudal vena cava	80	Left flank
Diaphragm	0	None
Descending duodenum	70	Penultimate intercostal space and right flank
Duodenum (cranial part)	100	Penultimate intercostal space
Intestinal loops	70	Penultimate intercostal space and right flank
Pancreas	40	Penultimate intercostal space
Greater Oment	100	Right flank
Right kidney	10	Penultimate intercostal space
Cecum	0	None

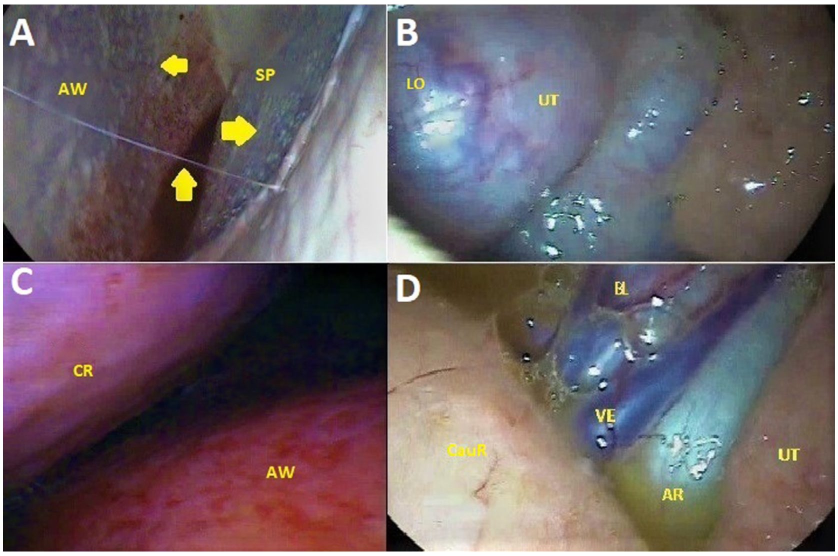

Fig. 1. Left flank laparoscopy with cranial and caudal views. **(A)** Visualization of the spleen (SP) and abdominal wall (AW). Arrows indicate dots and fibrin stripes on these structures. **(B)** Caudal view of the uterus (UT) and left ovary (LO). **(C)** Ventral view of the caudal rumen (CR) and abdominal wall (AW). **(D)** Insertion of the endoscope further allowed visualization of the broad ligament (BL), uterine and ovarian veins (VE) and arteries (AR), and the space between the caudal rumen (CauR) and uterus (UT).

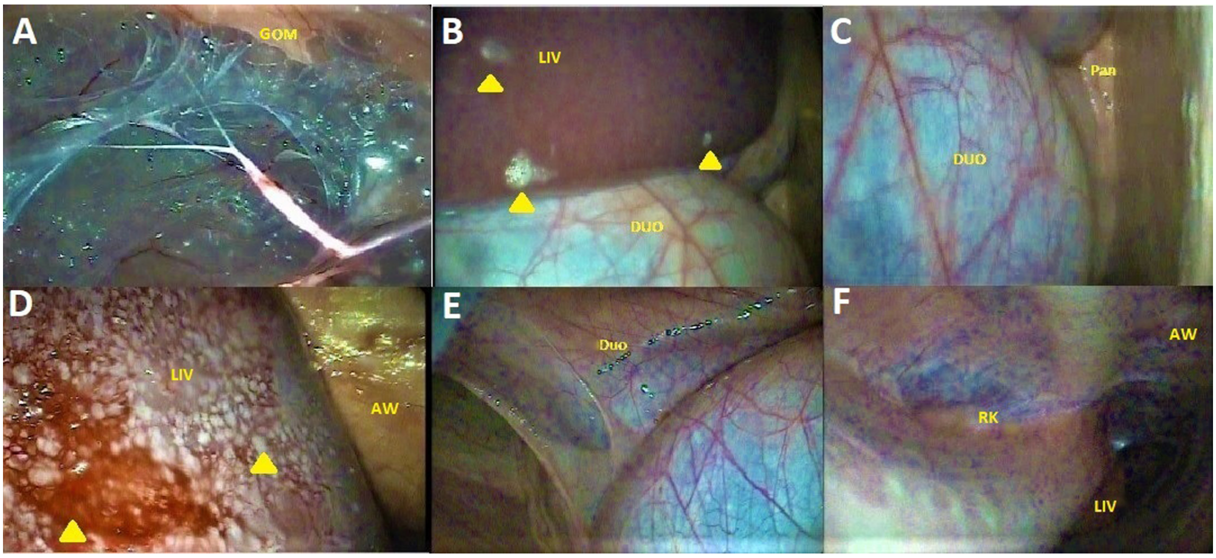

Fig. 2. Right side laparoscopy. **(A)** Observation of the left flank coming directly across the great omentum (GOM) and its thick laminated structure. **(B)** The liver (LIV) is beside the right intercostal access and the duodenum (DUO). Arrows indicate dots of fibrin. **(C)** Using the intercostal access, the pancreas (Pan) is located ventrally. **(D)** In one animal, the liver was filled with fibrin and had hemorrhagic points (indicated by arrows). **(E)** Positioning the endoscope caudally allowed visualization of the mesoduodenum and duodenum (DUO). **(F)** Positioning the endoscope cranially allowed views of the liver (LIV) and right kidney in the retroperitoneal space (RK).

of abomasopexy [7, 20]. The present study has confirmed that such procedures are also feasible for buffaloes.

Access through the left flank and right intercostal space proved to be most effective and allowed good visualization of most organs and their structures. Access through the right flank was less effective due to the extremely thick skin and the dense greater omentum at this side. The greater omentum weighs approximately 6 kg in buffaloes, which is closer to the 3 kg in cattle [16], and this made it impossible to progress with the 30-cm endoscope. A 57-cm rigid endoscope would be more preferable for use on this side [10].

It was not possible to obtain a wide view of both the right and left sides of the abdominal cavity in the buffaloes [13]. This may be attributed to the digestive tract of the buffaloes, which had a higher food storage capacity due to the considerably larger and more complex rumen and reticulum when compared with those of cattle [15]. However, a good inspection of the organs mentioned above was still possible. In cattle, it is easy to explore and identify the viscera through a port on the right flank [10]. As indicated, this was not the case for buffaloes, due to peculiarities of the stomach and omentum of the buffaloes [15].

Morphological peculiarities of buffaloes were also observed in this study. These include the surface of the non-glandular stomach having a darker color, with black pigmentation evident in the mucosa of the reticulum and the abomasum. These contrast with those of cattle, which, for example, demonstrate a brownish aspect [17]. This characteristic is related to the increased tissue mass and larger blood vessels in the buffaloes, demonstrating intense vascularization and increased absorptive capacity [17]. It was also observed during laparoscopy that the stomach occupies a large part of the abdominal cavity. This has been previously mentioned in studies that have demonstrated that the organ composes 3/4 of the abdomen, and, when empty, the rumen alone weighs around 6.370 kg and is 108 cm long and 70 cm wide [16]. When compared with cattle of the same body weight, the full stomach of the buffaloes weighed 50 kg, compared with only 38 kg for the cattle [16]. Another interesting fact is that the small intestine in cattle proved to be longer than that of buffaloes, while the large intestine showed the opposite trend. However, the full length of the intestines in cattle is longer than that in buffaloes [16].

Some regions of the abdomen were not accessible using our access ports. It was not possible to view the diaphragm, left kidney, reticulum, omasum, and abomasum when accessing the buffaloes from the left flank. The cecum and bladder could not be viewed when accessing from the right flank. In cattle, however, it is possible to access the diaphragm, bladder, and cecum [7]. This may relate to structural differences between cattle and buffaloes, as well as differences in the size and weight of the animals since the buffaloes had a higher proportion of body size and weight than reported in cattle.

Access to the most cranial region on the right side via the intercostal port allowed good access to the liver as presented it this study. The clear perspective on the liver even permitted video-assisted liver biopsy procedures, which facilitated its observation and manipulation. The feasibility of laparoscopic access to perform liver biopsies is particularly relevant for the species studied here since liver diseases are prevalent in buffaloes [3, 4, 14] and often go unnoticed until they are observed in slaughterhouses causing economic losses to producers [4, 14]. Furthermore, ultrasonography often cannot identify the lesion, whereas the degree of detail in terms of depth, color, presence of fibrin, aspect, and texture, which is possible with laparoscopy, would allow for a precise diagnosis.

Diagnosis of other abdominal diseases can also be enhanced by laparoscopy. Peritonitis and inflammatory signs, such as congested blood vessels, the presence of fibrin and adhesion between abdominal structures, and large amounts of fluid with differences in color and turbidity, are easily observed with laparoscopy [6]. Some cases of peritonitis are caused by the presence of foreign bodies. This is a syndrome that is occurring with increasing frequency and can often be diagnosed with laparoscopy when performed cranially [19]. Laparoscopy can also be used to collect samples of fluid and for adhesiolysis, further illustrating the role of laparoscopy for diagnosis and treatment.

Another common abdominal affliction in buffaloes is traumatic reticuloperitonitis, which is usually diagnosed using ultrasound [7]. Previous studies with cattle have shown that laparoscopy is superior to clinical examination [25] and could be an important tool for the diagnosis and characterization of lesions from traumatic reticuloperitonitis. For cattle, laparoscopy was performed through the left flank in cases of suspected reticuloperitonitis, and in all cases, red or yellow fibrin deposits were easily identified on the surface of the rumen [25]. It was also possible to visualize adhesions between the rumen and reticulum in cattle, facilitating the diagnosis of this condition based on the observation of fibrin and fluid. This also demonstrates the value of a minimal intervention approach such as laparoscopy for the diagnosis of adhesions [25].

Ultrasound is a useful tool, but it is of minimal value for the diagnosis of abdominal disorders, such as omental bursitis and abomasal ulcerations [11]. Laparoscopy can be used in these instances, and it allows the identification of ulcerations, which is not always possible with ultrasonography. This is also true for detecting internal abscesses [2], which can be located and even treated endosurgically, because drainage, fluid aspiration, local application of medicine, biopsies, and adhesiolysis can all be performed laparoscopically.

In this study, we obtained satisfactory visualization of the uterus and ovaries. This is important for the development of therapeutic and manipulative interventions to enhance buffalo reproduction. This warrants further investigation since ovarian functional disorders, such as subestrus, persistent corpus luteum, ovarian cysts, inflammation, and neoplasms, are frequently observed in buffaloes [3, 23].

The pancreas is particularly difficult to access in cattle [7], and the visualization of the pancreas is usually contingent on the weight of the animal. In the current study, it was possible to access the pancreas of two of the buffaloes. The right kidney, surrounded by adipose tissue in the retroperitoneal space [13], was reached in only one buffalo. Regarding the preparation for laparoscopic procedures, previous studies have shown that prolonged fasting for approximately 18–24 hr is essential. This allows for the intestinal compartments to be emptied, facilitating better visualization and a reduced risk of iatrogenesis when introducing the cannula or trocar [12]. The fasting duration adopted in this study provided adequate intracavitary space for viewing through the endoscope on both sides, even though the rumen occupies a large space in the left portion.

In this study, a CO_2 pressure of 15 mmHg was used. This was within the generally recommended range of 12 − 15 mmHg [13]. Exceeding a pressure of 20 mmHg is not recommended [7]. The pressure used here was sufficient to remove the viscera from the abdominal wall, and there was no evidence of intraoperative abdominal discomfort due to the use of CO_2. There was also no evidence of abdominal discomfort 72 hr after the surgical procedure, which is an important practical consideration when using the video-surgical resource [22]. Procaine penicillin was selected for use for antimicrobial therapy. Although laparoscopic surgery is considered relatively sterile, the procedure was performed in an open area, and there was the risk of environmental contamination.

This study has confirmed that laparoscopic access through the left flank and last intercostal space in healthy buffaloes in the quadruped position is feasible. Access from the right flank was not as effective but it could be improved by using a longer rigid endoscope. Laparoscopy is a promising technique for the exploration, diagnosis, and treatment of buffalo disorders since it can be performed with the animal in a quadruped position. Laparoscopy also allows the access and visualization of organs and internal structures without requiring a more invasive intervention, which consequently protects animal welfare and health.

POTENTIAL CONFLICTS OF INTEREST. The authors have nothing to disclose.

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