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Surgical Anatomy and Approach to the Abdominal Wall of Domestic Animals

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KD, SA, BA reviewed the literature and wrote the first draft of the manuscript under the direction of the authors KM, AK who made their corrections for the validation of the final document submitted. All authors read and approved the final manuscript.

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ABSTRACT

The variety of procedures that can be performed on the organs contained in the abdominal cavity is such that there are many different ways to approach them. The different laparotomies available are adapted to both the type of organ to be approached and the type of procedure to be performed; they must also take into account the anatomy of the abdominal wall, so as to be as minimally disruptive as possible. This article successively describes the surgical anatomy of the abdominal wall and the different types of laparotomies used in scheduled surgery.

Keywords: Abdomen; abdominal; anatomy; animals; surgery; domestic; way.

1. INTRODUCTION

Abdominal diseases are a frequent reason for consultation, taking into account the frequency of diseases in animals received at the EISMV clinic in Dakar in general and in domestic carnivores in particular [1,2]. Indeed, these conditions are numerous and varied and affect the digestive system (foreign bodies, dilatation/torsion syndromes, intestinal tumors...), urogenital (hydronephrosis, pyelonephritis, polycystic nephritis, urolithiasis, ureteral ectopia, congenital malformation, cystitis, ureteral calculi, prostatitis.

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At the EISMV veterinary clinic in Dakar, abdominal pathologies, particularly those affecting the digestive system, are predominant.

Generally speaking, among abdominal wall pathologies, ventration is the most frequent postoperative complication in general surgery [3]. L'éventration est une complication post-opératoire fréquente puisqu'elle survient dans 2% à 10% des laparotomies [4,5,6,7,1]. Venting is the protrusion of viscera under the skin through an unnatural opening in the abdominal wall. This condition usually occurs after a laparotomy. The eventration may result from a failure to heal due to infection of the wound or more commonly when chronic tension is placed on the abdominal muscles. Large ventures can lead to severe pain, skin ulcers and respiratory problems [7,1]. Different risk factors affect the development of a ventricle. The factors due to the surgical technique are the material used for the suture and the method of suture used but especially the type of incision (median, oblique or transverse).

Surgical treatment allows the resolution of a large number of these pathologies, and it requires a good mastery of the approach.

Having a good knowledge of anatomy is therefore essential for the veterinary clinician to ensure anatomical precision and a very good healing after the surgical act.

2. MUSCLESOF THE LATERAL-VENTRAL WALL OF THE ABDOMEN

These muscles are all even, flat and wide, partly fleshy and partly aponeurotic. Arranged in superimposed layers, they constitute the totality of the regions of the abdomen and the flank. They also play an important role in the organization of the hypochondrium and epigastrium. The wall that they constitute is also connected, caudally and on each side, to the root of the pelvic limb by a very remarkable passage region: the inguinal or groin region. Four muscles are superimposed in the latero-ventral wall of the abdomen: the external oblique muscle, the internal oblique muscle, the rectus muscle, and the transverse abdominal muscle.

Various formations are still attached to these muscles. A fibro-elastic coating, the abdominal tunic, lines their surface and contributes passively, especially in large species, to the support of the abdominal viscera. On the other hand, the oblique and transverse muscles intertwine, on the median plane, the fibers of their aponeuroses with those of the opposite muscles by forming a solid raphe: the white line, extending from the pubis to the sternum and bearing the umbilical scar. This white line thickens and widens considerably at its pubic insertion where it merges with a large tendon common to all abdominal muscles: the prepubic tendon. Finally, on either side of the latter, there is a remarkable interstice between the two oblique muscles or their dependencies: the inguinal space or "canal", of great surgical interest [8].

2.1 Abdominal Tunic (Fig. 2)

The abdominal tunic is a yellow fibroelastic expansion that lines the surface of the two external oblique muscles of the abdomen. In domestic mammals, it is developed in proportion to the mass of the abdominal viscera. Very reduced in carnivores and pigs, it reaches its maximum extent in large herbivores. Formed of elastic fibers mixed with a few collagenous bundles, this covering is thick and very adherent in the vicinity of the prepubic tendon and the white line. It becomes thinner and easier to separate in its lateral and cranial parts. In Equidae and Ox, it extends below the sternal region and covers the hypochondrium; in the former, it even extends beyond the limits of the external oblique muscle of the abdomen. It is much thinner in small ruminants and limited in pigs to the caudal half of the abdomen, where it forms a narrow band. In Carnivores, it is even weaker and almost devoid of elastic bundles. The abdominal tunic is covered by the skin and the cutaneous muscle of the trunk, which is separated by a thick layer of loose and mobile connective tissue, crossed by numerous vessels and nerves. Opposite the prepubic tendon or in its vicinity, it attaches: in the male, to the dartos, the subcutaneous envelope of the testicles, as well as, in domestic species, to the elastic tissue of the prepuce in the male, to the suspensory apparatus of the udders in the female. Its deep face adheres to the external oblique muscle of the abdomen, in a much more intimate way opposite the aponeurotic part of this muscle than opposite its fleshy part. This yellow tunic strengthens the contraction of the muscles on whose surface it extends. But its most important role is that of an elastic strap that supports the mass of the abdominal viscera. It passively opposes the pressure they exert on the abdominal wall, both because of their weight and because of the way quadrupeds stand [8,10].

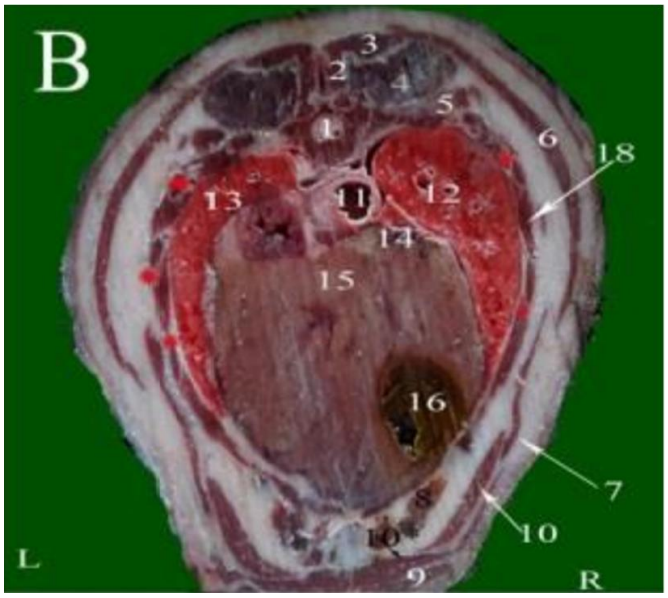

Fig. 1. Cross anatomical section at the level of the cranial part of the epigastric region (10 th thoracic vertebra) of the dog. [9]

1. 10th thoracic vertebra. 2. Right multifidus thoracis. 3. Right longissimus thoracis muscle. 4. Right iliocostalis thoracis muscle. 5. Right levator costorum muscle. 6. Right latisssimus dorsi muscle. 7. Right muscle obliquus externus abdominis. 8. Right transverse thoracis muscle. 9. Right deep pectoral muscle. 10. Right rectus abdominis muscle. 11. Aorta. 12. Caudal lobe of the right lung. 13. Caudal lobe of the left lung. 14. Caudal vena cava. 15. Liver. 16. Gall bladder. 17. Falciform ligament. 18. Right intercostal muscles

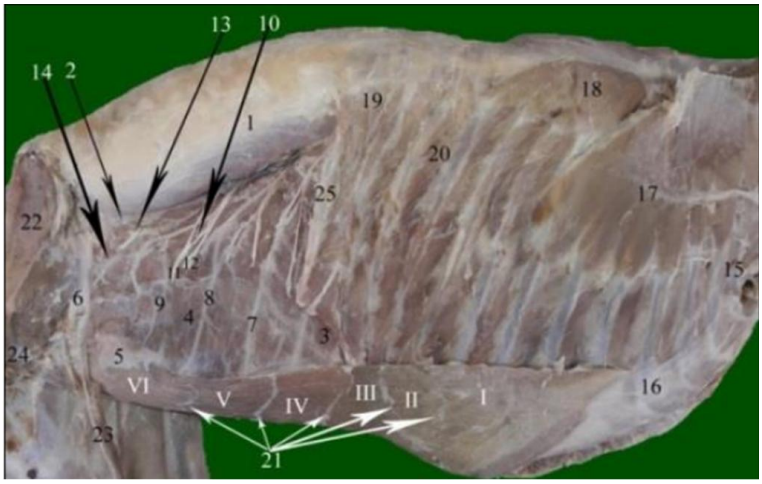

Fig. 2. Right view of the lateral abdominal wall showing the muscle transversus abdominis and muscle rectus abdominis [9]

1. Thoracolumbar fascia. 2. Aponeurotic origin of the muscle transversus abdominis. 3. Costal part of the muscle transversus abdominis. 4. Lumbar part of the muscle transversus abdominis. 5. Aponeurosis of the muscle transversus abdominis. 6. Transverse abdominal fascia. 7. Medial ramus of nerve costoabdominalis. 8. Medial ramus of the nerve iliohypogastricus cranialis. 9. Medial ramus of the nerve iliohypogastricus caudalis. 10. Connecting branch between the lateral ramus of nerve iliohypogastricus caudalis and the lateral ramus of the nerve ilioinguinalis. 11. Lateral ramus of the nerve ilioinguinalis. 12. Lateral ramus of the nerve iliohypogastricus caudalis. 13. Lateral ramus of the nerve cutaneus femoris lateralis. 14. Medial ramus of the nerve ilioinguinalis. 15. First rib. 16. Aponeurotic origin of the muscle rectus abdominis. 17. Serratus ventralis muscle. 18. Serratus dorsalis cranialis muscle. 19. Serratus dorsalis caudalis. 20. External intercostal muscles. 21. Intersections tendinae. 22. Ilium. 23. Spermatic cord. 24.Pectin oss pubis. 25. Last rib. I. II. III. IV. V and VI. First, Second. Third, Fourth, Fifth and Sixth segment of the muscle rectus abdominis respectively

2.2 External Oblique Muscle of the Abdomen (Figs. 1 and 2)

The external oblique muscle of the abdomen is the most superficial and largest of the abdominal muscles. It extends from the lateral aspect of the thorax and the edge of the lumbar region to the linea alba and the groin crease, where its fascia connects to specific formations: the inguinal arch and the medial thigh fascia.

It is a flat, very wide, irregularly triangular muscle, which comprises a dorsocranial fleshy part and a ventrocaudal aponeurosis. The fleshy part constitutes a wideband spread over the entire surface of the hypochondrium and on the ventral end of the ribs (asternals and last sternals). It is formed of parallel bundles, oriented obliquely in a ventro-caudal direction. Progressively widened towards its caudal part, it is divided at its cranio-dorsal edge into regular serrations whose number is equal to that of the ribs, minus the first three or four. The opposite edge, hardly sinuous, is continued by aponeurosis. At the dorsocaudal end, the bundles, which have become almost longitudinal, extend directly from the proximal end of the last rib and the thoracolumbar fascia to the iliac crest, the hip angle, or the inguinal region. The external oblique muscle of the abdomen supports and compresses the abdominal viscera. As such, it is involved in all acts that involve muscular effort. In addition, it pulls the ribs in a caudal direction and thus contributes powerfully to expiration. Finally, it contributes to the flexion of the spine, directly or laterally, depending on whether the action is bilateral or unilateral. Blood is supplied by the dorsal intercostal, lumbar, iliac circumflex, and cranial abdominal (Carnivores, Pigs, Rabbits) arteries, secondarily by branches of the musculo-phrenic, cranial and caudal epigastric arteries. The innervation is provided by the intercostal nerves of the spaces covered by the insertions of the fleshy part and by the ventral branches of the first two or three lumbar nerves [8,10].

2.3 Internal Oblique Muscle of the Abdomen (Figs. 1 and 2)

The internal oblique muscle of the abdomen is flat, almost as wide as the previous one, which covers it completely. It radiates from the ilium bone and the edge of the lumbar region to the last ribs, the Manche line, and down to the groin fold.

Molded on the flank and belly regions, this muscle comprises a fleshy part and an aponeurosis, the latter directly continuing the former. The fleshy part is thick, especially at the level of the chord of the flank, which contributes to drawing the protrusion in domestic Mammals. It presents a flabelliform disposition, its most cranial bundles being almost longitudinal and the most caudal ones following the fold of the groin. On the whole, its fascicles run ventro-cranially and their orientation is approximately perpendicular to that of the external oblique.

In carnivores, the rabbit, covers the entire flank region. It is the same in Ruminants and Pigs, but in these species, its cranial part, which responds to the paralumbar fossa, is thinned and partially dissociated. This dissociation is much clearer in Equidae, where the fleshy part, devoid of lumbar attachment, leaves the para-lumbar fossa (hollow of the flank) uncovered, in the cranial part of which we find a small muscle completely isolated: the retractor muscle of the last rib.
The internal oblique muscle is an auxiliary of the external oblique. Like the latter, it pulls the ribs in a caudal direction and is involved in exhalation; it also tightens the abdomen and indirectly contributes to the flexion of the spine [8,10].

2.4 Transverse Abdominal Muscle (Figs. 1 and 2)

The transverse abdominal muscle is flat and wide; it occupies the deepest plane of the abdominal wall. Formed by parallel fibers that run dorsoventrally, following the concavity of the abdominal wall (hence its name), this muscle has a fleshy part and an aponeurosis. The fleshy part is dorsal or dorso-cranial. It occupies the deep surface of the hypochondrium, which it extends caudally, then widens in the region of the flank, which it occupies almost entirely. Under the hypochondrium, it is divided at its dorsal edge into serrations that correspond to the asternal ribs or their cartilages. The part which occupies the flank begins on the contrary, at its dorsal edge, by a short aponeurotic blade that connects it to the lumbar region and whose extent is variable with the species. The most caudal part, weakened, dissociated in thin and not very consistent bundles in the domestic Mammals, is more solid in Man, as if to ensure better support of the viscera in the erect position; it does not reach in any case the bottom of the inguinal region. The aponeurosis is shaped like an irregular triangle. Its dorsocranial border follows the fleshy part. Its ventral border corresponds to the white line. Its caudal border, poorly defined, reaches the inguinal arch only near the hip and

the very loose bundles that constitute it dissociate ventrally.

The transverse muscle tightens the abdomen: it lifts the viscera and presses them against the lumbar region. It also lowers the costal arches to which it attaches and acts as an auxiliary to the expiratory muscles. Blood is supplied by divisions of the dorsal intercostal, musculo-phrenic, cranial abdominal and deep iliac circumflex arteries. The nerves originate from the last intercostals and the ventral branches of the first lumbar nerves [8,10,2].

2.5 The Rectus Abdominis Muscle

The rectus abdominis muscle is flat, in the form of a wideband extending from the ventral aspect of the sternum and costal cartilages to the pubic bone. It is enlarged in the middle and much narrower at the caudal end, which is extended by the prepubic tendon, than at the cranial end, which ends in a more or less long aponeurosis; this cranial part is narrowed in ungulates, but enlarged in humans and carnivores. The muscle is cut by a series of strong, regular and transverse tendon intersections, which give it a polygastric structure and its particular appearance. These intersections, which evoke its metameric nature, are variable according to individuals and even more so from one species to another. There are about ten in Equidae, five in cattle, seven in sheep, eight to ten in pigs, four or five in carnivores and three, sometimes four, in humans. These intersections are very close to the walls of the fibrous sheath that envelops the muscle and are more or less symmetrical from one side to the other. The most caudal belly of the muscle is always the longest and the intersections are generally less spaced in the part between the umbilicus and the xiphoid region.

The rectus abdominis muscle is enclosed in a fibrous sheath formed by the terminal aponeuroses of the oblique and transverse muscles. This sheath is made up of two blades, one superficial and the other deep, which meet at the lateral edge of the muscle and meet at the linea alba. The aponeurotic intersections adhere to them on both sides, but the superficial blade is the most difficult to detach. This one is the thickest. It is formed by the aponeuroses of the two oblique muscles, to which a part of the aponeurosis of the transversus is added caudally. The deep blade is weaker; it is formed in principle by the aponeurosis of the transverse muscle, to which is joined a sheet which is detached from that of the internal oblique opposite the lateral edge of the rectus muscle. Its constitution varies with the levels: the deep expansion of the aponeurosis of the internal oblique muscle exists only in the epigastric region or its vicinity.

Through its sheath, the rectus abdominis muscle responds on its ventral side to the ascending pectoralis, to a small extent of the fleshy part of the external oblique, and in the rest of its surface, to the subcutaneous formations. Also through its sheath, the deep or dorsal side responds to the costal cartilages, the corresponding intercostal muscles, and in the rest of its extent to the transversalis fascia and the subperitoneal connective tissue. The cranial and caudal deep epigastric arteries and veins run along the lateral border on this side.

The rectus abdominis muscle lifts and compresses the abdominal viscera. It also brings the pelvis closer to the thorax and thus flexes the lumbar region.

Finally, pulling the ribs in a caudal direction, it contributes to expiration.

Blood is supplied by the deep epigastric arteries, cranial and caudal. Innervation comes from the intercostal nerves (except the first) and the ventral branches of the first three lumbar nerves. It is remarkable that despite its metamerized appearance, the rectus abdominis muscle receives segmental nerves in much greater number than the fleshy bellies that constitute it [8,10,2].

2.6 Retractor Muscle of the Last Rib

The retractor muscle of the last rib or costal retractor is a flat, triangular muscle, located in the lumbocostal angle; the orientation of its fibers could make it related to the internal intercostal system. It originates at the lateral end of the first lumbar transverse processes and ends at the caudal edge or the internal face of the last rib. Taking a fixed point at the lumbar vertebrae, it pulls the latter in a caudal direction and fixes it in this position; it initiates expiration and this action seems to be transmitted to the more cranial ribs by the intervention of the internal intercostal muscles [3].

2.7 Fascia Transversalis

The transversalis fascia is a vast fibrous expansion that covers the deep face of the

transverse abdominal muscle and extends to the abdominal face of the diaphragm. It begins at the lateral border of the lumbar region, where it connects to the fascia iliaca, and ends ventrally at the linea alba. Its fibers are mainly transverse, but there are also fibers oblique or longitudinal, especially in its ventral part. Its thickness is not uniform. In domestic mammals and especially in large ungulates, whose visceral support is provided differently, it is especially developed on the lateral walls and opposite the rectus abdominis muscle [8,10,2].

2.8 White Line

The linea alba is a narrow, odd, median fibrous blade, extending from the xiphoid process of the sternum to the cranial border of the pubic bones, where it merges with the prepubic tendon. It is a sort of thick raphe resulting from the medial crossing of the aponeurotic fibers belonging to the right and left broad abdominal muscles. This very strong fibrous cord is bordered on each side by the medial edge of the rectus abdominis muscle, which adheres to it and to whose sheath it attaches. Its thickness varies according to the level and the species; it is generally maximal in the pubic region. The width also presents variations, but these are not analogous in all the species [8,10,2].

2.9 Prepubic Tendon

The prepubic tendon is a strong quadrilateral fibrous blade inserted at the cranial edge of the two pubic bones, from one iliopubic eminence to the other. It is complex in structure and directly extends the linea alba and the tendons of the rectus abdominis muscles and receives part of the aponeurotic fibers of the oblique and transverse abdominal muscles on both sides.

Excavated on each side, the prepubic tendon is not placed in direct prolongation of the pubic bones, but forms with them an obtuse dihedral open ventro-caudally. It is indeed oblique in a ventro-cranial direction, much more so in ungulates than in carnivores. This orientation is so strongly plunging in ungulates that the angle formed by the tendon and the pubic bones can reach 90°. In cattle, the insertion even extends far into the ventral side of the pubic bones, whose cranial edge thus forms a kind of threshold between the abdominal cavity and the pelvic floor. Knowledge of these arrangements is important for obstetrics and surgery. [8,10,2].

2.10 Inguinal Space Or Canal (Fig. 3)

The inguinal space or canal is an interstice located on the side of the prepubic region and opens on the one hand in the subcutaneous space of the groin and on the other hand under the prepubic peritoneum. Very oblique in lateral and dorsal direction and rapidly narrowed towards its deep end, it gives way in the male to the spermatic cord and in both sexes to important vessels and nerves. Of great surgical interest, it presents two walls, two orifices and a content.

These walls are not limited to the inguinal space itself. They belong respectively to the external oblique and internal oblique muscles of the abdomen which, directly leaning everywhere else, move away from each other at the bottom of the groin fold, near the pubis bone.

Very unequal and of very different constitution, these orifices are two in number: one is subcutaneous or superficial, the other deep, abdominal.

- **Superficial inguinal ring :** it is an orifice in the shape of an elongated slit in the same direction as the groin fold, i.e. in a cranio-lateral direction. In the Ungulates, it takes on an oval shape and widens considerably when the limb is pulled in abduction. It is pierced in the aponeurosis of the external oblique muscle, slightly cranial to the pubic bone, on the side of the prepubic tendon.
- **Deep inguinal ring:** this is a much smaller orifice than the previous one, a simple slit between the inguinal arch and the edge of the muscle internal oblique. It is real only in the male, after the descent of the testicle; in the female or the cryptorchid male, it remains in principle virtual. Located on the side of the cranial strait of the pelvis, lateral to the edge of the pubis, not far from the tubercle of the lesser psoas, it is separated from that of the opposite side by the entire width of this strait. In the female, the fascia transversalis and the peritoneum pass tangentially over its surface. In the male, during migration of the testis, the peritoneum and transversalis fascia evaginate at this level in front of the gland, to form its deepest envelopes.

The contents of the inguinal space are different in males and females. In the male, the most

important part is the spermatic cord surrounded by the deep or intra-inguinal testicular envelopes: internal spermatic fascia, lined internally by the parietal lamina of the serosa and covered on its caudo-lateral side by the cremaster muscle. Among domestic mammals, the rabbit is an exception, the testis only descending into the scrotum during mating and the cremaster then enveloping the fibro-serosa on all sides. The spermatic cord itself includes the vas deferens, the testicular vessels and the mesos that suspend them inside the serosa. Around the cord there is a lamellar connective tissue, dependent on the external spermatic fascia, in which vessels and nerves that reach the subinguinal region and the scrotum run in contact with the cord itself or in its vicinity: external pudendal artery, its satellite vein and branches of the genitofemoral nerve. In the female, the inguinal space, narrower, is only occupied by connective tissue in which the external pudendal vessels (mammary in the Ungulates) and the branches of the genitofemoral nerve run, moreover arranged more or less like their counterparts in the male [8,11].

3. REGIONS OF THE ABDOMINAL WALL

The ventro-lateral wall of the abdomen, whose constituents we have just studied, is thus vast and its organization presents great local variations. Three major regions must be distinguished, whose anatomical structures are different. One is ventral and odd: it corresponds to the region of the "belly". The other two are lateral and each of them is repeated on the right and on the left: they are the hypochondrium and the flank; the latter is connected to the pelvis and to the root of the pelvic limb by the inguinal region [10].

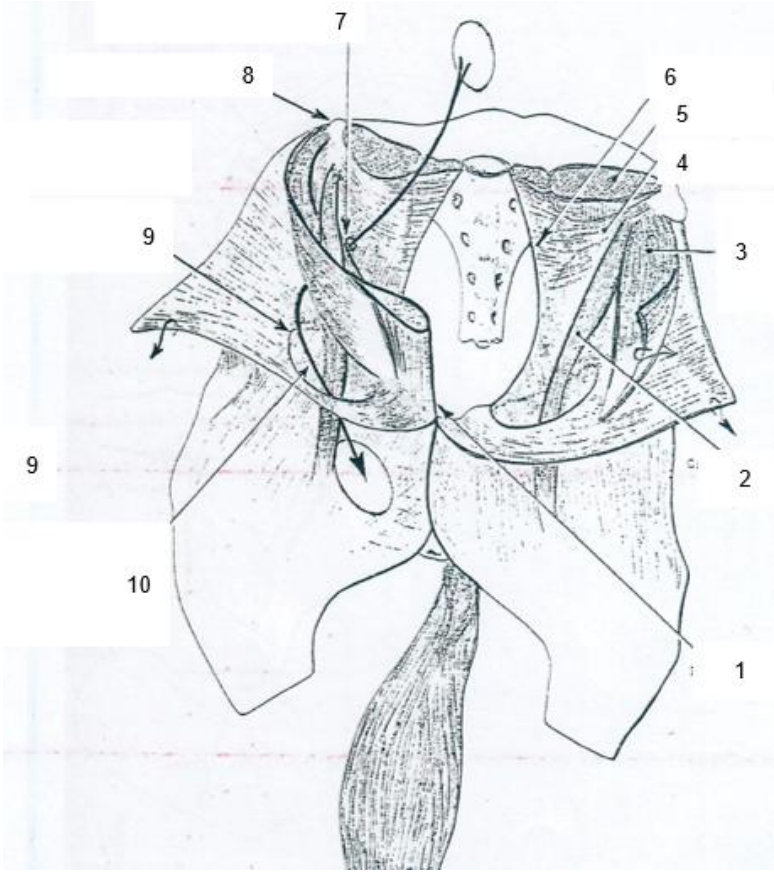

Fig. 3. Inguinal region [12]

1: Prepubic tendon; 2: Cremaster muscle; 3: Internal oblique muscle; 4: Fascia illiaca; 5: Psoas major muscle; 6: Tendon of the small psoas muscle; 7: Superficial inguinal ring; 8: Hip angle; 9: Superior inguinal ring; 10: The arrow indicates the direction of migration of the testicles

3.1 Belly Region

It extends from the xiphoid process of the sternum to the cranial edge of the pubic bones. It corresponds to the subregions of the epigastrium, the belly proper and the hypogastrium or prepubic region. The first of these three subregions covers the ventral parts of the two costal arches and between them the xiphoid cartilage; its surface is covered by the most caudal part of the ascending pectoral muscles and by the cranial end of the fleshy part of the external oblique muscles of the abdomen. The hypogastric region is supported by the prepubic tendon in domestic mammals [10].

3.2 Hypochondrial Region

This region is indeed characterized by the presence of the ventral ends of the asternal ribs and all their cartilages, as well as the corresponding intercostal muscles. It belongs only in appearance to the thorax: because of the very particular mode of attachment of the diaphragm, it covers only abdominal viscera. It is remarkably extensive in cattle and pigs [10].

3.3 Flank Region

This region extends from the costal arch to the cranial edge of the thigh and from the lumbar border to the belly, to which its curvature connects in an insensitive way. It is very long in Carnivores and Rabbits, still vast in Ruminants and Pigs, but very short in Equidae; in the latter, barely a handbreadth separates the last rib from the cranial border of the thigh. The flank is, like the belly, characterized by the absence of any bony formation. It is almost exclusively constituted by the fleshy parts of the three flat muscles of the abdomen: external oblique, internal oblique and transverse. These muscles are also covered, in the subcutaneous plane, by the cutaneous muscle of the trunk, from which a thick layer of very mobile connective tissue separates them [7,10].

4. LAPAROTOMIES

Laparotomies are surgical procedures that consist of opening the abdominal cavity. They constitute the first and last operative steps of all abdominal surgery operations [11,12].

4.1 Indication for Laparotomies

It is traditional to contrast semiological indications and therapeutic indications for laparotomy.

4.1.1 Semiological indications

Exploratory laparotomy is the name given to coeliotomy whose sole purpose is to examine the abdominal viscera on a live animal.

This indication is quite exceptional in large species. It is, on the other hand, much more frequent in small species, although its relative importance tends to decrease due to the development of endoscopy (laparoscopy) and radiology techniques.

Exploratory laparotomy allows a rapid and complete examination of all the abdominal viscera. It very often allows for the decision to perform a life-saving curative operation, for example the extraction of a migrating foreign body causing recurrent subocclusions, or the removal of a tumor. One should never hesitate to perform it provided that the instrumentation is available to allow the eventual completion of the specific times. Therefore, in veterinary practice, there should be no technical difference between an exploratory laparotomy with a therapeutic aim [12].

4.1.2 Therapeutic indications

The purpose of laparotomies is to allow the surgeon to intervene on the abdominal organs. They are the first and last operative steps in all procedures involving the liver, spleen, kidney, and urinary tract, as well as the digestive tract.

In domestic animals, laparotomies are most often performed for interventions on the reproductive system, (ovariectomies, castration of cryptorchid males), caesarean operations, hysterectomy.
The treatment of abdominal wall malformations, in particular the surgical cure of hernias, uses specific laparotomy techniques called kelotomies [11,12,13].

4.2 Criterion for the Choice of the Place of Election

The place of choice for abdominal surgery is determined by seven criteria which are based on three imperatives: safety of the patient, solidity and aesthetics.

- The chosen site must provide convenient access to the organ to be operated on: this condition is the most important of all in terms of surgical safety.
- The organization of the dissection must minimize parietal damage, allowing the

muscles to be incised in the direction of their fibers, reducing to a strict minimum the sectioning of the motor nerves of the wall, which cause amyotrophy and thus secondary weakening, and reducing to a minimum the sectioning of the vascular trunks for the same reason.

- The place of choice must allow the incisions to be enlarged in order to increase the possibilities of intervention on the organ concerned. This criterion is particularly important in obstetrical surgery and carcinology, disciplines where the volume of the element on which we intervene can present very important fluctuations.
- The repair must be easy to perform.
- The incisions must not seriously compromise the solidity of the walls; for example, opening the abdominal cavity in purely fascial areas must be avoided. In particular, in all species, one must refrain from intervening in the posterior zone of the flank leak, which is constituted solely by the overlap of the two aponeuroses of the two oblique muscles of the abdomen.
- The parietal operative sinus must drain easily. The accumulation of serosities in the areas of muscle detachment facilitates the formation of abscesses or phlegmons of the walls.
- Finally, the skin wound should, as far as possible, leave an inconspicuous scar **[12].**

4.3 Anatomical Classification of Laparotomies (Fig. 4)

According to their place of choice, it is possible to classify laparotomies into four groups:

4.3.1 Low laparotomies (Fig. 4)

4.3.1.1 Midline laparotomies

These are performed through the white line. They have the great advantage of allowing the pathway to be widened. The incision is limited in front by the xiphoid process and in the back by the pubis. In males, the skin incision is not median in the caudal region but avoids the sheath, while the puncture of the linea alba is median. Post-operative recovery is rapid, the scar is not very visible and solidity is ensured by strong fascia.

On the other hand, healing is slow due to the lack of irrigation. This route involves risks of eventration because the viscera weigh down the incision. Intraperitoneal fluids can also get in between the sutures and form collections in this area. Depending on the location of the incision, a distinction is made between supra-umbilical, umbilical, sub-umbilical, and xipho-pubic laparotomy (it includes all the first three), according to the landmarks on the white line [11,14,15].

4.3.1.2 Paramedian laparotomies

Paramedian laparotomies are performed on a line parallel to the midline.
The advantage of this opening is its rapid healing because the region is better vascularized. The solidity is good because the stitches are supported by solid fascia.
It requires a period of hemostasis of the vessels; the haemorrhage is generally not very abundant because the incision of the rectus abdominis muscle is made in the direction of the fibers.
As the thickness of the wall to be crossed may be relatively large in this area, abdominal exploration is more difficult. It is no longer recommended today in domestic carnivores for this reason [11,14,15].

4.3.2 High laparotomies (Fig. 4)

4.3.2.1 Oblique laparotomies

These laparotomies can be performed along the axes of the external oblique (sub-costo-abdominal or costo-lumbar) or the internal oblique (sub-costo-alumbar). These techniques have the same advantages. Cleavage between the muscle fibers is easy and does not cause hemorrhaging. Closure is easy and healing is rapid. However, since the two muscle planes are perpendicular, one of them must be cut to access the abdominal cavity.

The opening of the abdominal cavity can be targeted on a particular organ to allow a wide exploration. In the first case, it is possible to limit the approach by knowing the topography of the target organ.

Thus, a subcostal laparotomy allows access to the ovaries in the bitch, and a sublumbar laparotomy allows the removal of an adrenal gland or a kidney. In the second case, the exploration of the abdomen is always performed after a median laparotomy along the linea alba. In conclusion, the vast majority of operations are performed along the white line. This technique is, in the end, simpler, and its possibilities of

enlargement are greater (extension on the linea alba, addition of a subcostal laparotomy, a thoracotomy by sternotomy, a pelvic symphysiotomy). [11,12,15].

4.3.2.2 Transverse laparotomies

Transverse laparotomies are performed along the axis of the fibres of the transverse muscle. They are located either in the hollow of the flank, or cross it to extend into its recess. Transverse laparotomies in the hollow of the flank (Abert's technique) can also be performed according to the fiber planes of the different muscles, which allows for blunt dissection. The advantage of such laparotomies is that they avoid the risk of postoperative ventrations, but they only allow very limited exploration (e.g.: oophorectomy for convenience). In the dorsal region, it is possible to access certain organs such as the kidney or the adrenal gland in the retroperitoneal region [11,15,16].

4.3.2.3 Laparotomy of the flank

Laparotomy under ilio-abdominal located below the flank recess under the wing of the ilium. The most frequent are those performed at the level of the right flank chord during intestinal surgery in cattle (OSTERMAN), those performed at the level of the left flank leakage during caesarean section in cows (GOFFINET-HERNAUX) or ovariectomy.

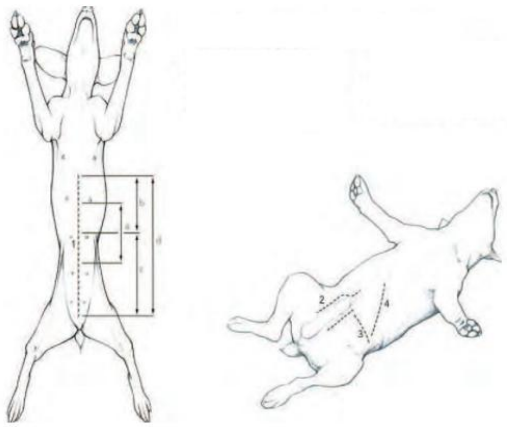

Fig. 4. The different sites of choice for laparotomies [19].
1: Median laparotomy; 2: Paramedian Laparotomy; 3: Transversal laparotomy; 4: Sub-costal laparotomy

4.3.3 Laparotomy by natural route (Fig. 4)

These are laparotomies performed at very specific locations in the abdomen.

- Ovariectomy by the vaginal route in the cow used to be very common in the nineteenth century but very little nowadays by experienced practitioners.
- Inguinal hernias, consist of an incision at the level of the inguinal region, mostly encountered in horses, sheep …. [11,15,16,17,18,20].

5. CONCLUSION

The muscles constitute the walls of the abdominal cavity. They contribute to maintain and protect the main digestive and urogenital viscera and are therefore of paramount importance.

The choice of one approach or another depends on the clinical and para-clinical assessment, but also largely depends on the anatomical situation of the organ on which the surgical procedure will take place.

A precise knowledge of the anatomy of the abdominal wall is essential for surgeons to understand its structure and its relationship with the surrounding organs, to know the necessary precautions to be taken during the laparotomy to ensure a rapid recovery and healing of the animal.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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