Laparoscopic exploration in dogs

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Introduction

Laparoscopy is a procedure which allows exploration of the whole of the abdominal cavity, thus making a comprehensive laparotomy unnecessary. As a diagnostic method for abdominal pathology it allows the different organs to be seen in detail and, at the same time, the possible lesions which may affect them to be assessed. Prior to resorting to the use of any procedure which entails laparoscopic surgery it is extremely important not to forget to carry out a systematic laparoscopic exploration (Nord and Boyd, 1996). Explorations such as these offer all the advantages of minimally invasive surgery such as (Böhm and others, 1995), for instance, the fact that they cause relatively little damage when performing small incisions in order to introduce instruments and, at the same time offer detailed images of the abdominal structures.

The term laparoscopy has its origin in the Greek roots lapará and skopein which mean ‘abdomen’ and ‘to examine’ respectively. The beginning of laparoscopy was purely for diagnostic purposes. The first exploration of the abdominal cavity was carried out in 1901 by George Kelling, who after ballooning air into the abdomen of a dog, introduced a cystoscope (Weber and others, 1994). It was in 1924 (Weber and others, 1994) when the Veress needle appeared, and this helped to reduce the risk of a visceral lesion by causing a pneumoperitoneum prior to the insertion of trocars. The progress made by laparoscopy ran parallel to the technological development achieved in the field of imagery as well as in that of the transmission of cold light. The next step consisted of biopsy samplings guided by laparoscopy, with the advantage of increasing the number of ports to mobilize viscera (hepatic, renal, pancreatic, splenic and tumoral mass biopsies, etc.). The first laparoscopic biopsy of a dog’s liver was carried out by Lettow in 1970. With the passing of time, diagnostic laparoscopy has gradually become a method of diagnosis that complements radiography and ultrasonography, particularly in those cases where the diagnosis is not clear and the possibility of using an exploratory laparotomy is being considered. Furthermore, diagnostic laparoscopy has also become a complementary diagnostic method in the field of biopsy where samples of those lesions of interest can be obtained with much more accurate monitoring of potential bleeding from the biopsied organ. This represents a breakthrough with respect to the use of percutaneous biopsies, since in these cases neither the monitoring of hemostasis nor the localization of the biopsy sample are so accurate (Bunch and others, 1985; Graber, 1993, Johonson and Twedt, 1997; Wildt and others, 1997).

It is also very useful in the field of oncology since it allows us to explore both the area of the neoplasia and its adjacent regions (lymph nodes). In the case of animals with abdominal trauma showing possible signs of a visceral rupture (bladder, spleen, pregnant uterus, etc.) a laparoscopic exploration may make it unnecessary to undergo an exploratory laparotomy, as long as the animal is hemodynamically stable. At present the development of therapeutic laparoscopy together with its application in the veterinary field and particularly in small animal surgery has its origin in the field of the genital apparatus of both males and females (ligature or tubal ligation, ovariectomies, laparoscopic vasectomies, cryptorchidism, etc.), and at present still continues to develop within the different surgical specialities.

The purpose of this article is to describe the process involved in a laparoscopic exploration and also to provide a description of the laparoscopic anatomy of the abdominal cavity in the canine species.

Materials and methods

The material used to carry out this research belongs to the Minimally Invasive Surgery Centre of Cáceres (CCMI) (Spain). Our laparoscopy research
began by using an endoscope and a trocar placement, carrying out laparoscopic explorations in the abdominal cavity, as well as using surgical procedures on genital and digestive system. The next step was the usage of laparoscopic towers with halogen light sources, up to the present systems of digital laparoscopic towers (3CCD) with Xenon light. The laparoscopic tower used in this research was:

- Colour video monitor Trinitron Pvm-14N1 E. Sony
- Video camera, Telecam SL pal 202120-20 and digivideo 202020-20 Storz
- Light source, Xenon 300, 201330-20 Storz
- Insufflation equipment, Electronic endoflator 264305-20, Storz

The studies were all performed with different species of animals (canine, ovine and porcine).

Optics measuring 10 mm and 7.5 mm optics, with 0° angle of vision, are used since these allow frontal vision thus making its operation and observation easier (Surgiview 10 mm/0°, Autosuture).

The use of optics with different angles of vision such as those with 25° and 50° is especially recommended in order to gain access to those regions of difficult access, as well as for those cases where an angled vision is required. The drawback is that they are more difficult to operate than those with 0° frontal vision.

For entry, porta trocars with a pyramid-shaped end are used since they penetrate the abdominal wall more easily than those with a cone-shaped end (Magne, 1990). These trocars are equipped with a safety device that will spring open when the layers of the abdominal wall are punctured, covering the sharp end so as not to damage the viscera. On the other hand, Luer adapters are also used to connect CO2 or to irrigate the inside of the trocar (Premium Surgiport 10.5 mm, Autosuture).

The pneumoperitoneum needle is a safer variation of the classical Veress needle, the so-called Surgineedle®, which has a safety pin that protrudes from the cutting end when there is no resistance from the tissues similar to that of trocars, as well as a being system which shows how the needle passes through the different layers of the patient.

The insufflators used are CO2 automatic insufflators, and by pre-setting the intra-abdominal pressure between 12-14 mm of Hg, the CO2 is eliminated very quickly (Graber, 1993). The reasons for choosing CO2 as the gas to be used for carrying out the pneumoperitoneum were based on two main features (Serrano, 1994):

- It is a non-combustible gas which means that electrocoagulation can be used without risk.
- Should there be a chance of emboli, the prognosis will be more favourable and the treatment easier than when using nitrous oxide.

The animal is fasted for twenty-four hours prior to the operation and access to water is withdrawn some hours beforehand. The animal is shaved for surgery and then preanesthesia is administered. Preanaesthetic medication (Atropine 0.01 mg/Kg IV), induction (Propofol 2-4 mg/Kg IV), maintain anaesthetic (Desfluorane 8%, inhalation agent and O2 92%), analgesia (Fentanyl 2-5 gr/Kg), and post surgical analgesia (Pethidine 3-4 mg/Kg). Urinary bladder and gastric drainage are carried out routinely in order to eliminate the air inside the stomach and to remove residual urine in order to facilitate manoeuvring during laparoscopy. The dog is placed in dorsal recumbency, and after that the surgery table will be tilted either to the right or to the left, depending on the area being explored.

The Veress needle has to be inserted below the xiphoid apophysis and alongside the midabdominal line, at a 45° angle so as to avoid damaging the falciform ligament and the cranial epigastrium vessels. Besides this is the area which allows a wider distance between the abdominal wall and the viscera. The next step is to check whether the needle has actually crossed the abdominal layers by introducing normal saline and by means of irrigation manoeuvres (if the needle is well placed, the normal saline cannot be recovered, and besides this, the spring will make a peculiar cracking (Jones, 1990).

It is extremely important to calculate the thickness of the abdominal wall as well as to handle the needle at a distance which is equivalent to the thickness of the wall, thus avoiding damage to the liver or the spleen which are in fact the two viscera most likely to be perforated. The needle is then connected to the automatic CO2 insufflator, at the beginning with a low flow of 1 litre per minute until a maximum intra-abdominal pressure of 14 mm of Hg is reached.

At a distance ranging between 2 and 3 cms from the umbilical scar, in a paraumbilical position, pressure is exerted with the end of the 10 mm trocar (when 10mm optics are used) and with that diameter a skin incision is made. The trocar is gently advanced until the characteristic cracking sound of the safety pin is heard, after which the trocar fixator has to be twisted on to the skin. This will be the only trocar introduced blindly since the remaining ones will be inserted under direct vision. The laparoscope is introduced after carrying out a white balance. A gauze is utilized so as to obtain a maximum fidelity of colour vision. The precaution taken to sink the optics in normal saline at 50ºC will prevent steaming. The first area to be explored is that of the pneumoperitoneum needle entrance.

The exploration may be started at this time, otherwise one or two more trocars may be introduced to insert the set of instruments which helps to separate the viscera and consequently enables viewing of all the abdominal structures.

The trocars for the set of instruments are placed some centimetres laterally and caudally to the trocar of the optics, placed symmetrically in each hemiabdomen (distance will depend on the size of the abdomen of the dog to be explored). Trocars may be 10
mm or 5 mm, though if the former is employed then adapters should applied at 5 mm if a set of instruments of this diameter is used. These trocars are to be inserted by means of direct vision, the abdominal wall will be pressed with a finger and the port of entry will be identified by using a laparoscope, the entire process being followed from the inside of the abdomen (Fig. 1).

After having inserted the trocars for the set of instruments, the Veress needle is removed and the CO2 connection is linked to one of the trocars of the set of instruments. It should never be connected to the trocar of the laparoscope because the optics will get cold and the image will be blurred by steam.

The exploration should be started on the upper quadrant of the abdominal cavity and the optics moved throughout the whole cavity in a clockwise direction. The different structures will be separated and moved by using the dissectors of the accessory trocar. The exploration will come to an end once we return to the starting point, thus completing the circular sphere. The movements of the set of instruments within the abdominal cavity should always be guided by the optics which must be operated gently.

In order to carry out a peaked laparoscopic exploration of a dog, the abdominal cavity should be divided into the right and left hemiabdomen (a division that will be made taking the mid abdominal line as a reference point) (Fig. 2).

**Diaphragm**

This is a cupola which separates the abdominal cavity from the thoracic cavity (Evans, 1993), comprising both the upper right quadrant and the upper left quadrant, and it is formed by a central tendon and a muscular border with a right pillar and a left pillar, the former being of a greater size and having an insertion at the level of the fourth lumbar vertebra. In order to see the diaphragm cruses, the liver must be moved cranially by placing the patient in Trendelenburg position and by inserting a separator so as to fix the liver in this new position.

The diaphragm is perforated by the oesophageal hiatus (oesophagus, vagus nerves and oesophageal vessels) and the aortic hiatus that is sited in between the two pillars and is used as an entrance to the aorta, the azygos vein and the thoracic duct. Finally, the hiatus of the caudal vena cava is hidden in its most dorsal portion by the liver. The heart movements may be seen through the central tendon due to the fact that the abdominal cavity has been insufflated with CO2 (Fig. 3).

**Liver**

The liver is located in the intrathoracic portion of the abdominal cavity, in direct contact with the diaphragm, and it is formed by six lobules:

- **Left lateral lobe**: it has a concave surface in contact with the stomach.
- **Quadrate lobe of the liver**: it is placed on the left of the gallbladder.
- **Left medial lobe**: it is placed in between the two above mentioned hepatic lobes.
- **Right medial lobe**: this lobule and the quadrate lobe cover the gallbladder; the hepatorenal ligament and the inferior vena cava can be seen below it.
- **Caudate lobe of the liver**: it has two processes, namely, the papillary process and the caudate process.
- **Right lateral lobe**: it is usually small in size.

The different lobes may be examined both on their lower surface and their parietal surface by introducing a dissector or a separator through a trocar (Dalton and Hill, 1972).
By doing this the gallbladder and the cystic duct can be seen, which when linked to the hepatic canals leads on to the common bile duct. If the patient has fasted a gallbladder great in size will be observed (Twedt, 1990).

The left part of the liver is in contact with the stomach, cranially with the diaphragm and with the right kidney leaving a renal fossa in the caudate process, as well as an impression caused by its contact with the duodenum.

The falciform ligament of the liver is a peritoneal plication which extends from the liver to the navel and that is usually filled with fat, thus making it difficult both inserting trocars (near the midline) and trying to see the contralateral hemiabdomen. This structure, together with the spleen, runs more risk of being damaged when inserting a Veress needle to carry out a pneumoperitoneum prior to the laparoscopic exploration (Fig. 4).

**Stomach**

The stomach, a dilatation of the digestive tube sited between the oesophagus and the duodenum (Evans, 1993) is situated in the intrathoracic region of the abdominal cavity, in the upper left quadrant. It occupies a transverse position, its volume varying a lot depending on the degree of alimentary repletion. It is a structure which due to its muscular nature expands and contracts upon necessity, varying its relationship with the adjacent organs. When the stomach is completely empty it is hidden below the liver, diaphragm and intestinal loops. The first region of the stomach that may be seen is the greater curvature, where the superficial wall of the greater omentum is fixed.

The branches of the right and left gastroepiploic arteries as well as those of the left gastric artery may also be seen, together with the nervous branches branching out of the vagus or pneumogastric nerve that run through the visceral and parietal surface of the stomach.

The region of the gastric fundus connects to the diaphragm, and the cardial portion of the stomach is hidden by the lobules of the liver. The stomach leaves a gastric impression on the liver, sited between the lateral left lobule and the papillary process of the caudate lobe. If this area needs to be seen, then a dissector should be inserted and the lobes of the liver raised.

Both the pylorus and the pyloric antrum are placed in the upper right quadrant of the abdomen, thus lodging on the right of the papillary process. The passage from the stomach to the duodenum is clearly observed.

The stomach is connected to the liver through the hepatogastric ligament and to the spleen through the gastrolienal ligament. The former is a part of the lesser omentum and the latter of the greater omentum. The stomach, when full, is in contact with the abdominal wall and moves the intestinal loops caudally (Fig. 5).

**Spleen**

The spleen is placed on the left of the stomach, being linked to it through the gastrolienal ligament, and it runs along the greater curvature of the stomach. It is in contact with the left abdominal wall and with the liver.

The phrenicosplenic ligament fixes the spleen to the tectum of the abdomen, or better to the left pillar of the diaphragm. Its anterior border is placed in between the 12th and the 13th thoracic vertebra (Evans, 1993).

It may be moved laterally by using forceps so as to allow viewing of the hilum of the spleen where the splenic artery and the splenic vein run (Fig. 6).

**Left kidney**

In order to have a perfect vision of the left kidney the animal must be tilted to the right so that the intestine moves medially. It is sited between the second and the fourth lumbar vertebra, in a more ventral position and not as fixed as the contralateral kidney.
It is in lateral contact with the spleen and the greater curvature of the stomach through the gastrolenal ligament, and cranially with the left suprarenal gland and the left lobule of the pancreas.

Furthermore, it is directly connected with the aorta through the renal artery, a linkage which may be easily seen by following the renal artery from the hilum of the kidney to the aorta. The outlet of the ureter running caudally toward the bladder can also be easily observed. The left suprarenal gland is sited in the cranial portion of the kidney, close to the aorta. The peritoneum lines it cranially while it is caudally lined by the perirenal fat.

It may be exposed by moving both the spleen and the stomach cranially and the kidney caudally (Fig. 7).

**Ureter**

The ureter finds its outlet in the dorsal portion of the neck of the urinary bladder (cervix vesicae) (Schaller, 1996) and on its way it is lined with a plication of the peritoneum coming from the dorsal body wall. Its trajectory from the kidney to the bladder may be followed, though in obese dogs this will turn out to be a difficult task since it is lined with a lot of fat. It may be easily seen when it crosses the deep circumflex iliac vessels and the superficial iliac vessels ventrally (Uson and others, 1996) (Fig. 8).

**Urinary bladder**

The urinary bladder is the organ which retains the urine coming from the kidneys through the ureters.

It is sited in the pelvis cavity in a central position and when it is full it advances towards the abdominal cavity. It is fixed by means of three ligaments, two of which are lateral and one is medial, and in fact the latter of these may be easily seen when setting the optics to 6 o’clock position. This ligament links the solum of the pelvis and the mid abdominal line to the central face of the urine bladder. The collateral ligaments fix the bladder to the lateral walls of the pelvic cavity, and in females also to the broad ligament of the uterus. In females both the neck of the uterus (cervix uteri) (Schaller, 1996) and the body of uterus are in contact with the dorsal face of the bladder. In males the deferent ducts (ductus deferens) (Schaller, 1996) crosses the neck of the bladder dorsally in addition to the prostate which envelops the urinary bladder neck (cervix vesicae) (Schaller, 1996) (Fig. 13).

**Female reproductive organs**

The ovaries are lodged just a few centimetres (from 1 to 3) from the caudal pole of the kidneys, and they are coated by the ovarian bag that has an opening in its medial face (Evans, 1993). The left ovary is sited in between the abdominal wall and the descending colon. The deposit of fat in the area may make vision difficult, especially at the mesosalpinx level. On the other hand, the right ovary is placed in a more cranial position than the left one and is sited dorsally to the descending duodenum which should be raised in order to see the right ovary and its suspensory ligament that is linked to the last two ribs.

Each ovary is connected with the respective uterine horn by the ligament of the ovary, that moves caudalwards the pelvic cavity. The round ligament of the uterus which runs towards the corresponding inguinal ring may be seen in this way.

The body of the uterus and the cervix uteri are connected to the urine bladder and the rectum (Fig. 9).

**Male reproductive organs**

The deferent ducts enter the abdominal cavity through the inguinal rings (either right or left). Arteries, veins and testicular nerves accompany the deferent duct when entering the abdominal cavity.
On their way to the prostate the deferent ducts cross with the ureters and the external iliac artery, shaping a cranial-dorsal arch which extends from the inguinal ring to the outlet sited in the prostate. The prostate is the only accessory sexual gland of the canine species (Evans, 1993). It is placed around the urinary bladder neck and covers the initial portion of the urethra, divided by a longitudinal fissure into two lobules, the right and the left ones. This gland may be more easily seen in adult dogs since, as a general rule, it is bigger in size. The deferent ducts have their outlet in the cranial-dorsal face of the prostate. To explore it the optics should be moved laterally and deeply towards the bladder by raising the latter by means of a clamp. The exploration has to be completed on both sides of the urinary bladder (Fig. 10).

Testes that have not descended may be found in proximity of the inguinal ring (cryptorchidism) (Silva and others, 1993).

Deep inguinal ring
The deep inguinal ring is bounded by the internal and external oblique muscles, and medially by the rectus abdominis muscle. The inguinal ring is placed very near the femoral ring (hiatus femoralis) (Schaller, 1996) and craniolaterally to it. In males it is used as the pathway of the vaginal process and the descended testis. The deferent duct and the testicular veins and nerves can be seen in adults.

In females it is surrounded by a lot of fat and it is used as the pathway of the vaginal process and the round ligament of the uterus. The inguinal rings are very interesting for veterinarians due to the frequent pathologies that may be found within this region such as, for instance, scrotal and inguinal hernias and cryptorchidism (Figg. 11 and 12).

Descending colon and rectum
The descending colon is the largest portion of the colon and it starts at the level of the left flexure of the colon (i.e. the splenic flexure). It is connected to the left ureter; in its final part the uterine horns (in females) and the urinary bladder are sited ventrally to it. The last intestinal portion is the rectum and it is placed in a mid position the urine bladder should be raised to visualize it (Fig. 13).

Right kidney
After tilting the animal to the left side and moving the descending duodenum, we can find the right kidney which is placed in a much more cranial position than the left one and is also more fixed in its position. The right kidney is related to almost all the structures in the upper right quadrant, namely:

![Figure 10 - Canine prostate (lateral view).](image1)

![Figure 11 - Right inguinal ring of female dogs.](image2)

![Figure 12 - Right inguinal ring of male dogs.](image3)

![Figure 13 - Abdominal and pelvic cavities of a female dog.](image4)

![Figure 14 - Right kidney.](image5)
• The liver, leaving a renal impression on its caudate lobe, having the hepatorenal ligament as a joining link, which may be easily seen when exploring the cranial pole of the kidney.
• The right adrenal gland, which is sited in the cranial portion of the kidney.
• The last rib.
• The descending duodenum, the right pancreatic lobule and the ascending colon, sited ventrally to it.
• The relation with the inferior vena cava is much more evident than in the left kidney, unlike the relation with the aorta which is more evident in the left kidney.
• The right ovary is distant few centimetres from the inferior pole of the kidney (Fig. 14).

Ascending and transverse colon

The ascending colon is connected to the kidney through the mesoduodenum and dorsally to the right lobule of the pancreas.

Cecum

The cecum is medial to the descending duodenum and it is sited laterally to the right pancreatic lobule (Fig. 15).

Pancreas

The pancreas is formed by a body and two lobes (the right and the left lobe) (Evans, 1993). The right lobe is connected to the right kidney and the descending duodenum by the mesoduodenum. The ascending colon is connected to the right lobe while the transverse colon corresponds with the left lobe. The body of the pancreas joins both lobes at a 45° angle, and the pylorus leaves a large impression on the cranial portion of the body of the pancreas. By raising the descending duodenum the whole of the right lobe of the pancreas can be observed. The remaining portions of the pancreas are difficult to gain access to since they are placed below the intestinal stretches and the omentum (Twedt, 1990) (Fig. 16).

Duodenum

The descending duodenum is sited ventrally to the right kidney and it covers the right lobe of the pancreas with the two laminas of the mesoduodenum. The exploration will end by visualizing the liver and the diaphragm, which is actually the starting point.

Discussion

The laparoscopic exploration constitutes an alternative diagnostic method in the dog, since it is a more conservative procedure than exploratory laparotomy and it may be used as a complement to ultrasounds and X-rays; the use of CT scan cannot be really said to be widespread in veterinary practice, at least up to now.

Carrying out a systematic laparoscopic exploration proves to be very useful as a prior step in learning laparoscopic surgery. The surgeon gets to know and gets used to:

• The bidimensionality of the image via monitor, which in fact is one of the most serious problem found at the initial stages of the learning process of laparoscopic surgery due to the loss of the feeling of depth.
• Change of the surgeon’s position in respect to the patient, since the surgeon will look at the monitor placed in front of him / her rather than at the abdomen of the patient.
• The induction of pneumoperitoneum, since the surgeon will get used to the correct insertion of the Veress needle as well as to the use of a CO2 insufflator.
• Both the introduction / insertion of trocars and the way to operate them, as well as a knowledge of their mechanism.
• The handling of the set of instruments and the optics within the abdominal cavity which is a requirement for undertaking surgery with adequate guarantees.
• The operation of laparoscopic equipments, so as to be acquainted with all types of connections and then be able to assemble a recording system or just printers.
• The real colour of visceras, which will be useful for the surgeon in the future when coming across lesions and modification of normal pigmentation.
• The carrying out of anatomical-surgical protocols, since once the medium is known, then it may be possible to propose protocols to gain access to the abdominal viscera.

The images provided by the laparoscope are magnified and for this reason some details can be seen that might be overlooked in a direct vision using laparotomy.

In the exploration that precedes a laparoscopic intervention it is very frequent to come across:
• Synechias or adhesions between different organs
• Abscesses
• Organomegalies
• Tumours
• Adenopathies

The training period of this technique must follow some steps to learn from the basis to the complex.

The first step is to get experienced of the laparoscopic equipment, both the components of a laparoscopic tower (i.e.: video monitor, video camera, light source, insufflator) and the surgical instruments (i.e. forceps, trocars, etc.).

The next step is to get used to the bidimensional images. This can be achieved by means of a simulator which allows to use the laparoscope and the forceps following the procedure via monitor.

After this learning period an experience using animals can be made in referenced teaching centres. Starting from the technique of inducing a pneumoperitonem and of carrying out a complete laparoscopic exploration, the surgical techniques and, finally, the therapeutic applications of laparoscopy are taught. Veterinary laparoscopy is developing in a slower way than human laparoscopy but in the same direction. The future of this technique is associated to its therapeutic capability that is being showed particularly for the digestive system (pi- loromiotomy, piloroplasty, colopexy), reproductive system (tubaric occlusion and ovariectomy, cryptorchidism) and urinary system (nefrectomy, cistotomy, etc).

The combination of the different minimally invasive techniques such as laparoscopy, endoscopy, interventional radiology and laparoscopic ultrasound may represent the future of veterinary surgery.

Summary

This research shows the guidelines to be followed in order to carry out a laparoscopic exploration of the abdominal cavity of a dog. The steps to be taken should always be the same with the procedure to be followed becoming a routine. Starting from the upper quadrant of the abdominal cavity of the dog, scan with optics moving in a clockwise direction until the starting point is reached again. To separate the different structures, insert instruments with the help of one or two outports.

Keywords

Laparoscopy, Dog, Anatomy.

References


