1

The Boundaries of the Abdomen

1.1 Introduction

The abdomen is the major cavity of the body in the domestic animals and human beings. It contains the gastrointestinal tract, the liver, spleen, pancreas, kidneys and the ovaries together with most of the female reproductive tract. The abdomen is separated from the thorax cranially by the **diaphragm** and the caudal ribs; caudally it is continuous with the pelvic cavity.

Dorsally the abdomen is bounded by the **vertebrae**. Laterally and ventrally the boundaries of the abdomen comprise the **abdominal wall**, a soft tissue structure consisting of muscle, connective tissue and the layers of the skin. The abdominal wall is capable of stretching in the short term, as when the gastrointestinal tract is full of ingesta, and more gradually to accommodate the expanding uterus in pregnancy.

Apart from the important functions of containing and protecting the abdominal contents, the muscular components of the abdominal wall can aid in the expulsion of faeces, urine and foetuses. In addition, contraction of the abdominal muscles can assist in breathing, coughing and sneezing.

1.2 The Diaphragm (Figure 8.3)

The diaphragm is the musculotendinous structure that separates the thoracic and abdominal cavities. It is dome-shaped with its apex pointing cranially. In the dog the diaphragm attaches to the **sternum** cranial to the **xiphoid cartilage** and to the medial surface of the 8th–13th ribs in the dog and cat. NB the horse has 18 pairs of ribs, ruminants 13, pigs 13–16. Dorsally the diaphragm attaches via the left and right crura to the third and fourth lumbar vertebrae. Dorsally the aorta, azygos vein and thoracic duct pass between the crura at the aortic hiatus. The oesophagus and the vagus nerves pass through the oesophageal hiatus located towards the centre of the diaphragm. The caval foramen (portal vena cava) is located on the right side of the central tendinous part of the diaphragm. Herniation of the diaphragm can occur as the result of trauma (see Section 1.7.4).

King's Applied Anatomy of the Abdomen and Pelvis of Domestic Mammals, First Edition. Geoff Skerritt.

Companion website: www.wiley.com/go/skerritt/abdomen

1.3 The Layers of the Abdominal Wall

Between the skin and the parietal peritoneum lie several layers of fascia and muscle. A proper appreciation of these layers, and the direction of their fibres, is important when making surgical incisions for entry to the abdominal cavity.

1.3.1 The skin

The skin, or common integument, varies in thickness between species and bodily location. The abdominal skin is very thick (4–5 mm) in the ox but is quite delicate and thin (1–3 mm) in the other domestic species. Hair grows from the skin in all of the species but is much less in the pig. In all species there is much less hair on the ventral abdomen than elsewhere. Most of the hair of the sheep has a specific structure and is termed wool. In all species except the pig a principal function of the hair/wool is to reduce heat loss; the pig relies on a large amount of subcutaneous fat for this function.

The domestic species vary in regard to the number and distribution of the mammary glands. The mare has only two mammary glands, and these are located either side of the midline on the ventral abdomen in a prepubic position. The cow usually has four mammary glands, collectively known as the udder; it is located mainly ventral to the caudal abdomen but with its caudal part ventral to the pelvis. The udder is suspended by strong elastic tissue extending essentially from the **linea alba** and the symphyseal tendon.

There are seven pairs of mammary glands in the sow, although only 8–10 are usually functional depending on litter size. In this species the mammary tissue extends in the body wall from the axilla to the level of the stifle.

The udder of small ruminants comprises two glands and is situated in the inguinal region. In the bitch there are usually five pairs of mammary glands; in the cat there are generally four pairs.

1.3.2 The subcutaneous fascia

Superficial fascia: In the pig this layer is adipose over most of its area and functions as an insulating layer promoting heat retention. However, in most other species this adipose tissue is not complete except in the inguinal region. In horses and cattle the **cutaneous muscle** is well developed in the superficial fascia layer and serves to twitch the skin to dislodge flies.

Deep fascia: In the horse and ox the deep fascia is developed as a thick sheet of fibroelastic tissue covering most of the external abdominal oblique muscle, the ribs and the tuber coxae. This is termed the **yellow elastic tunic** providing support for the abdominal contents and contributing to the suspensory apparatus of the udder in the cow.

1.3.3 The rectus abdominis muscle (Figures 1.1 and 1.2)

Origin: The ventral surfaces of the sternal ribs and sternum.

Insertion: The cranial border of the pubis with the **prepubic tendon**. The prepubic tendon is the tendon of insertion of the two rectus abdominis muscles, although most of its fibres extend between the iliopubic eminences.

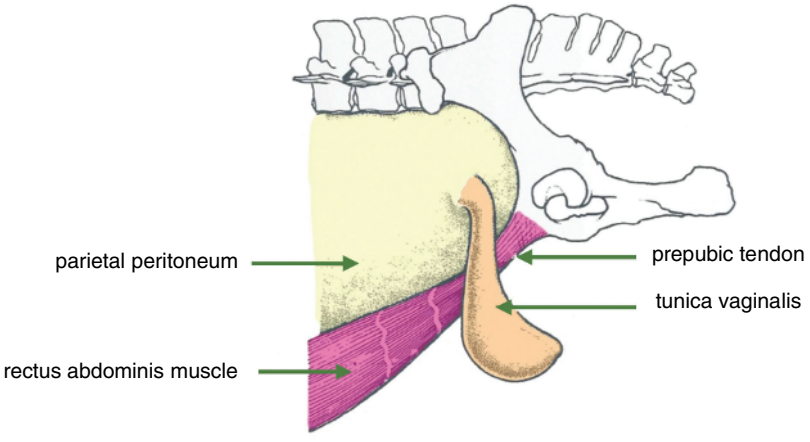

Figure 1.1 Lateral view of inguinal region of horse showing the rectus abdominis muscle. The peritoneum of the vaginal tunic is strongly reinforced by fusion with the internal spermatic fascia (derived from the transverse abdominal muscle).

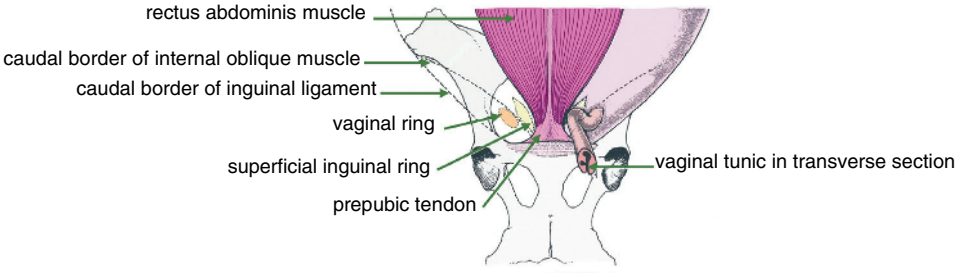

Figure 1.2 Ventral view of the inguinal region of horse showing the rectus abdominis muscle. The left side of the diagram shows the relative positions of the superficial inguinal ring and the vaginal ring. On the right side of the diagram the vaginal tunic is shown wending its way from the deep inguinal ring, through the inguinal canal and out through the superficial inguinal ring.

Structure: The left and right muscles are separated longitudinally by the linea alba, a band of fibrous tissue extending from the xiphoid cartilage to the prepubic tendon. A series of three to six transverse tendinous inscriptions cross each muscle belly, but the resulting muscle segments are not correlated with the nerve supply.

Species variations: In the **ox** there is wide separation of the medial borders of the rectus abdominis muscles. caudally. In the immature animal the linea alba is perforated by the umbilicus.

1.3.4 External abdominal oblique muscle (Figures 1.3–1.5)

Origin: The lateral surfaces of the ribs caudal to the fourth rib and the lumbodorsal fascia.

Insertion: The linea alba and prepubic tendon.

Structure: Most of the muscle fibres run caudoventrally. At its origin it consists of muscle fibres but towards its insertion caudoventrally it becomes a tendinous

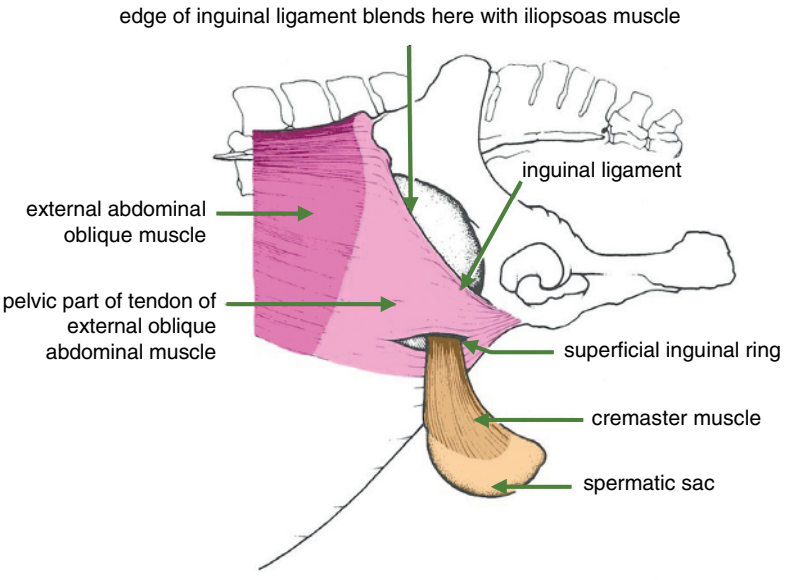

Figure 1.3 Lateral view of the inguinal region of the horse left external oblique abdominal muscle. The spermatic sac is seen emerging from the left superficial inguinal ring.The spermatic sac contains the testicle and the spermatic cord (See Figure 15.4).For a definition of the spermatic sac see Section 16.4

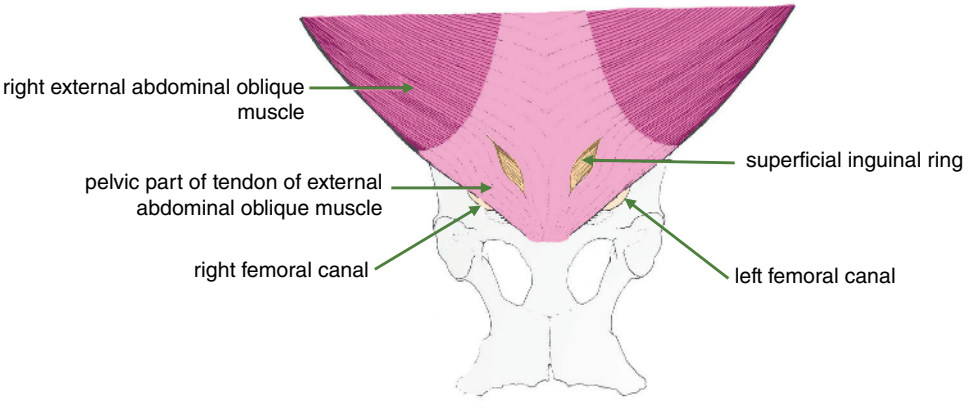

Figure 1.4 Ventral view of inguinal region of the horse showing the left and right external abdominal oblique muscles. The arrows indicate the left and right femoral canals, providing exit for the femoral arteries and veins.

aponeurosis. Towards its insertion in the prepubic tendon there is a slit in the aponeurosis; this is the **superficial inguinal ring**. The slit divides the tendon into an abdominal part cranially and a pelvic part caudally. The caudal edge of the pelvic part of the tendon is the **inguinal ligament**.

Species variations: The external abdominal oblique muscle of the **dog** and **pig** is mainly muscular almost to the dorsal edge of the rectus abdominis muscle. In

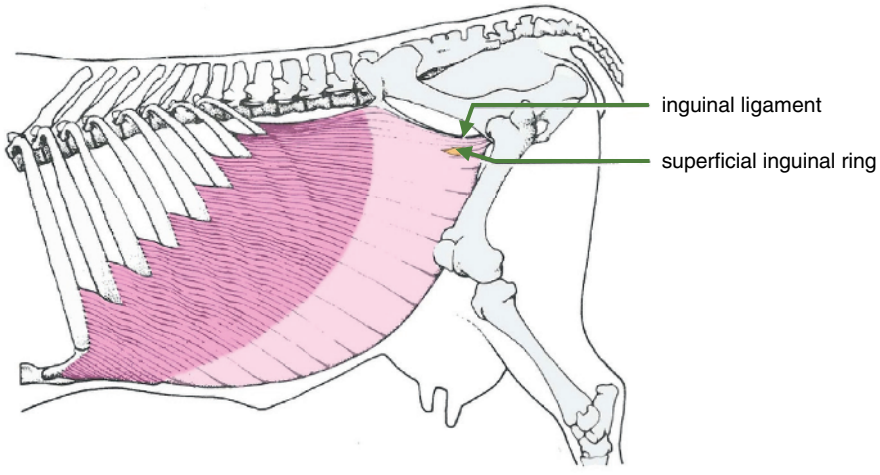

Figure 1.5 Lateral view of the abdomen of the ox showing the left external abdominal oblique muscle.

ruminants there is no origin from the lumbodorsal fascia, but there is an insertion on the tuber coxae. In the ox the aponeurosis of this muscle is extensive. In the **horse** the external abdominal oblique muscle is very large and inserts onto the femoral fascia, linea alba, tuber coxae and the prepubic tendon.

1.3.5 Internal abdominal oblique muscle (Figures 1.6–1.8)

Origin: Tuber coxae and lumbodorsal fascia.

Insertion: Linea alba (except for the most caudal part), last rib and cartilages of the caudal ribs.

Structure: This is a sheet of muscle and tendon with the fibres running cranioventrally. It is muscular at its origin and becomes tendinous ventrally. In the male a slip of the internal abdominal oblique muscle passes through the inguinal canal on the lateral aspect of the vaginal process and becomes the cremaster muscle (see Section 16.4).

Species variations: The fibres of this muscle run almost ventrally in the **dog**. In carnivores the tendinous portion divides to pass dorsally and ventrally to the rectus abdominis muscle in the cranial third of the abdomen; it passes only ventrally in the caudal two-thirds of the abdomen. In the **ox** the internal abdominal oblique is quite substantial, being the largest flank muscle in this species; its tendon passes both ventrally and dorsally to the rectus abdominis. In the **horse** the internal abdominal oblique muscle originates only from the tuber coxae, and its tendon passes ventrally to the rectus abdominis. See Figures 1.10a–c for a summary of the species variation of the sheath of the rectus abdominis.

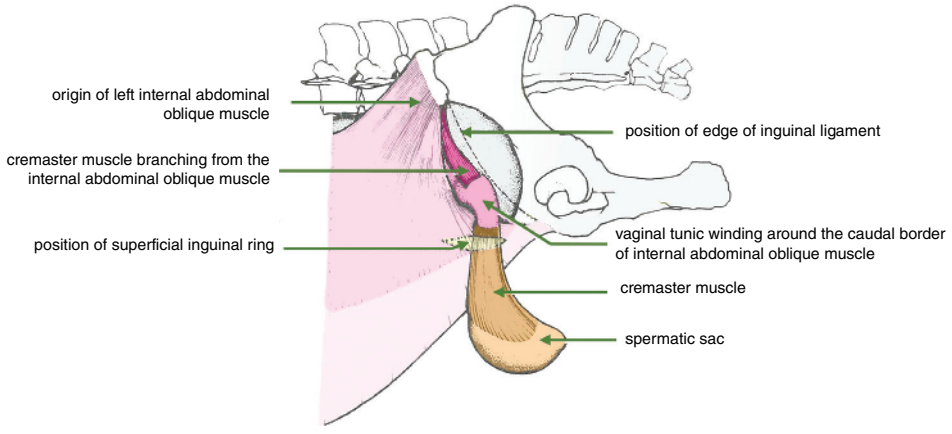

Figure 1.6 Lateral view of inguinal area of horse showing the internal abdominal oblique muscle. The left external abdominal oblique muscle has been removed although the position of the left superficial inguinal ring is shown. The mid-section of the left cremaster muscle has been excised to expose the vaginal tunic.

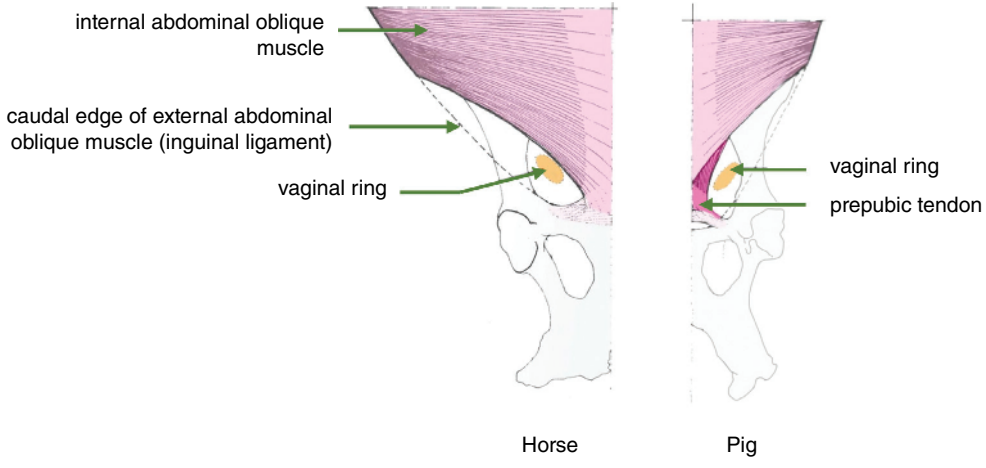

Figure 1.7 Ventral view of inguinal region showing internal abdominal oblique muscle.

1.3.6 Transverse abdominal muscle (Figure 1.9)

Origin: The medial surfaces of the ventral parts of the caudal ribs and the deep layers of the lumbodorsal fascia.

Insertion: The linea alba.

Structure: Again this muscle is sheet-like, although its fibres run ventrally and transversely to the longitudinal axis. Caudally the muscle thins out to only a fascial layer.

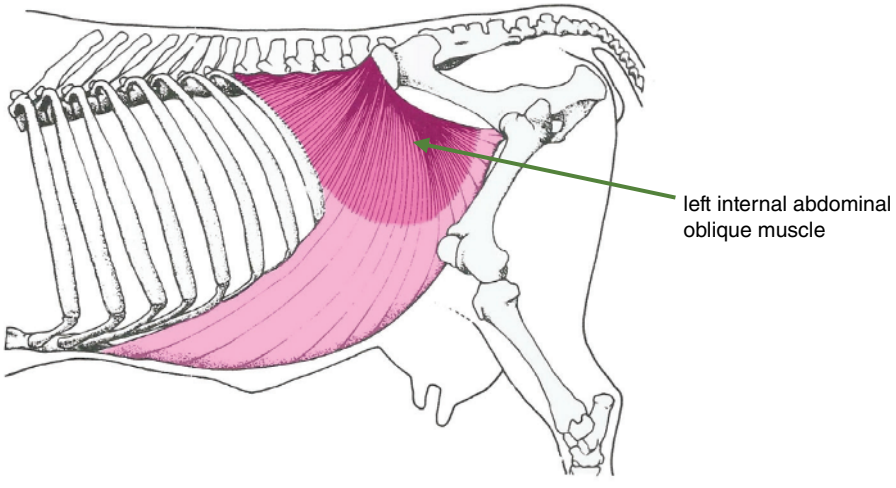

Figure 1.8 Lateral view of abdomen of ox showing left abdominal oblique muscle. The external abdominal oblique has been removed.

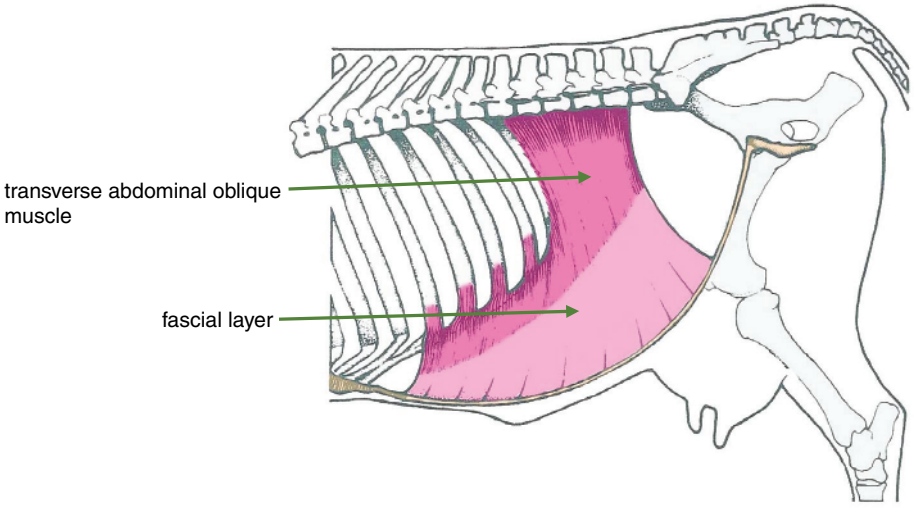

Figure 1.9 Medial view of abdomen of ox showing the transverse abdominal muscle.

Species variations: In the **dog** the cranial two-thirds of the tendon pass dorsally to the rectus abdominis with the caudal third passing ventrally.

1.3.7 Retroperitoneal fascia

This tissue layer is equivalent to the superficial fascia but less defined. Its significance is due to its large fat content in the adult pig, fat ponies and beef breeds of cattle. Where

the fascia is minimal the peritoneum is closely applied to the transverse abdominal muscle. The **falciform** ligament (see Sections 3.3 and 3.4) is a fold of peritoneum attached to the liver. It is a remnant of the peritoneum that contained the umbilical vein of the foetus; it attaches to the abdominal wall at the umbilicus.

1.3.8 Parietal peritoneum

This peritoneal layer lines the whole abdominal wall. It is a largely transparent and delicate layer that is reflected as mesenteries that are continuous with the visceral peritoneum that covers the abdominal viscera. The peritoneum comprises an outer layer of simple squamous epithelium called the mesothelium and is supported by a layer of loose connective tissue.

1.4 The Sheath of the Rectus Abdominis Muscle (Figures 1.10a–c)

The aponeuroses of the external, internal and transverse abdominal oblique muscles together form a sheath that encloses the rectus abdominis muscle either side of the midline of the abdominal wall. There are species differences and, in the dog, variations in the craniocaudal location.

Species variations: In the caudal third of the abdomen of the **dog** the tendon of the transverse abdominal muscle lies ventral to the rectus abdominis muscle. In the middle third of the abdomen the transverse abdominal tendon lies dorsal, and that of the internal abdominal oblique muscle passes ventral to the rectus abdominis (as in the **horse**). In the cranial third of the abdomen the tendon of the transverse abdominal muscle lies dorsal to the rectus muscle. In addition, the internal oblique tendon divides into a ventral and dorsal portion (as in the **ox**).

In the **horse** the aponeurosis of the internal oblique muscle lies ventral to the rectus abdominis. In addition, in this species, the yellow abdominal tunic is present.

In the **ox** the aponeurosis of the internal oblique divides to pass on both sides of the rectus abdominis, and a yellow abdominal tunic is again present. In this species the linea alba is particularly wide.

1.5 Clinical Importance of the Ventral Body Wall

A surgical incision in the abdominal wall is called a laparotomy. It may be made in the midline, to either side of the midline or in the flank on either side. The choice of location of the laparotomy depends on a number of factors:

i) The avascularity of the linea alba resulting in slow healing; this is a particular problem especially in cattle where the linea alba is extensive.
ii) The bulk and weight of the abdominal contents leading to slow healing and risk of herniation.
iii) In the dog the ventral sheath of the rectus abdominis is particularly strong, and failure to suture this may result in breakdown of a midline incision.
iv) In a midline incision contraction of the muscles of the abdominal wall tends to retract the wound edges laterally.

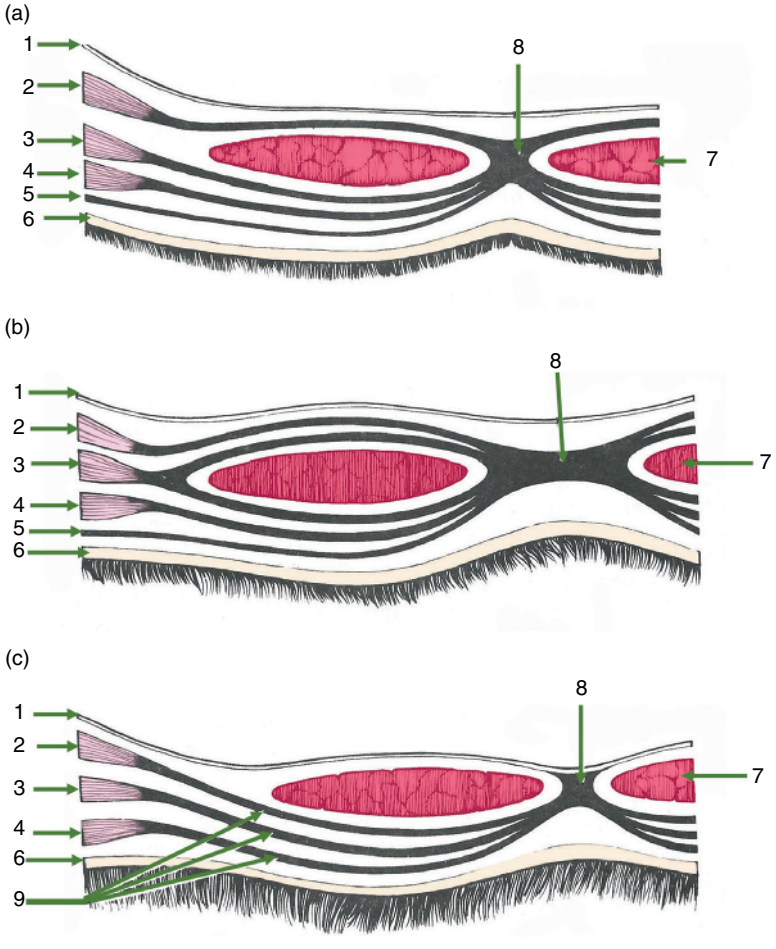

Figure 1.10 Transverse sections through the ventral body wall to show the species variation in the sheath of the rectus abdominis. (a) The horse, (b) the ox and (c) the dog (caudal third of abdomen only). 1 = parietal peritoneum; 2 = transverse abdominis muscle; 3 = interior oblique abdominis muscle; 4 = exterior oblique abdominis muscle; 5 = yellow abdominis tunic; 6 = skin; 7 = rectus abdominis muscle; 8 = linea alba; 9 = ventral sheath of rectus abdominis muscle

v) Flank incisions should be parallel to the muscle fibres to minimise bleeding from the vascular muscular tissue.
vi) In the cow a further complication of a midline incision is that branches of the mammary vein may cross the midline to anastomose with the opposite mammary vein.

1.6 The Inguinal Canal (Figures 1.11 and 1.12)

The inguinal canal is a potential space extending between the superficial and deep inguinal rings. The canal does not have a surrounding wall. The external opening (superficial inguinal ring) is a slit in the aponeurosis thereby dividing it into two parts, an abdominal part (cranially) and a pelvic part (caudally).

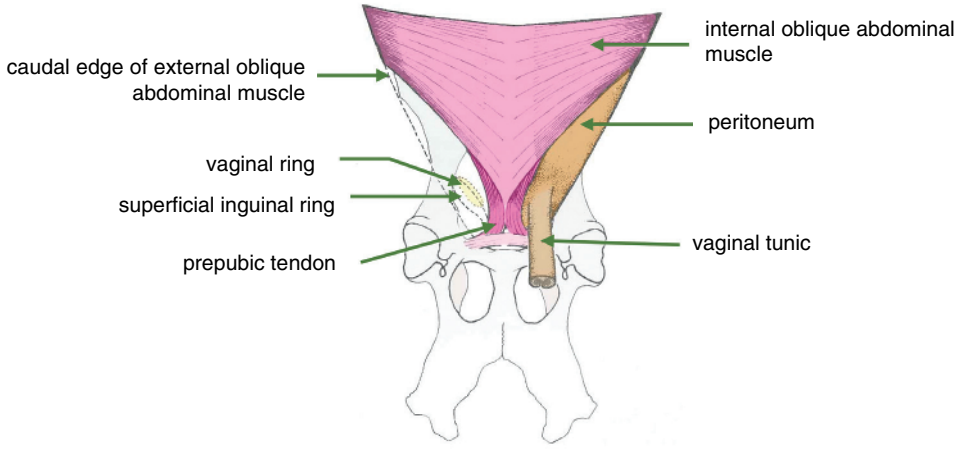

Figure 1.11 Ventral view of inguinal canal of the pig. The left side of the diagram shows the superimposition of the superficial inguinal ring almost directly upon the vaginal ring in this species.

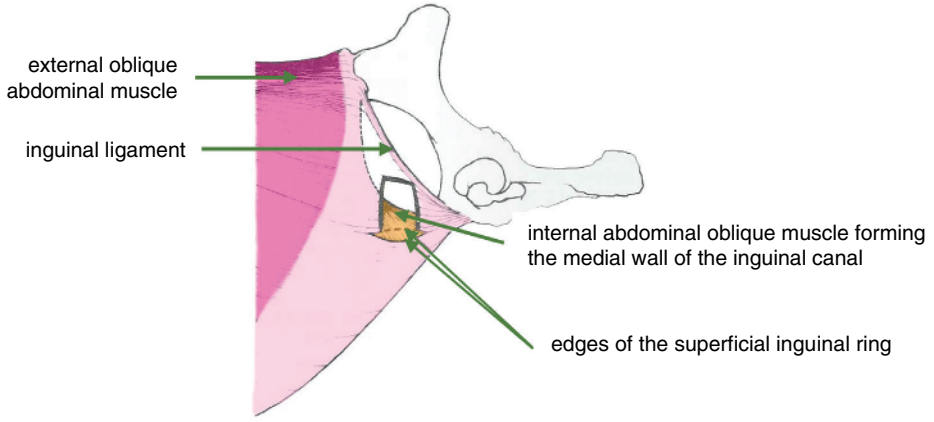

Figure 1.12 Lateral view of the inguinal canal of the horse. A window has been cut from the pelvic part of the tendon of the external abdominal oblique muscle immediately adjoining the superficial inguinal ring. This exposes that part of the internal oblique abdominal muscle which forms the medial (deep) wall of the inguinal canal.

Species variations: The deep inguinal ring is different in the **pig** from that in the horse due to the different extent to which the internal oblique abdominal muscle inserts caudally. In the **horse** the deep inguinal ring is small, being bordered caudally by the inguinal ligament and cranially by the caudal edge of the internal oblique muscle (Figure 1.12) In the **pig** the deep inguinal ring is larger, bordered caudally by the inguinal ligament, cranially by the caudal edge of the internal abdominal oblique muscle and medially by the lateral border of the rectus abdominal muscle and the prepubic tendon (Figure 1.11). In the other domestic animals, the anatomy of the inguinal ring is between the horse and the pig but tends to be closer to the latter.

In the male foetus of all species an outpouching of parietal peritoneum, the **vaginal process** (Figure 16.6), enters the inguinal canal. The **gubernaculum** (see Section 16.9) develops from mesenchyme partly within the inguinal canal and joins the testes to the scrotum. In the adult male the inguinal canal contains the vaginal tunic, the cremaster muscle and the spermatic cord in addition to the external pudendal artery and vein, the inguinal lymph vessels and nerves. In the adult female it is only in the bitch that a rudimentary vaginal process extends through the inguinal canal.

1.7 Hernias

A hernia occurs when an organ or mesentery pushes through an opening in the muscle or tissue that normally holds it in place. Hernias occur most commonly in the abdomen when there is a deficit or weakness in the abdominal wall, but they may also occur at the diaphragm or the perineum. The several sites where hernias may occur are as follows:

1) Inguinal
2) Umbilical
3) Perineal
4) Diaphragmatic
5) Post-operative.

1.7.1 Inguinal hernia

The vaginal process develops in the embryo as an extension of the parietal peritoneum. Therefore the cavity of the vaginal process is continuous with the peritoneal cavity via the vaginal ring. In the male of all species and the bitch it is possible for abdominal contents (e.g. small intestine or great omentum) to protrude through the vaginal ring and enter the vaginal process. Within the vaginal process the herniated organ or tissue passes through the inguinal canal and may enter the scrotum. An inguinal hernia may or may not be reducible; an irreducible hernia may become strangulated if the blood supply becomes interrupted.

Congenital inguinal hernias are common in pigs, but in sheep they are thought to be a result of trauma. In the horse inheritance has not been proven, but they are more common in certain breeds.

1.7.2 Umbilical hernia

Normally, at birth, the umbilical ring closes and the umbilical blood vessels, the vitelline duct and the allantoic stalk begin to degenerate. If contraction of the umbilical ring does not occur completely it is possible for abdominal contents to enter the aperture and appear as a soft swelling beneath the umbilical scar.

1.7.3 Perineal hernia

The perineum is the part of the body wall that occludes the caudal opening of the pelvic cavity; it surrounds the anus and the urogenital opening. The major portion of the

perineum, comprising the levator ani and coccygeus muscles, is called the **pelvic diaphragm**. A hernia through the pelvic diaphragm can occur as a result of a defect in the musculature. This is a fairly complex anatomical area including the external anal sphincter, superficial gluteal muscle and sacrotuberous ligament.

Perineal hernias occur mainly in older male dogs and certain breeds, e.g. the Boxer, Boston Terrier, Pekingese and crossbreds.

1.7.4 Diaphragmatic hernia

The diaphragm separates the abdominal cavity from the thorax. Sudden increases in pressure in the abdomen can result in tears of the diaphragm with the consequence that abdominal organs can be forced into the thoracic cavity. This situation can occur as the result of a road traffic accident. Congenital hernias of the diaphragm are of rare occurrence in the dog and horse.

1.7.5 Post-operative hernia

A surgical incision in the abdominal wall is normally closed either with sutures or staples. If there is breakdown along the incision, there is a risk of herniation of abdominal organs. This situation may result from a variety of circumstances, e.g. poor healing of the incision due to inadequate vascularisation, pressure from the weight of the abdominal organs, faulty suturing technique and interference with the wound by the patient.