Laparoscopic Anatomy of the Abdomen in Dorsal Recumbent Male Donkey (*Equus acinus*)

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Abstract

Laparoscopic anatomy of the abdomen is an applied anatomical study, which provides an accurate and detailed description of the anatomy of the abdomen of donkey positioned in dorsal recumbency. It has a diagnostic and a therapeutic surgical importance. The laparoscopy was performed on ten adult apparently healthy male donkeys average of 7-12 years old. In order to record the normal laparoscopic anatomy of the abdomen in dorsal recumbency. The preoperative techniques were considered. General anesthesia was induced and maintained with total intravenous agents. Laparoscope was delivered into the abdomen via an umbilical main cannula. Laparoscope and associated video recording system were used to obtain a clear, magnified and panoramic shoots of the abdominal cavity. The anatomical findings obtained were more real and vital than that of fixed cadavers. The peristaltic motility as well as the vascularization of the serous layer of peritoneum and the abdominal organs was notified. The study described two dangerous triangular areas; TD and TP especially during endoscopic repair of inguinal hernia. The work is considered as a gate to further endoscopic anatomy and the donkey was an ideal experimental model.

Keywords: Donkey, laparoscopy, dorsal recumbence, laparoscopic anatomy.

Introduction

Endoscopic anatomy of live animal differs than the structural anatomy in a cadaver. For successful laparoscopy, surgeons need to gain full detailed anatomical information about structures dealing with in the abdomen. Different studies described the laparoscopic anatomy of dogs were carried out by Atiba (2003) and of equines by Galuppo et al. (1995). Most authors used fixed animal bodies fixed in 10% formalin concentrate in their description of domestic animals (El-Hagri, 1967; Nickle et al.,

1973; Dyce et al., 1987) & König and Liebich, 2014).

In the present study, tried to describe the abdominal structures in the life state. The anatomical descriptive terminology were used according to NAV (2005).

Laparoscopy is an endoscopic surgical procedure by which a variety of intra-abdominal and pelvic diagnostic and therapeutic procedures can be performed (Kumar, 2014).

Since the first canine experimental laparoscopic procedure done in 1901, laparoscopic procedures were described in different animal species including equine (Hendrickson, 2012) ,cattle (Babkine and Desrochers, 2005), small ruminants (Dovenski et al.,2012), canines (Abd El-Alim, 2008) and in some exotic animals (Anderson et al.,1996). Laparoscopy is a minimal invasive procedure aims to achieve the purpose of traditional surgical procedures with minimal intra and post-operative complications and as well as tissue damage.

Food withholding period, degree of pneumoperitoneum and animal position are main factors affecting organ arrangement and relationship within the abdominal cavity, another factor affecting the endoscopic view of abdominal cavity is the endoscope port position.

Material and methods

Ten adult apparently healthy local breed donkeys with average weight 230-250 kg, aged from 7-12 years were used for this study.

Animals were fasted for 24 hours and water was allowed *ad lib*. Prior surgery, general health chick up was performed to ascertain good general health status of the experimental animals. Antibiotics and anti-inflammatories were administered 12 hours prior and 72 hours post surgery.

Animals were sedated by using xylazine Hcl in a dose of 1.1 mg/kg Bwt and anesthesia was induced by Ketamine Hcl in a dose of 2.2 mg/kg Bwt. Anesthesia was maintained by repeated one third ketamine dose (Delling, 2005). Local analgesic was infiltrated at the umbilicus. Animals were dorsally positioned and secured by robes to the surgical table.

Ventral abdomen was clipped, scrubbed, draped and prepared for aseptic surgery. The umbilicus incised and grasped by two towel clamps and the main portal safety cannula were directly inserted into the abdominal cavity (open technique according to Palmer (1993).

Standard pneumoperitoneum to 12 *mm hg* was created using automatic insufflator. Rigid endoscope with 10 *mm* outer diameter, 45 *cm* length and zero degree-viewing angle connected to high definition video camera and display were used to obtain a highly magnified intra abdominal view.

Xenon cold daylight was used to Illuminate the abdominal cavity. Anatomical structures of the abdominal cavity were obtained while animal in Trendelenburg position [the head tilted down the level of hind quarter] while the anatomy of cranial portion of abdominal cavity was obtained with the animal positioned in reverse Trendelenburg position [the head up position] (Fig 1).

The anatomical features, organ arrangement and relations were recorded. The laparoscope was removed and gas was permit to escape. Umbilical wound was sutured and antiseptics were applied. Animals were positioned in lateral recumbence and allowed for recovery.

Results

Laparoscopic investigation of the abdominal cavity in the dorsal recumbent male donkeys reveals most of the anatomical structures and organs that lodged in the intra-thoracic and intra-pelvic portions of the abdominal cavity. Some of the internal organs of the abdomen may not appear in regard to the huge sized large intestinal mass. In general consideration, the anatomical examination in the live animals differ than that of dead fixed one. Although in the former condition, the investigator can examine the color of the peritoneum with the configuration of its vascularization as well as that of the organs and peristaltic movement of intestinal tract. In both parts of the abdominal cavity; the cranial Intra-thoracic and caudal Intra-pelvic part: the large intestine especially the ventral parts of the ascending and descending colon as well as the jejunum of small intestine, form obstacles that mask some other abdominal organs.

Intestine (Figs 2,3,5,6 &8)

It should be noted that the motile activity of live intestine in the examined cases reveals that the anatomical arrangement of the large and small parts of intestine is changed during examination, in addition, the attended posture of investigation may shift the cecum to unseen area. The ventral ascending colon (colon ascendens) has right and left portions (pars dextrum & pars sinistrum); the former is related to the ventral parts of the liver, while the latter one is related to the spleen. These structures are connected together cranially by the sternal flexure (flexura sternalis).

The intestinal mass is similar in shape and they have an external segmentation, which are connected externally together by longitudinal fibrous bands (Taeniae coli) and the segmentations are known by haustra coli or sacculations. The descending colon (colon descen-dens) is lodged caudally at the pelvic inlet and characterized by double taeniae as well as two rows of sacculations that model the final form of fecal mater.

Regarding to the intra-thoracic part of the abdominal cavity, the organs that significantly investigated are the caudoventral part of diaphragm, liver and spleen.

Diaphragma (Figs 2,3&4)

Due to extension of the ascending colon, the dorsal parts and roots of the diaphragm could not be detected. Meanwhile, the laparoscopic examination in recumbent position detects the ventral parts of diaphragm; the fleshy parts (costal and sternal) (Pars costalis & pars sternalis) and central tendinous part (Centrum tendineum). The costal parts are attached to the ribs laterally and met ventrally to form the sternal part on the xiphoid cartilage. Both halves of the costal part of the diaphragm are broad flat muscle fibers, measures about 10-13 cm in width and extends from the ribs laterally to the central tendinous part. The later is characterized by its whitish fibrous appearance and branched phrenic veins in between. Both parts of the diaphragm are covered by serous colorless parietal layer of peritoneum.

Hepar (Figs 3,4&5)

The cranioventrally exposed parts of the liver, are reddish to brownish in color with sharp, tapered and pointed cranioventral border. The interlobar fissure (Incisura interlobares) which lies between the quadrate and left central lobes are characterized by the emergence of the falciform and round ligament of liver (Lig. teres hepatis), which pass ventrally on the abdominal wall to the umbilicus (Fig 2). The caudodorsal border of the liver was attached to the central tendenous part of the diaphragm by the triangular ligament (Fig 4).

Lien (Fig 5)

The spleen is bluish in color, present in the left hypochondric subregion of the intra-thoracic part of the abdominal cavity. Its two surfaces could be seen. The parietal surface is related to the lateral abdominal wall and the visceral one to the ascending colon.

Vesica urinaria (Figs 6,7&8)

The most important organ in the intra-pelvic part of the abdominal cavity is the urinary bladder. It covers the overlaying structures; urogenital fold and rectum

The urinary bladder is a distended or an empty sac that lies on the pubic tubercle and extends on the pubic symphysis. The cranial portion of the bladder is covered by serous parietal peritoneum while the caudal one is retroperitoneal. It is present between the vesico pubic pelvic pouch ventrally and genitovesical pouch dorsally. It is connected to the pelvic and abdominal wall laterally by a peritoneal fold, the right and left lateral vesico umbilical ligaments (Lig. Vesicae laterale). Each free border of the ligaments has a

remnant of the right and left umbilical artery respectively, which are now the round ligaments of urinary bladder (Lig. teres vesicae).

The cranioventral border of the bladder is connected to the floor of the abdominal cavity with a peritoneal fold; middle vesico-umbilical ligament (Lig. Vesicae medianum). The mid point of junction between the folds of the bladder is represented by the remnant of uracus of the embryo.

Peritoneum (Figs 7&9)

It is a colorless glistening vascularized serous membrane lines the abdominal wall internally. It has two portions; parietal and visceral. The former lines to the abdominal wall and covers the cranial portions of the organs of the pelvic cavity to form the pelvic pouches. In the recumbent poisoned cases, the vesicopubic pouch is clearly seen. The visceral part of the peritoneum covers the abdominal organs and in some locations it forms a ligamentous attachment between the adjacent organs or fixes the organs with the abdominal wall. The peritoneum carries minute capillary tree extends along the membrane.

The inguinal region is an important region from the anatomical point of view. The most characteristic anatomical structure is the spermatic cord, which has vascular and non-vascular parts as well as mesentery. The vascular part is formed by the testicular artery (A. testicularis) and vein (V. testicularis) that enter and leave the testis respectively (Fig 9). The non vascular part is the vas deferens which emerges from the cord to the pelvic urethra (Fig 8). The mesentery that lodged in between is the mesorchium, which suspends the testis with the dorsal abdominal wall in the sublumbar region. All the above mentioned structures reach and leave the testis via the vaginal ring.

It is important to point out that the investigator must differentiate between the vaginal ring and deep inguinal ring. The vaginal ring is a slit like opening measures about 2-2.5 cm in width and is located on the deep inguinal ring on the caudal border of the internal abdominal obliqueus muscle (M. obliquus internus abdominis). This ring is formed due to invagination of the testicle with the vas deferens and surrounded blood vessels and bounded by the parietal peritoneum.

Ductus deferens (Figs 6-9&10)

The vas deferens emerges from the vaginal ring to the abdominal cavity and passes in a caudo-ventromedial direction crossing the round ligament caudo-dorsally to the bladder. It should be noticed that the triangular area that restricted laterally by the spermatic vessels and medially by the vas deferens, the parietal peritoneum covers on the external iliac artery and vein (A &V iliaca externa) as well as the obtiurator

nerve (N. Obtiuratorius) which pass within the area, so that it is a contra indicated to surgeons to do surgical interference in this area avoiding injury of that vital structures. This area is known by the triangle of doom (TD). On the lateral side to TD, the imaginary ilio-pubic line encloses with the spermatic cord, a triangular area of pain (TP) that includes the femoral nerve (N. femoralis) and lateral cutaneous femoral n. (N. cutaneus femoris lateralis). The surgical activity is dangerous in this area (Figs 7,8,9&10).

Discussion

The endoscopic anatomical study in the living donkey of the recent work, revealed the most anatomical structures of the abdominal cavity that could be seen in a recumbent position. The study notified the abdominal contents including the shape and the coloration of the serous peritoneum as well as the intestine with the adjacent organs. The anatomical findings were more real and vital than that of postmortem one and gave an accurate anatomical data for surgeons.

The current descriptive findings recorded the motility of the intestine and the absence of organ impressions as well as detecting real coloration of tissues. On the other hand, and according to the fixation process that depends on replacing the blood by the 10% formalin, the authors described the organs in fixed state and preserved in the body in situ with direct contact together showing the impressions on the organs, in addition to discoloration of the tissues and organs.

The laparoscopic appearance of the large intestine in this study notified the disappearance of the cecum on the floor of the abdomen that is due to the preparation protocol before the endoscopy, in addition to the prestaltic motility. Nickle et al. (1973), Dyce et al.(1987) and König and Liebich (2014) in domestic animals, mentioned that the cecum run on the floor of the abdominal cavity, it extended from the right paralumbar fossa caudally to the xiphoid region cranially.

Concerning the liver and spleen, the laparoscopic finding recorded them without impressions from adjacent organs as well as normal colorization. Nickle et al. (1973) & Dyce et al. (1987) in domestic animals cited impressions on both.

The anatomical structures of the diaphragm, were similar with that of most of authors (El- Hagri, 1967; Nickle et al.,1973 and Dyce et al., 1987) in domestic animals.

The laparoscopic anatomy of the serous peritoneum, showed in our study fullness of the capillaries with blood and vascularization of the membrane was clear. These statement were not recorded in the available literatures.

The study is totally in agreement with the authors in describing the urinary bladder (Nickle et al., 1973; Dyce et al., 1987 and König and Liebich, 2014) in domestic animals.

In the field of surgical anatomy, concerning the inguinal region it should be noticed that the testicular vessels and vas deferens comprises a triangular area known as triangle of doom; through it the external iliac vessels pass and the peritoneum covers up on, so it should be notified that it is dangerous to interfere or dissect within the area during the endoscopic repair of inguinal hernia, it could be fatal. A result which is totally in agreement with that of Spaw (1991) and O'Malley et al.(1997) in man. Moreover, the present findings added the presence of the obturator nerve within the area.

It was significant to point out the triangular area, which is located laterally to the triangle of doom between the testicular vessels and the imagery iliopubic line. It contains the femoral nerve, lateral cutaneous femoral branch of femoral nerve, so the activity within this area may cause sever pain, the area named triangle of pain. Similar results were recorded by Spaw (1991) and O'Malley et al.(1997) in man. The described areas of doom and pain of the present study were scanty in the available veterinary anatomical literatures.

On the other hand, it is important to differentiate between the vaginal ring and the deep inguinal ring, as mentioned Sisson, Grossman & Getty (1975) in domestic animals.

Laparoscopy involves insertion of a rigid endoscope into the abdominal cavity through a minute abdominal incision, which is usually the umbilicus of the patient; it provides the operator with a highly magnified image of the abdominal organs. In recent years laparoscopy had evolved almost all fields of traditional surgery, a complete thorough understanding of laparoscopic abdominal and pelvic anatomy of dorsal recumbent donkeys will enhance the diagnostic and therapeutic abilities of laparoscopy procedures.

In the present laparoscopic anatomical study of the abdominal cavity in donkeys, the mean procedure time was 35±7minutes that permits thorough investigation of both cranial and caudal portions of the abdomen.

The total intravenous anesthetic protocol presented by Mama (2000), was satisfying and provided an adequate anesthetic duration and proper efficacy which could be considered in short duration procedures with reduced intra-thoracic compression and adequate intestinal evacuation which are recommended by El-Khamary et al. (2016), while the standard laparoscopic procedures in dorsally recumbent animals are

recommended to be performed under the effect of general inhalant anesthesia according to Fischer (1998).

In order to avoid the heamodynamic hazards arising from pneumoperitoneum and putting the animal in head down position *trendlinburg* as mentioned by Hofmeister et al. (2008), fasting the animal for 24 hours with minimal tilting degree [15^{o}] and standard Co_2 pneumoperitoneum pressure [*12 mm/ hg*] as recommended by El-Khamary et al. (2016), were optimal for the procedure. In agreement with Abd El-Alim (2013), food withholding for a period of 24 up to 72 hours is a standard step in equine laparoscopy, in addition, another essential step to provide a roomy operating space within the abdomen is the Co_2 abdominal insufflation *pneumoperitoneum* from a ranging pressure 12 *mm/hg* up to 15 *mm/hg.*

In agreement with Galuppo (2002), Hendrickson (2012) and Abd El-Alim (2013), umbilicus as a place for main cannula insertion was preferable for dorsal recumbent laparoscopic procedures. It provides an easy access with minimal resistance and leaves post-operative non-remark-able scar. It also enabled the operator to explore the whole abdomen and pelvic cavity without the need to change its position or additional part.

In accordance with almost all authors reported on laparoscopy, Xenon cold light provided a well clear bright vision of the abdominal organs. With assistance of high-resolution camera, the output video frames provided the operator with high quality images of the abdominal structures. Even small structures such as capillaries were clearly viewed due to the magnification capabilities of the multi lenses rigid endoscope. Thirty degree viewing angle rigid endoscopes were reported to be more favorable than those with zero-degree angle due to wider frames provided by the last ones (Freeman et al.,1999). Meanwhile, the zero-degree endoscope used in the study provided good satisfactory images of the abdomen and its contents.

The live intra-abdominal and intrapelvic videos and images via laparoscopy provided the surgeon with a detailed anatomical features of the abdominal and pelvic organs and structures which will ease the process of diagnosing the intra-abdominal disorders and to reduce its intra and post-operative complications.

Conclusion

The present study provided detailed anatomical description of the abdominal and pelvic organs and structures of generally anesthetized dorsally recumbent donkeys. The external features of diaphragm, liver, spleen, kidneys, urinary bladder and

vas deference, their distribution and relations were recorded in live animals. The use of advanced visualization of abdominal and pelvic cavities through a key hole abdominal incision – laparoscopy – is consi-dered a promising toll for diagnostic and surgical therapeutic procedures in equines with abdominal disorders and could be an alternate to traditional laparotomy procedures.

According to the results of this study, donkeys could be considered as animal model to experimentally study the advanced diagnostic and surgical techniques of equines and opens the door for further comparative endoscopic anatomy.

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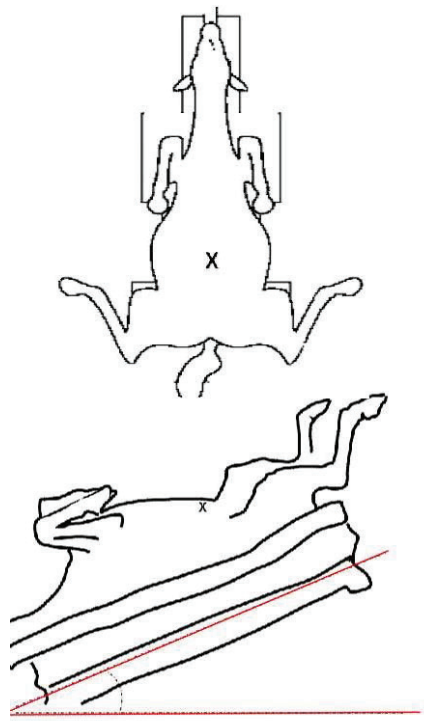

Fig (1): Diagram showing the position of examined donkey in dorsal recumbence and (X) is the site of operation

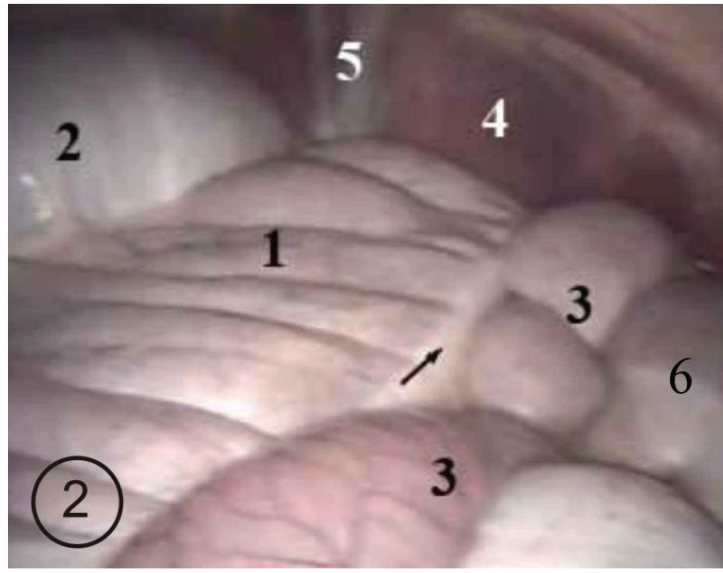

Fig (2): Photograph showing the cranial aspect of the abdominal cavity.1 Colon ascendens (pars ventrale dexterum), 2 Colon ascendens (pars dorsale dexterum), 3 Jejunum, 4 Diaphragma (pars costalis), 5 Falciform and lig. Teres hepatis, 6 Colon acendens (pars ventrale sinistrum), The arrow indicates the taenia on the 1.

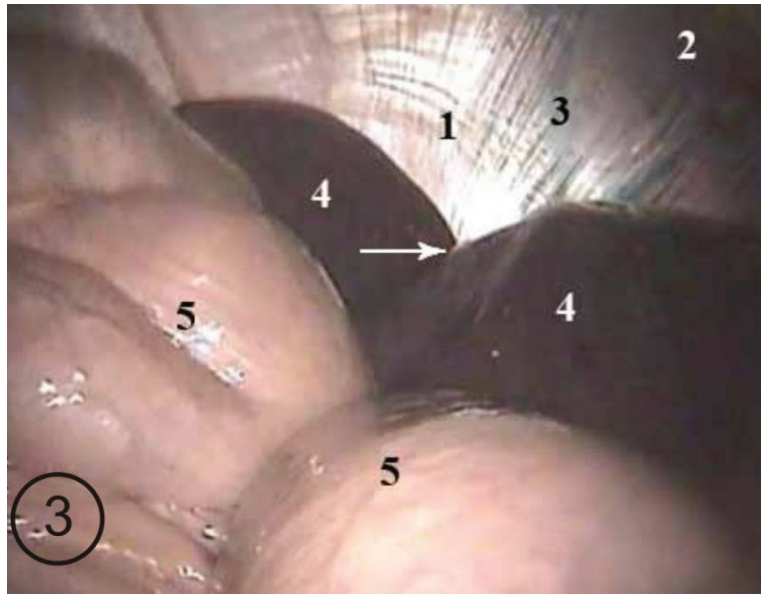

Fig (3): Photograph showing the cranial aspect of the abdominal cavity
1Diaphragma (pars centrum tendineum), 2 Diaphragma pars costalis, 3 V. phrenici, 4 Lobus hepatis sinister, 5 Colon ascendens (flexura sternalis) (diaphragmatica ventralis). The arrow indicates the incisura interlobares hepar.

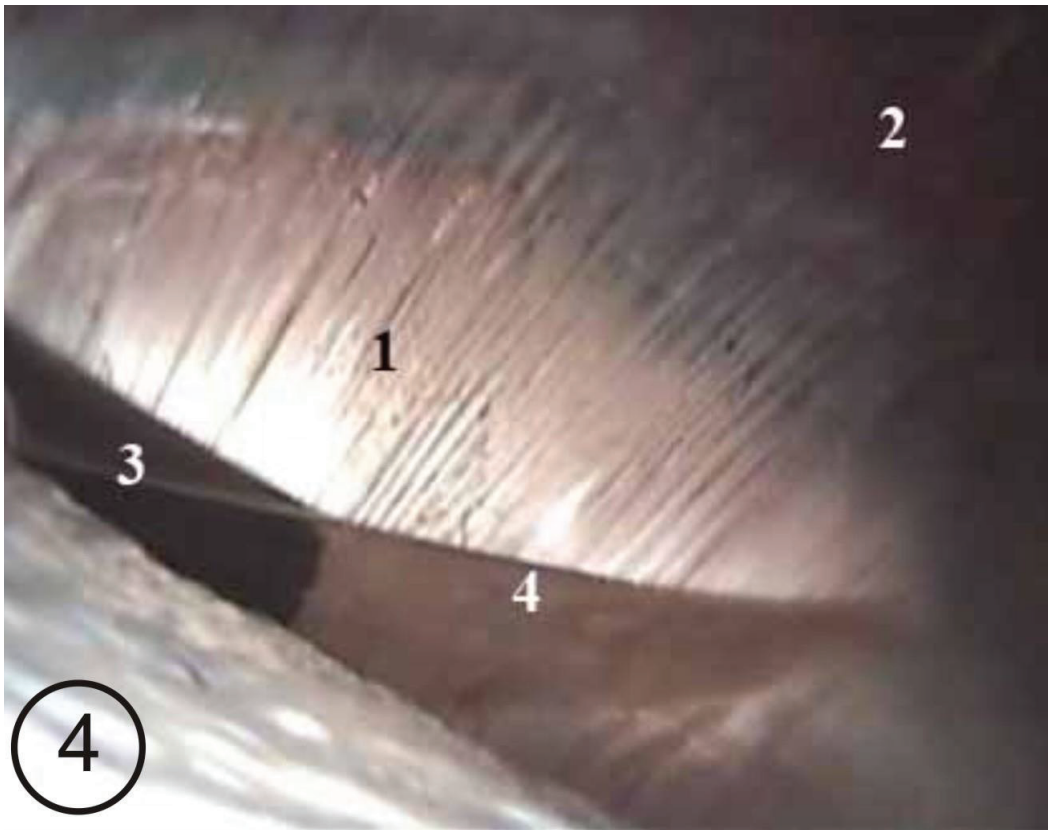

Fig (4): Photograph showing the cranial aspect of the abdominal cavity
1 Diaphragma (pars centrum tendineum), 2 Diaphragma (pars costalis), 3 Lobus hapatis sinister (margo dorsalis), 4 Left triangular ligament of liver.

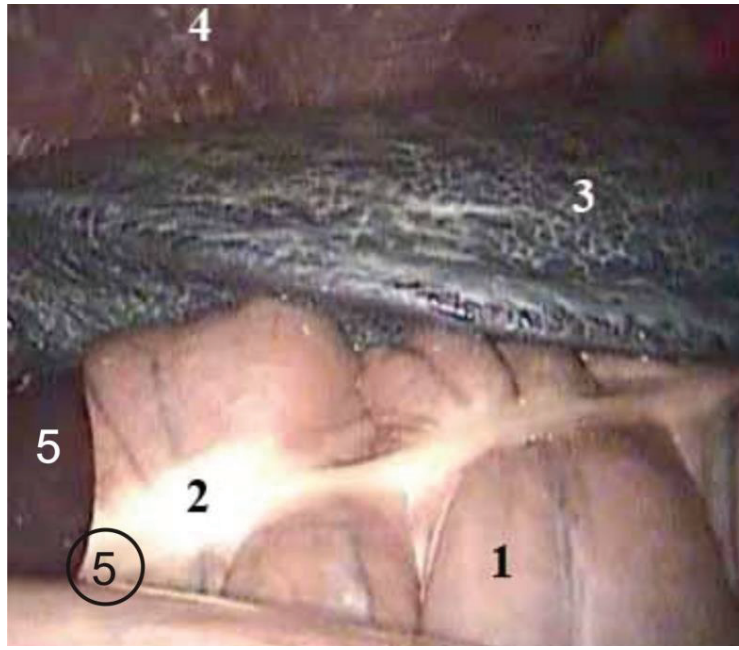

Fig (5): Photograph showing the left aspect of the intra-thoracic part of the adominal cavity. 1 Colon ascendens (pars ventrale sinistrum), 2 Taenia, 3 Lien (facies parietalis), 4 Diaphragma (pars costalis), 5 hepar.

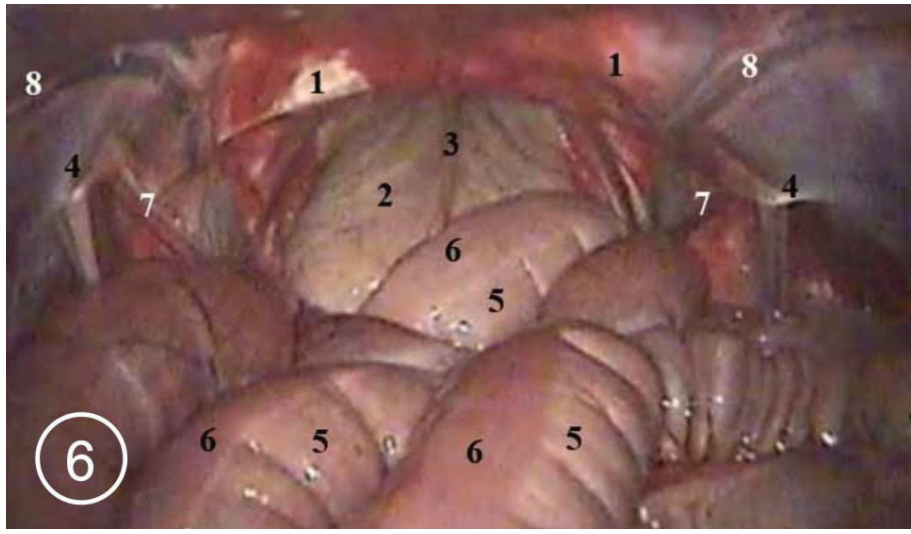

Fig (6): Photograph showing the caudal part of the abdominal cavity 1 Lig. Inguinale, 2 Distended vesica urinaria, 3 Lig. Vesicae medianum, 4 Vaginal ring, 5 Haustrae colon descendens, 6 Taenia, 7 Ductus deferens, 8 A &V. epigastrica caudalis profundus.

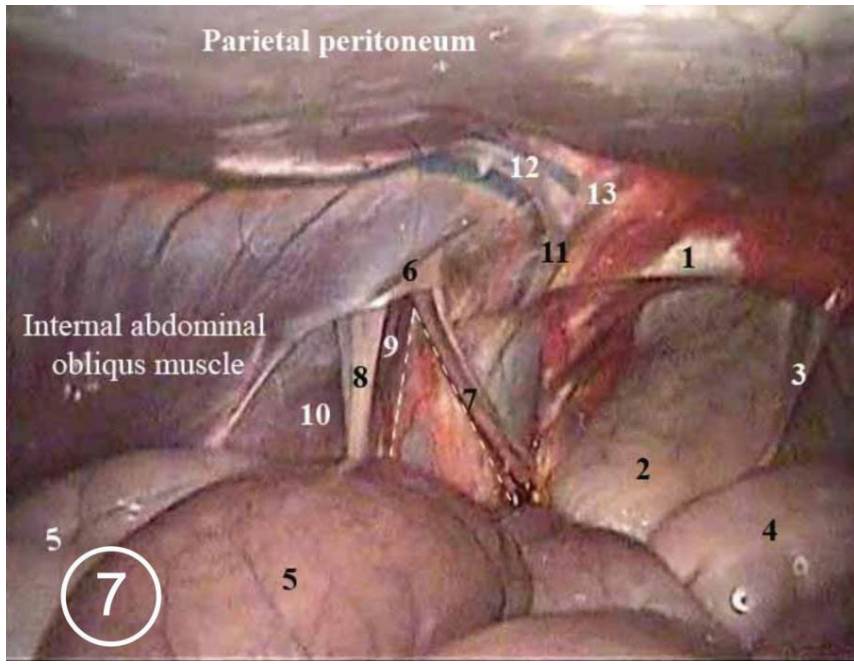

Fig (7): Photograph showing the triangle of doom

1 Lig. Inguinale, 2 Distended vesica urinaria, 3 Lig. Vesicae medianum, 4 Colon descendens, 5 Jejunum, 6 Vaginal ring, 7 Ductus deferens, 8 Mesorchium, 9 Testicular vessels, 10 Cremastricus externus muscle, 11 Truncus pudendoepigastricus, 12 A. & V. epigastrica caudalis profundus, 13 A. & V. pudenda externa.

The dotted lines indicates the triangle of doom.

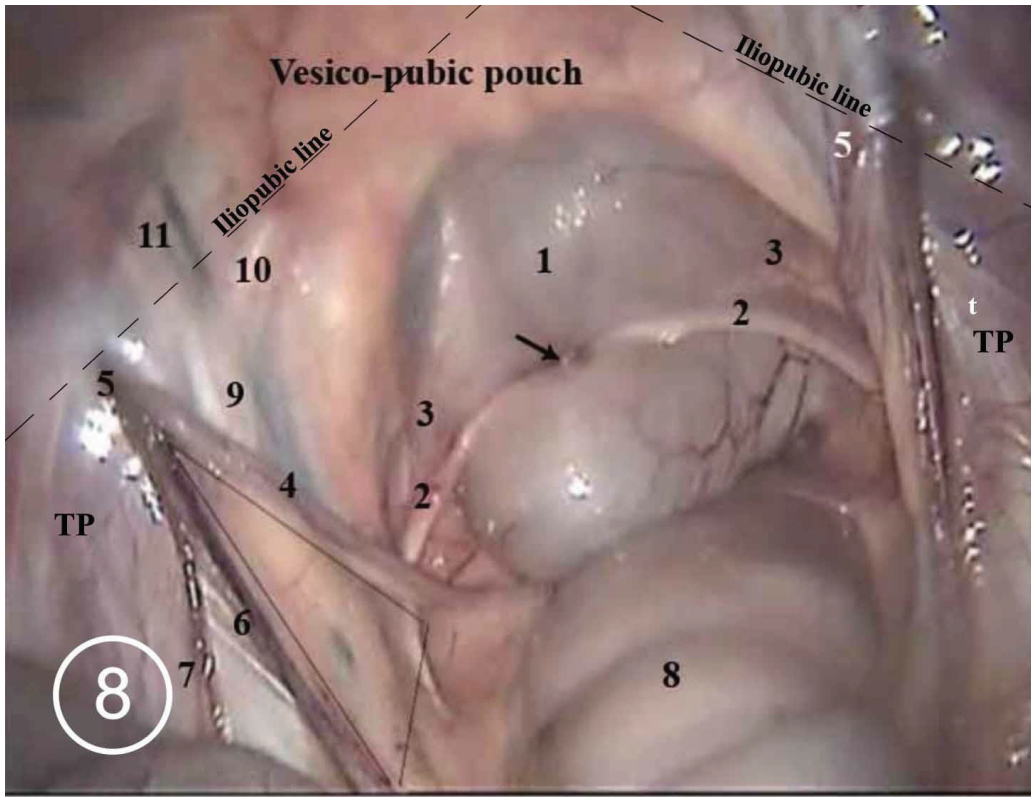

Fig (8): Photograph showing the pelvic inlet.
1 Distended vesica urinaria, 2 Ligamentum teres vesicae, 3 Lig. Vesicae laterale, 4 Ductus deferens, 5 Vaginal ring, 6 V. testicularis, 7 A. testicularis, 8 Colon descendens, 9 Truncus pudendoepigastricus, 10 A. & V. pudenda externa, 11 A. & V. epigastrica caudalis profundus.
The arrow indicates the remnant of the urachus.
The triangular area with dashed lines indicates the triangle of doom.
TP indicates the triangle of pain.

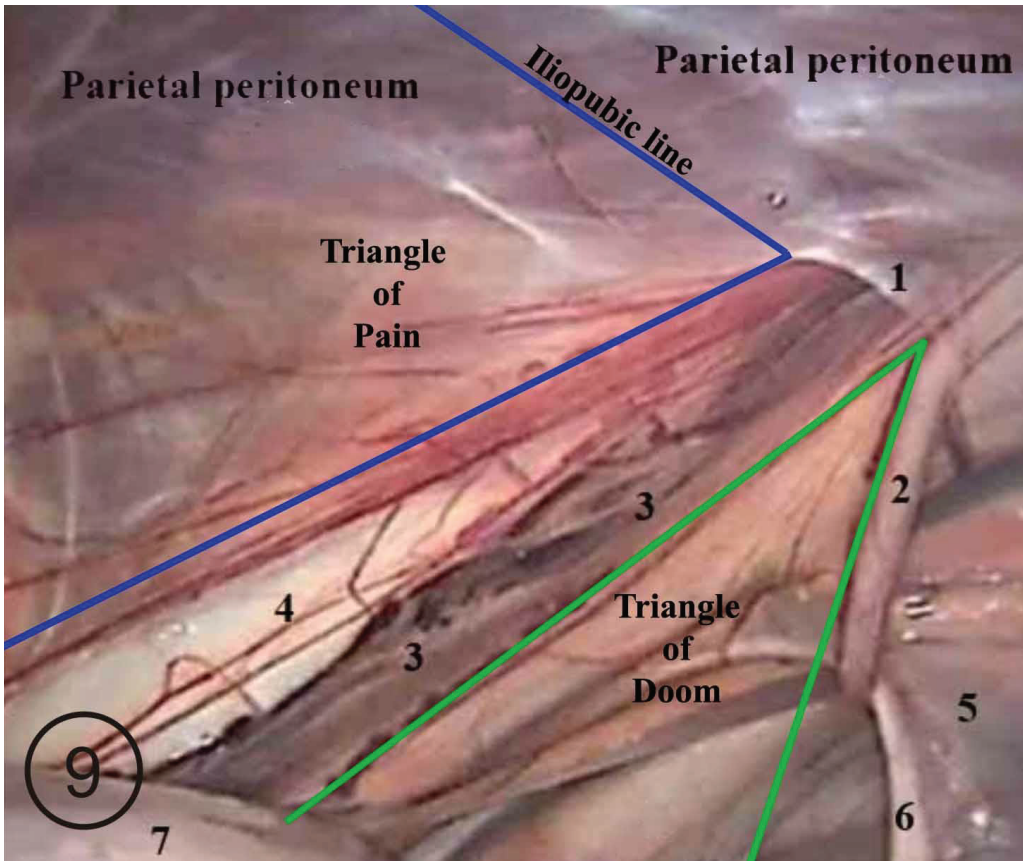

Fig (9): Photograph showing the inguinal region.
1 Vaginal ring, 2 Ductus deferens, 3 A. & V. Testicularis, 4 Mesorchium, 5 Lig. Vesicae laterale, 6 Ligamentum teres vesicae, 7 Colon descendens.

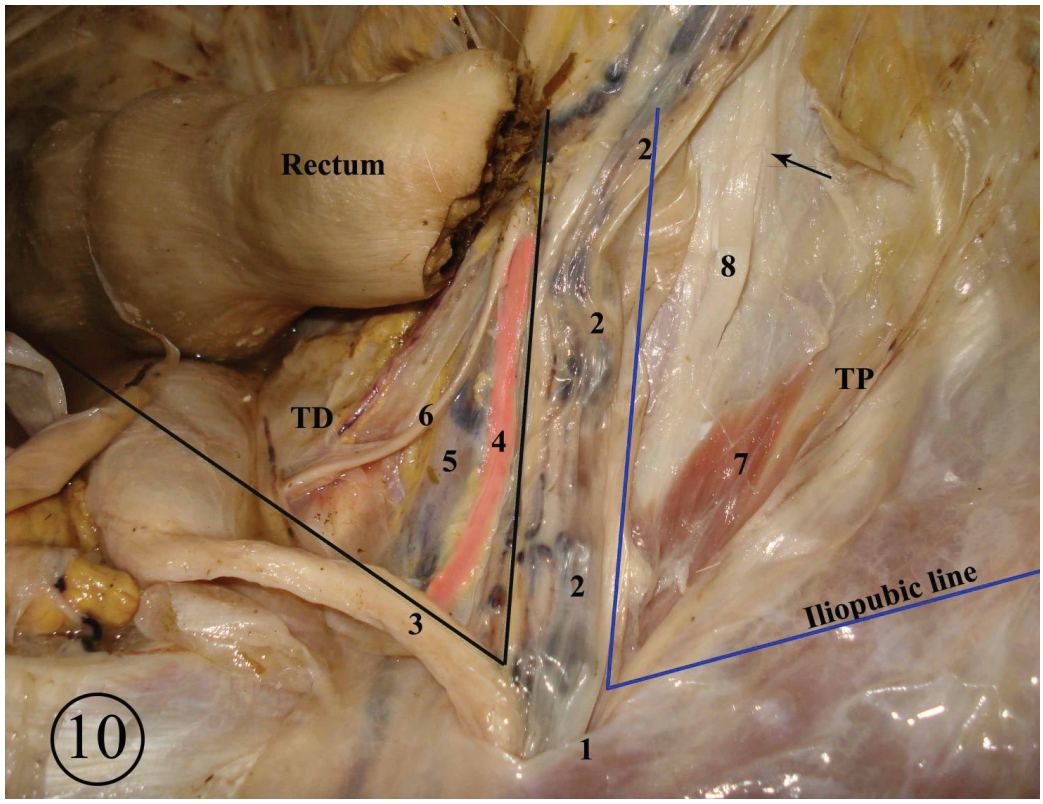

Fig (10): Photograph showing the inguinal region (Carcass dissection).
1 Vaginal ring, 2 A. & V. Testicularis, 3 Ductus deferens, 4 A. Iliaca externa, 5 V. Iliaca externa, 6 N. Obtiuratorius, 7 M. cremaster, 8 N. Femoralis. The arrow indicates N. cutaneus femoris lateralis.
TP within the bluish arms indicates the triangle of pain.
TD within the black arms indicates the triangle of doom.