L'enseignement de l'anatomie des appareils digestif, urinaire et génital par l'utilisation de vidéos d'anatomie 3D en anglais, intérêts pédagogiques par rapport aux méthodes classiques d'enseignement

ABDOMINAL

WALL

I.   INTRODUCTION

The trunk is a columnar cavity divided by the thoracoabdominal diaphragm. (Figure 1)

Above the diaphragm, is the thorax bounded by the thoracic wall.

Below the diaphragm, is the abdominal cavity covered by the anterior and posterior abdominal

walls.

The anterior abdominal wall is skeletal, muscular and aponeurotic.

The posterior abdominal wall is skeletal and muscular.

The abdominal cavity contains the digestive and urogenital viscera.

Below the pelvic brim, is the pelvic cavity, the latter can be distinguished from the abdominal

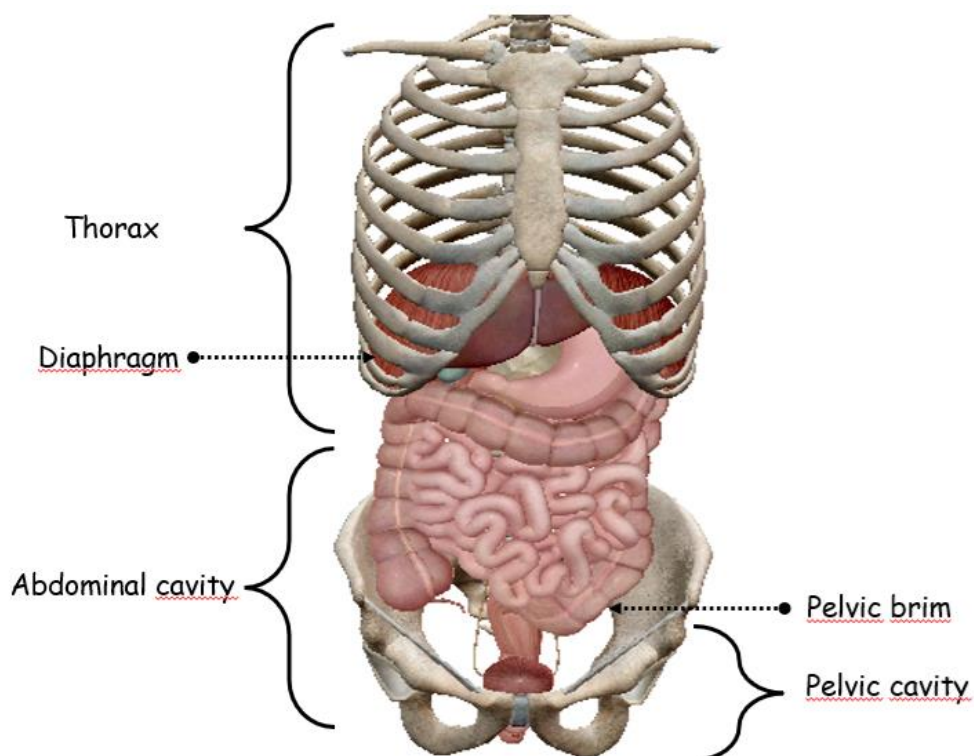cavity proper. It is closed below by the pelvic diaphragm.

Figure 1: Anterior view of the trunk

II. DESCRIPTIVE ANATOMY

A- ANTERIOR ABDOMINAL WALL

1. Skeleton of anterior abdominal wall

The skeleton of the anterior abdominal wall consists of, upwards, the thoracic outlet limited by the xiphisternum and the costal margins forwards and the 11th and 12th ribs backwards, downwards, the pelvic bones namely the hip bones brought together forwards by the pubic symphysis and hinged backwards with the sacrum through the sacroiliac joints. (Figure 2) The pelvic brim is limited, backwards, by the sacral promontory, the arcuate lines, laterally, and the upper edge of the pubic symphysis at the front.
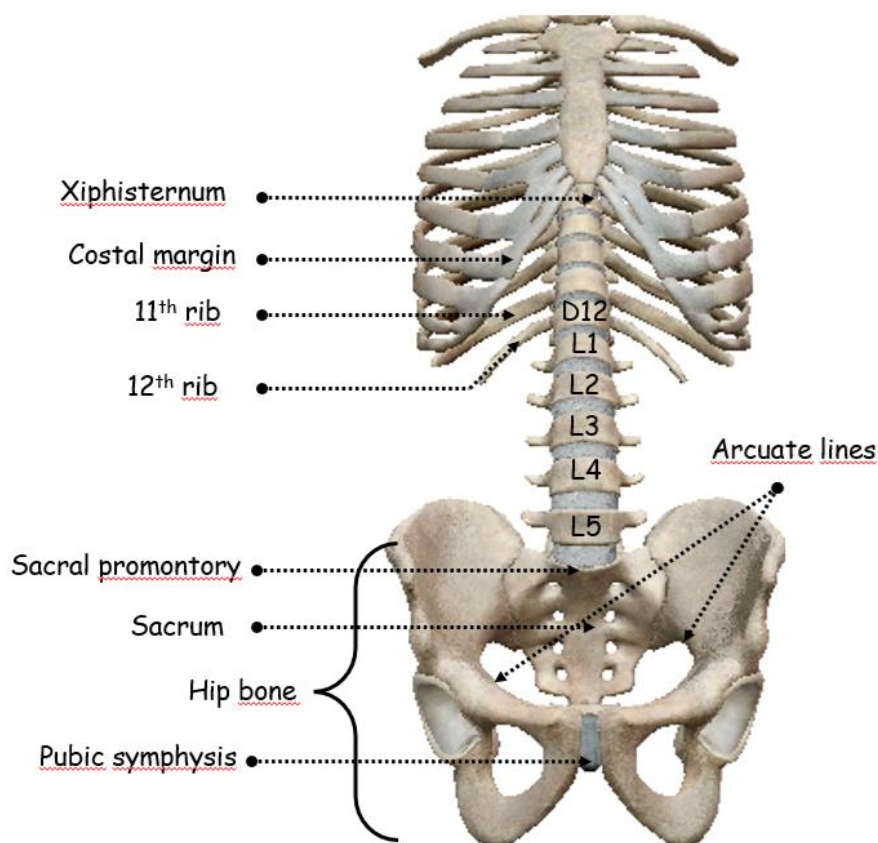

Figure 2: Anterior view of skeleton of anterior abdominal wall

2. Anterolateral abdominal muscles and aponeuroses

The anterolateral abdominal muscles and aponeuroses are, namely from surface to depth, the external oblique muscle, the internal oblique muscle and the transversus abdominis muscle.

They fuse together ventrally to form the rectus abdominis muscle.

The pyramidalis muscle stands in front of the rectus abdominis muscle.

3. Surface marking of anterior abdominal wall

On the surface, nine regions of the anterior abdominal wall are distinguished.

They are delineated by two lateral sagittal lines on each side and two horizontal lines. The vertical line extends from the midclavicular point downwards to the midinguinal point on the inguinal ligament midway between the pubic symphysis and the anterior superior iliac spine.

The midline crosses the umbilicus, each lateral sagittal line passes by the midway between the midline and the superior anterior iliac spine.

The lower transverse line is the intertubercular plane between the tubercles of the iliac crests.

The upper transverse line is the transpyloric plane midway between the jugular notch and the top of the pubic symphysis although some clinicians use the subcostal plane passing by the xiphisternum and the lower border of the tenth ribs which is a little lower.

The surface marking of the anterior abdominal wall has a major clinical interest.

Thus, three lateral regions on each side are distinguished.

The right and left hypochondrial regions, the right and left lumbar regions and the right and left iliac regions.

The right hypochondrial region is the projection of the liver, gall bladder and right colic flexure.

The spleen, fundus of the stomach and left colic flexure project on the left hypochondrial region.

The right lumbar region contains the right kidney and the ascending colon.

The left kidney and the descending colon project towards the left lumbar region.

The right and left iliac regions contain, respectively, the cecum and appendix and right adnexa in women and the sigmoid colon and left adnexa in women.

The three central regions consist of the epigastric, the umbilical and the hypogastric regions.

The epigastric region is the projection of the pyloric region of the stomach, left lobe of the liver, pancreas and heart.

The small intestine and the transverse colon project towards the umbilical region.

The hypogastric region contains the urinary bladder and the fundus of uterus in women.
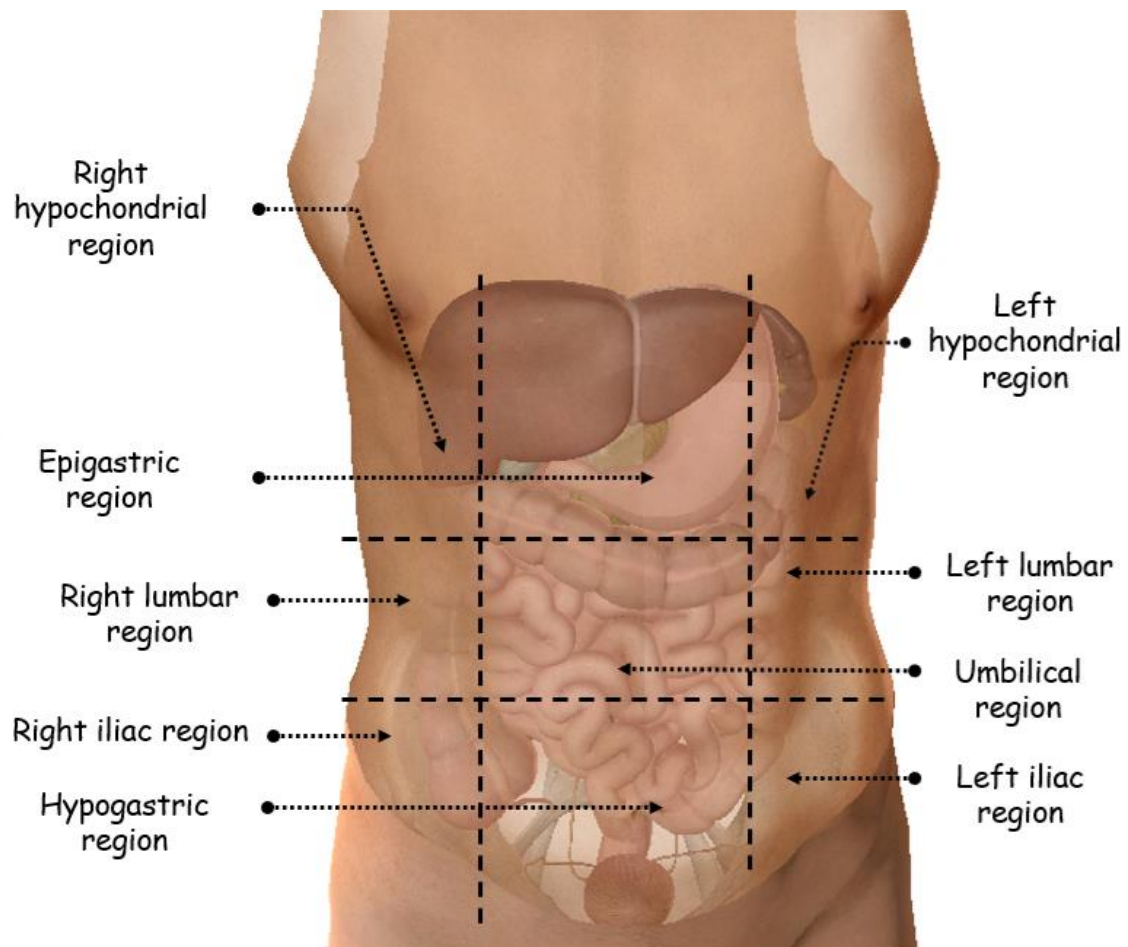
.

Figure 3: Anterior view of the surface of
the trunk

4. Skin and subcutaneous tissue

The skin of the anterior abdominal wall is thin and flexible.

The superficial subcutaneous tissue is fatty above the superficial fascia.

The superficialis fascia of the anterior abdominal wall is the fascia of Scarpa, it is continuous with

the the external spermatic fascia, the superficial fascia of perineum of Colles, the superficial fascia

of the penis in men and of the clitoris in women and the fascia lata two centimetres and half below

the inguinal canal.

The deep subcutaneous tissue is fatty below the fascia of Scarpa.

The skin tension lines here are transverse and arciform near the pubis.

5. Rectus abdominis muscle

The rectus abdominis muscle is a paired muscle.

It arises by two heads. The medial head arises from in front of the pubic symphysis. The lateral head arises from the upper border of the pubic crest. They attach by a relatively small tendon that rapidly thickens. The two muscles lie edge to edge in the lower part but broaden out above separated by the linea alba.

The thoracic insertions are arranged into three superficial, intermediate and deep layers.

The external oblique layer attaches in front of the fifth to seventh costal cartilages.

The internal oblique layer attaches to the costal margin at the lower border of seventh cartilage.

The transversus layer consists of xiphisternal fibres.

The heads of rectus abdominis contain three tendinous intersections, the upper towards the xiphisternum, the lower towards the umbilicus and the middle at the midway between the latters. The tendinous intersections blend with the anterior layer of the rectus sheath and do not penetrate to the posterior surface of the muscle.

The rectus abdominis muscle is compressor of the abdomen, flexor of the vertebral column and depressor of ribs.
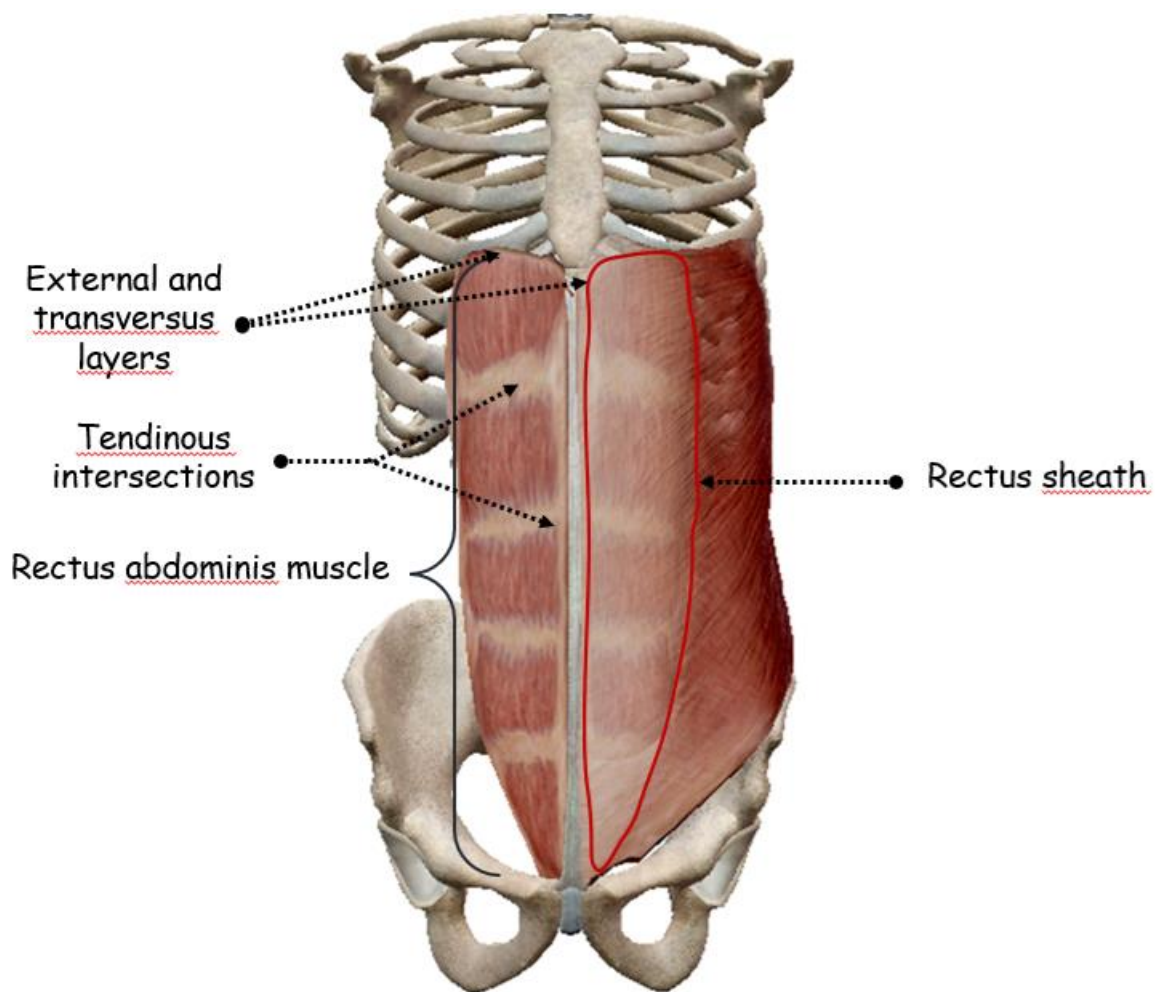
Figure 4: Anterior view of the skeleton of the trunk showing
the recti abdominis muscles

6. Pyramidalis muscle

The pyramidalis muscle is paired triangular muscle that arises from the pubic crest

between the lower portion of rectus abdominis and the anterior layer of its sheath and converges

with its fellow into the linea alba four centimetres above its origin.

7. External oblique muscle

The external oblique muscle is a paired muscle. It is the most superficial oblique

muscle. The external oblique is large and thick.

Its fleshy origin arises by eight digitations one from each of the lower eight ribs just lateral to their anterior extremities forming an oblique line backwards and downwards. The lower four slips interdigitate with the costal fibres of latissimus dorsi and the upper four with corresponding digitations of serratus anterior. Its heads are sloping downwards and forwards.

Its insertion is wide and mostly aponeurotic. It attaches, backwards, by fleshy free fibres onto the anterior half of the outer lip of the iliac crest and form the anterior boundary of lumbar triangle of Petit and, forwards, by aponeurotic fibres directed obliquely downwards and forwards from the anterior superior iliac spine to pubic tubercle interdigitating with each other above the pubic symphysis across the front of the rectus abdominis to the whole length of the linea alba up to the xiphisternum as the only structure in the anterior sheath of the rectus muscle above the costal margin. Downwards, it forms the inguinal ligament of Poupart between the anterior superior iliac spine and the pubic tubercle and the superficial inguinal ring, V-shaped, with medial limb down to the pubic crest and lateral limb down to the pubic crest.

The inguinal ligament extends from the anterior superior iliac spine and the pubic tubercle, it is rolled inwards to form a gutter, it adheres to the iliac fascia and is continuous with the fascia lata. Its lateral end represents the origin to part of the internal oblique and transversus abdominis muscle. Its medial end is marked by the lacunar ligament of Gimbernat that extends backwards to the pectineal line forming with its crescentic free edge the medial margin of the femoral ring.

The reflected fibres of the external oblique aponeurosis are traced upwards and medially behind the spermatic cord to interdigitate in the linea alba with those of the opposite side.

The intercrural fibres are fibres running at right angles to the limbs near the apex of the superficial inguinal ring preventing them from separating.

The external oblique muscle is depressor of ribs and controlateral rotator of trunk, the simultaneous actions of the two external obliques produce the flexion of the vertebral column.

8. Internal oblique muscle

The internal oblique muscle stands at the internal surface of the external oblique muscle and is attached, by fleshy fibres, to the whole length of the lumbar fascia, to the intermediate area of the anterior two-thirds of the iliac crest and to the lateral two-thirds of the inguinal ligament.

The fibres from the lumbar fascia run upwards along the costal margin, to which they are attached and become aponeurotic at the tip of the ninth costal cartilage, they split around the rectus muscle below the costal margin joining the linea alba.

The anterior layer adheres to the tendinous intersections of rectus abdominis and continues until the pubic insertions of the muscle when the posterior layer ends two centimetres and half below the umbilicus in a curved free margin, concave downwards, the arcuate line of Douglas.

The fibres from the inguinal ligament continue into an aponeurosis that is attached to the crest of the pubic bone and, more laterally, to the pectineal line.

Their lateral margin consists of muscle fibres in front of the spermatic cord continuous with cremaster muscle.

The medial margin consists of tendinous fibres behind the cord fused with a similar arrangement of the transversus aponeurosis to form the conjoint tendon.

The internal oblique muscle is compressor of the abdomen and ipsilateral rotator of trunk; the simultaneous action of the two oblique muscles produces flexion of the vertebral column.

9. Cremaster muscle

The cremaster muscle is the muscular wall of the spermatic cord.

Its lateral head is continuous with the lateral margin of the interal oblique aponeurosis and ends in the anterolateral part of the spermatic cord in men and of the round ligament in women.

Its medial head is attached to the pubis and ends in the posteromedial part of the cremasteric fascia.

10. Transversus abdominis muscle

The transversus abdominis muscle attaches, by fleshy fibres, inside each costal cartilage of the whole costal margin interdigitating with the costal origin of the diaphragm, onto the lumbar fascia lateral to the quadratus lumborum, the internal lip of the anterior two-thirds of the iliac crest, the fascia over iliacus and on the lateral half of the inguinal ligament deep to the internal oblique.

Its head is transverse and flat.

It becomes aponeurotic and fuses with the posterior layer of the internal oblique aponeurosis and fuses laterally downwards with the internal oblique to form the conjoint tendon behind the spermatic cord.

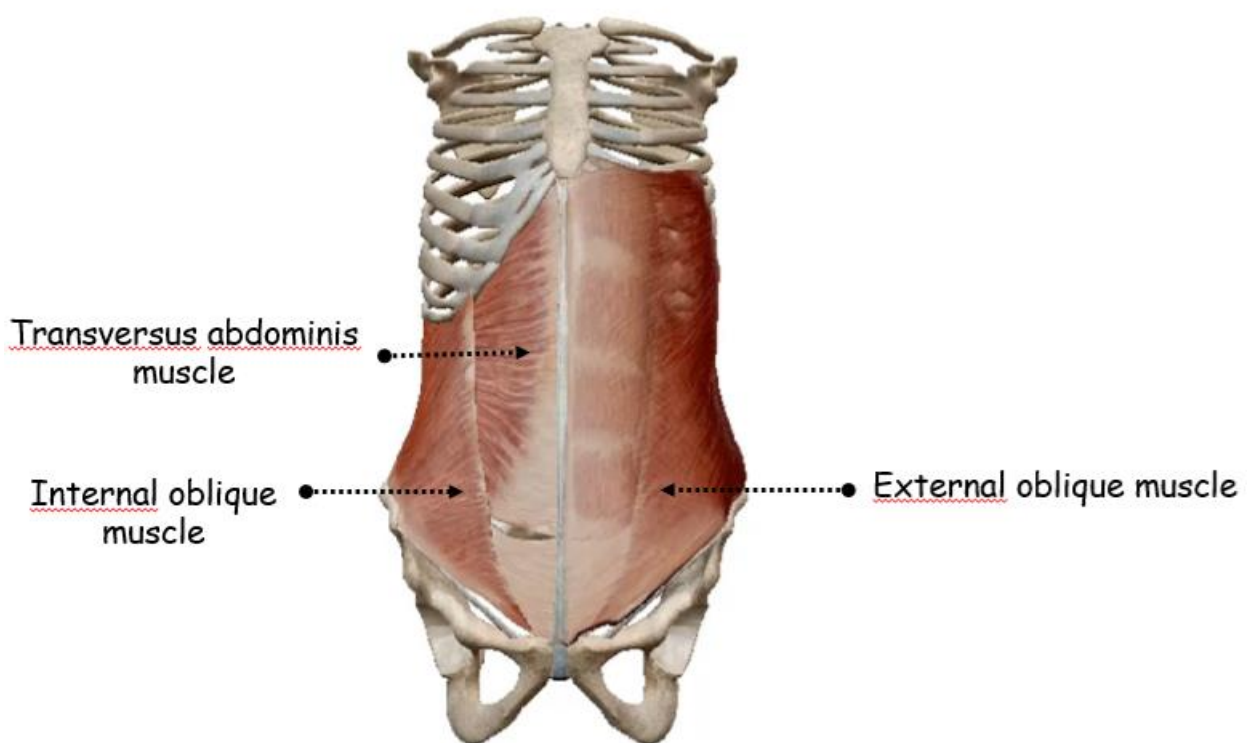The transversus abdominis muscle is compressor of the abdomen.

Figure 5: Anterior view of the skeleton of the trunk showing
the anterolateral abdominal muscles

11. Transversalis fascia

The transversalis fascia is a constant loose and cellular aponeurosis interposed between the posterior layer of rectus sheath forwards and the aponeurosis of transversus abdominis muscle laterally and the parietal peritoneum backwards.

Its lower thickened below the arcuate line of Douglas between the iliac crest and pubis constitutes the iliopubic tract. It continues with the lacunar ligament forming the medial boundary of the femoral ring and has bony and fibrous attachments on the iliac crest, the iliac fascia, the upper border of the inguinal ligament and the pecten of pubis. Upwards, it is prolonged by the diaphragmatic fascia, backwards, it is fixed to the anterior layer of the thoracolumbar fascia.

12. Rectus sheath

The rectus sheath is formed of the aponeurosis of the internal oblique that splits into anterior and posterior layers to enclose the rectus muscle, the external oblique aponeurosis that fuses with the anterior layer to form the anterior layer of the sheath and the transversus aponeurosis that fuses with the posterior layer to form the posterior layer of the sheath.

The posterior layer of the sheath is attached to the costal margin, seventh, eighth and ninth costal cartilages consisting of the transversus and internal oblique layers of the thoracic insertion of rectus abdominis.

The anterior layer of the sheath is attached to the fifth, sixth and seventh cartilages consisting of its external oblique layer.

Below the umbilicus the aponeuroses of internal oblique and transversus fuse completely, whereas that of the external oblique fuses only to the most medial part of the sheath. (Figure 7)

Two centimetres and half below the umbilicus all three aponeuroses pass in front of the muscle. Behind the latter, they end forming a free lower margin, concave and ill-defined, joining the linea alba and the lateral border of rectus muscle, the arcuate line or the semicircular line of Douglas.

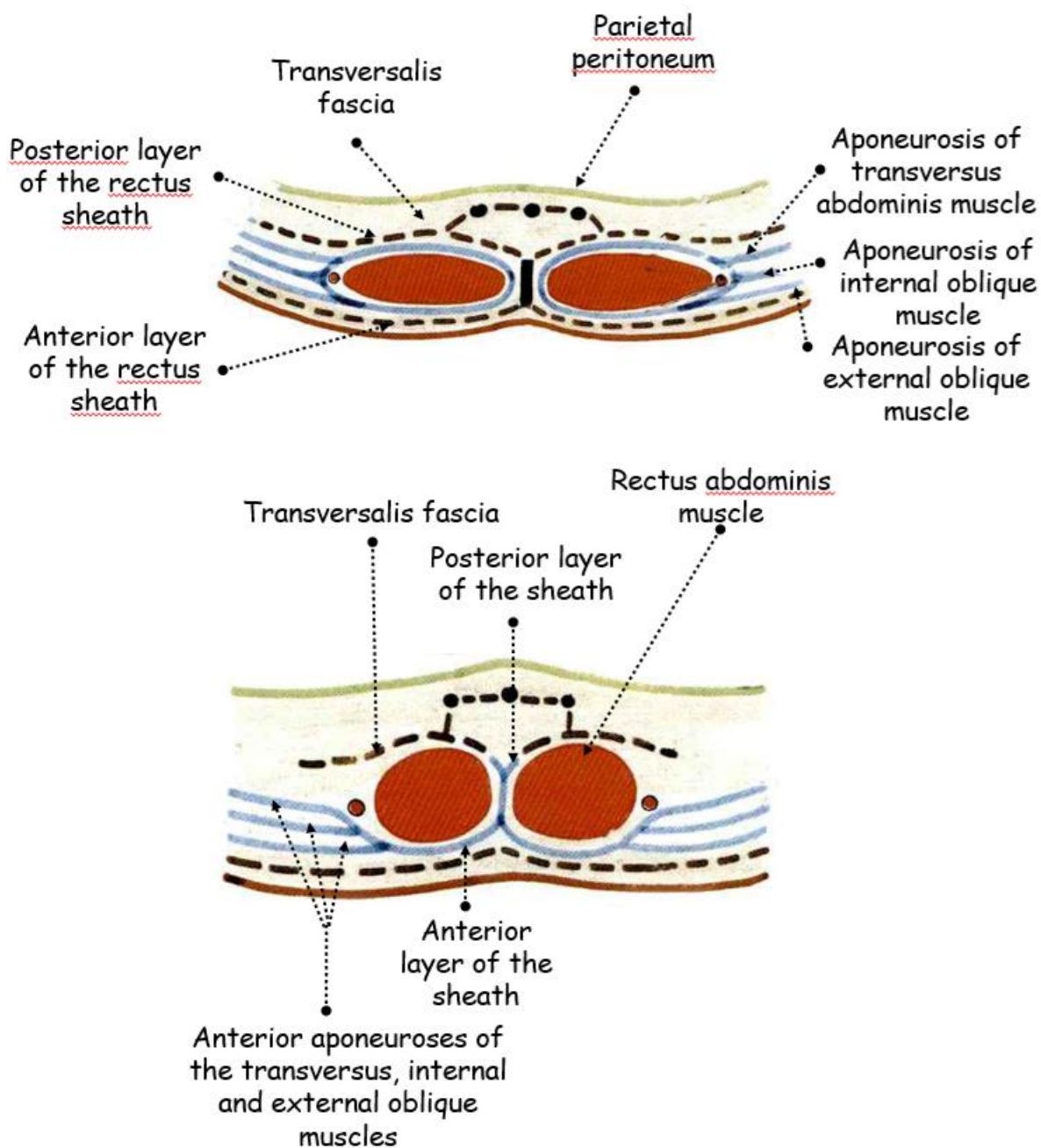It encloses the recti and pyramidalis muscles.

Figure 7: Horizontal section of the anterior abdominal wall above the umbilicus

13. Interfoveolar ligament of Hasselbach

The interfoveolar ligament of Hasselbach is a fibrous band that extends laterally from the semicircular line of Douglas, sloping downwards and laterally and crosses backwards the spermatic cord in men and the round ligament in women towards the deep inguinal ring.

14. Linea alba

The linea alba projects towards the medial border of the recti abdominis muscles and represents the most medial part of the rectus sheath. It is the midline fusion of the aponeuroses of external oblique and internal oblique forwards and transversus abdominis and internal oblique backwards. It forms a median groove at the midline. It extends from the xiphisternum to the pubic tubercle. The deepest fibres of the rectus sheat, also known as adminiculum lineae albae, are larger and triangular in shape fixed to the posterior edge of the pubic crest.

The umbilicus lies at the midway point of this line.

Above the umbilicus, the linea alba is larger three centimetres wide.

Below the umbilicus, it is one centimetre wide, it is where the pyramidalis muscle is inserted and the fundiform ligament of penis in men and clitoris in women are fixed.

The linea alba is a weakness zone of the anterior abdominal wall.

15. Semilunar line

The semilunar line constitutes the splitting point of the internal oblique aponeurosis. It is vertical along the lateral border of the rectus muscle. It has the shape of a shallow, concave inside and bloodless groove that curves up from the pubic tubercle to the costal margin at the tip of the ninth costal cartilage. The semilunar line is not to be confused with the semicircular line, it is a weakness zone of the anterolateral abdominal wall.

16. Umbilicus

The umbilicus is the circular four millimetres wide fibrous scar of the umbilical cord, the fetal-maternal connection. It contains the obliterated orifices of the three umbilical vessels.

The ligamentum teres is the remnant of umbilical vein.

The median umbilical ligament is the remnant of the urachus.

The medial umbilical ligaments, on each side of the median umbilical ligament, are remnants of the umbilical arteries.

The ileal Meckel's diverticulum is the remnant of the villointestinal duct which apex may be adherent to the umbilicus or connected thereto by a fibrous cord.

The umbilicus may have a variable situation. Usually, it is situated towards the aortic bifurcation and L4 vertebra below midway between the xiphisternum and the pubic symphysis. It goes down with age.

The mamelon is the central hump of the umbilicus, it overlies a mass of fatty tissue.

The cicatrix is the fusion of the fibrous structures of the umbilicus with transversalis fascia, umbilical fascia and parietal peritoneum.

The cushion is a slightly raised skin margin which surrounds the mamelon and the cicatrix and contains the umbilical ring continuous with the linea alba. The ligamentum teres is attached to the upper border of the umbilical ring when the medial and median umbilical ligaments and umbilical fascia are attached to its lower border. The parietal peritoneum overlying them forms the umbilical fossa around the ring containing medial and median umbilical folds. The umbilical fascia, half-horn shaped remnant of the sheath of the umbilical arteries, is concave backwards raised by the umbilical arteries and umbilical ligaments, it suspends the anterolateral part of the bladder to the umbilical ring and forms the posterior boundary of the retropubic space. It is, also, attached to the pubovesical ligaments in women and to the puboprostatic ligaments in men downwards.

The furrows are depressions surrounding the mamelon.

Structurally, the umbilicus is lined by a hairless and fatless thin layer of skin.

The umbilicus is an important landmark of the anterior abdominal wall and constitutes a weakness zone.

17. Inguinal canal

The inguinal canal is an oblique columnar intermuscular six centimetres long slit. It lies above the medial half of the inguinal ligament sloping forwards and medially.

It transmits the spermatic cord and the ilioinguinal nerve in the male and the round ligament of the uterus and ilioinguinal nerve in the female. It is a weakness zone of the anterior abdominal wall.

The inguinal canal commences at the deep inguinal ring. The latter lies above the midpoint of the inguinal ligament and is subcutaneous.

Structurally, it is an opening in the transversalis fascia that rounds upwards.

The deep inguinal ring is triangular bounded laterally and upwards by the angle between the transversus muscle fibres and the inguinal ligament and medially by the tansversalis fascia thickened as the sharp interfoveolar ligament containing the inferior epigastric vessels and projected along the canal like a sleeve from the armhole of a coat as the internal spermatic fascia.

Covered with the parietal peritoneum forming the medial umbilical fold raised by the medial umbilical ligament and the lateral umbilical ligament raised by the inferior epigastric vessels, this region contains two fossae delineated by these folds.

The medial inguinal fossa is bounded by the medial and lateral folds when the lateral inguinal fossa is bounded medially by the lateral inguinal fold and laterally by the deep inguinal ring.

The inguinal canal ends at the superficial inguinal ring.

It is a V-shaped opening formed by the fibres of the external oblique aponeurosis running parallel to the inguinal ligament, their lower border, until they diverge from each other. The lateral crus is attached to the pubic tubercle and the medial crus attaches to the pubic crest near the pubic symphysis. The intervening part of the pubic crest receives no attachment from the external oblique aponeurosis and forms the base of the ring. The intercrural fibres run at right angles across the external oblique aponeurosis at the point of junction of the crura, bind the crura together and serve as a visible landmark. As the superficial inguinal ring is rounded by the

intercrural fibres, it is columnar and two centimetres and half deep and one centimetre wide. It is narrow in women and its floor is made of the reflected part of the inguinal ligament.

The anterior wall of the inguinal canal is made up of, from surface to depth, the skin, the superficial epigastric and circumflex iliac vessels, the superficialis fascia continuous with the fascia lata two centimetres and half above the inguinal ligament the lateral crus of the external oblique and the lateral part of the internal oblique and tranversus muscle.

The floor is the formed by the union of the transversalis fascia to the inguinal ligament joining the anterior superior spine and the pubic tubercle. The lacunar ligament fills the angle between the inguinal ligament upwards and the pectineal line downwards at the pubic crest with the abdominal surface of the inguinal canal facing forwards and upwards.

The roof of the inguinal canal is made of the arched lower borders of the internal oblique and transversus abdominis muscles forming the conjoint tendon medially attached to the pectineal line at right angle to the lacunar ligament backwards.

The posterior wall is made of, from inside to outside, the conjoint tendon, the interfoveolar ligament of Hasselbach and the transversalis fascia. The inguinal trigone is an orifice medial to the deep inguinal ring separated by the interfoveolar ligament of Hasselbach and bounded downwards by the inguinal ligament and medially by the lateral border of the rectus abdominis, it is floored by the transversalis fascia and the parietal peritoneum behind towards the medial inguinal fossa.

18. Femoral canal

The femoral canal is a loose dead space medial to the femoral sheath.

It represents the route by which the efferent lymph vessels from the deep inguinal nodes pass to the abdomen through its opening, the femoral ring.

The femoral ring is a wide opening of the abdominal end of the femoral canal with four boundaries. Forwards, the boundary is the medial part of the inguinal ligament, medially, it is the crescentic edge of the lacunar ligament and the iliopubic tract, backwards, it is the pectineal ligament and laterally, the medial border of the femoral vein.

The femoral canal contains the lymph node of Cloquet which in the female drains directly the clitoris and in the male the glans penis.

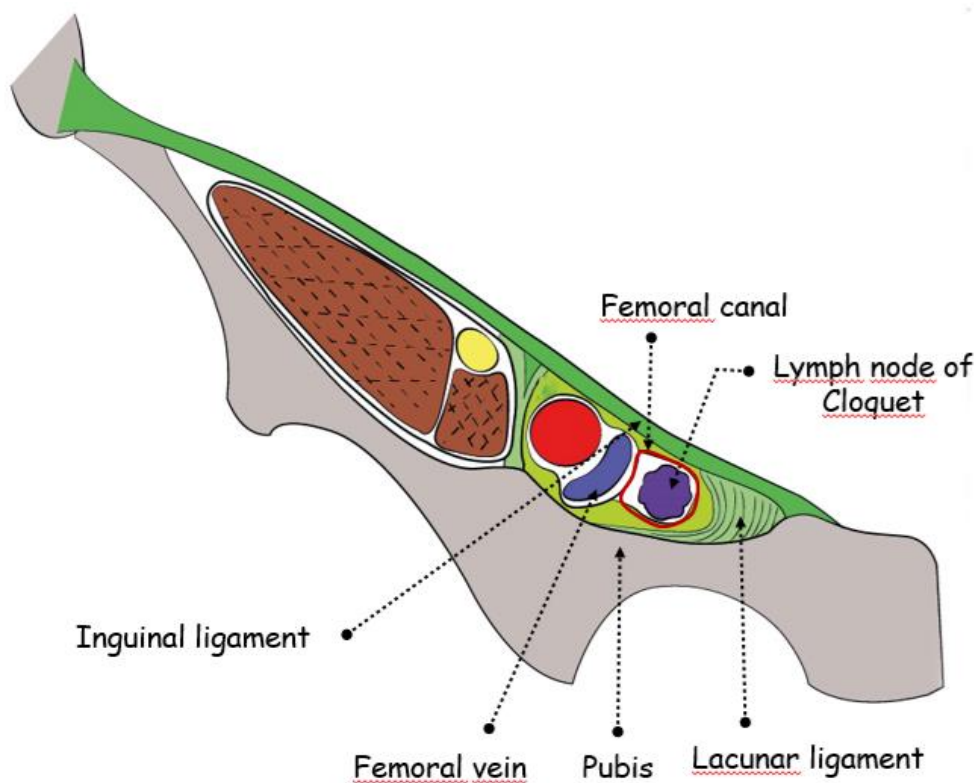The femoral canal is a weakness zone of the anterior abdominal wall.

Figure 8: Anterior view of the femoral ring

B-   POSTERIOR ABDOMINAL WALL

1.   Skeleton of the posterior abdominal wall

The skeleton of the posterior abdominal wall consists of, upwards, the twelfth ribs, backwards, the vertebral column from T12 to L5 vertebrae and, downwards, the margin that lies between posterior superior iliac spines passing by S2 vertebra and the iliac crests on each side towards L4 vertebra.

On the surface, the intertubercular line joins the two iliac crests and passes by the spinous process of L4 vertebra. The vertebral region is marked by the vertebral sulcus corresponding to the spinous processes of the lumbar vertebrae and the longitudinal protrusion of the erector spinae mass.

The lumbar region is continuous on each side with the lateral abdominal wall. The kidneys, upper ureters, pleurae and the spleen on the left project towards it.

2.   Posterior abdominal muscles and aponeuroses

The posterior abdominal muscles and aponeuroses are, namely from surface to depth, the erector spinae mass, the outer layer of posterior thoracic muscles, the proper muscles of the posterior abdominal wall and the crura of the diaphragm.

The lumbar fascia is a three layers fascia containing the proper muscles of the posterior abdominal wall.

The erector spinae mass is the superficial layer of vertebral column muscles. Namely, from inside to outside, the erector spinae mass consists of spinalis muscle, longissimus muscle and iliocostalis muscle.

The outer layer of posterior thoracic muscles consists of, from depth to surface, serratus posterior inferior and latissimus dorsi muscle.

The proper muscles of the posterior abdominal wall are, from back to front, quadratus lumborum muscle, psoas major muscle and iliacus muscle.

3. Skin and subcutaneous tissue

The skin and superficial subcutaneous tissue have variable thickness.

4. Erector spinae mass

The erector spinae mass is the most powerful muscle group of the vertebral column. It commences deep to the lumbar fascia on the back of the sacrum and the inner side of the iliac crest. It consists of large numbers of muscle and tendon bundles forming a thick mass of fibres that diverges upwards and divides into two main bundles, the iliocostalis laterally and longissimus medially.

5. Iliocostalis fibres

The iliocostalis fibres arise from shining tendons into the angles of the lower six ribs, from these attachments new muscle bundles arise and each runs up to be attached to the angle of the six ribs above; from there further fibres run up to reach the transverse processes of the lower four cervical vertebrae.

6. Longissimus fibres

The longissimus fibres are more medial. They are inserted into the gutter between transverse processes and ribs and are replaced by new fibres on the medial side that pass up to the transverse processes of the lower cervical vertebrae; from these insertions new bundles arise and pass upwards into the mastoid process deep to splenius capitis. It overlies the lateral border of semispinalis capitis and is covered over by splenius muscle.

7. Spinalis fibres

The spinalis fibres are the most medial and less important part of erector spinae. They run alongside the spinous processes and are small and often indefinite, usually blending with semispinalis fibres.

8. Action of the erector spinae mass

The action of the erector spinae mass produces extension of the vertebral column and ipsilateral lateral flexion of the vertebral column.

9. Latissimus dorsi muscle

The latissimus dorsi is a flat sheet of muscle covering such a large area of the back covered by the lower triangular part of trapezius.
It is triangular in shape with medial base and lateral apex and has a very wide origin and very narrow insertion.

Its origin commences above at the spine of T7 vertebra and extends downwards along the spinous

processes and supraspinous ligaments of all the lumbar and sacral vertebrae.

The muscle is fleshy in the thoracic portion and aponeurotic in the lumbar and sacral portions

fusing with the posterior layer of the lumbar fascia attached to the central ridge on the posterior

part of the crest of the ilium and posterior third of the outer lip of the iliac crest more laterally.

Its upper border runs horizontally and is covered by the lower triangular part of trapezius and

flows over the inferior angle of the scapula, from which a few fibres arise to join the muscle.

Its lateral border is thicker and more rounded, it runs vertically upwards reinforced by four slips

from the lowest four ribs, whose fibres of origin interdigitate with those of the external oblique

and forms the posterior boundary of the lumbar triangle of Petit.

The muscle converges towards the posterior axillary fold forming its lower border and sweeps

spirally around the lower border of teres major.

Its insertion, by a terminal tendon about two centimetres and half broad, enters the intertubercular

groove of humerus and attaches to its floor.

The latissimus dorsi muscle is medial rotator of the arm, adductor of the upper limb above

 the shoulder and elevator of the pelvis and trunk.

10. Serratus posterior inferior muscle

The serratus posterior inferior arises from the lower two thoracic and the upper two

lumbar spinous processes and from the intervening supraspinous ligaments. It fuses with the

posterior lamella of the lumbar fascia deep to latissimus dorsi. In shape, it is a flat sheet of

muscle, it slopes upwards in contact with the thoracolumbar fascia and is inserted just lateral to the angles of the lowest four ribs.

The serratus posterior inferior muscle is, functionally, a weak muscle of respiration and depressor of lower ribs during expiration.

11. Proper muscles of the posterior abdominal wall

The proper muscles of the posterior abdominal wall are continuous with the anterior abdominal wall through aponeurosis of transversus abdominis. The latter thickens at its upper part forming the lumbocostal triangle, a fibrous band that crosses from the twelfth rib to the tips of the transverse processes of the first and second lumbar vertebrae.

Namely, from back to front, the proper muscles of the posterior abdominal wall are quadratus lumborum towards the transverse processes, psoas major in front of the transverse processes and iliacus muscle in the iliac fossa.

12. Quadratus lumborum muscle

The quadratus lumborum is flat sheet of muscle lying deep in the paravertebral gutter edge to edge with psoas medially and transversus abdominis laterally. It lies in the anterior compartment of the lumbar fascia.

The quadratus lumborum arises from the stout transverse process of L5 vertebra, from the strong iliolumbar ligament and from a short length of the adjoining iliac crest.

It passes upwards to the transverse processes of the upper four lumbar vertebrae and to the inferior border of the medial half of the twelfth rib.

Its lateral border slopes upwards and medially and so crosses the lateral border of iliocostalis.

Its anterior surface is covered by the anterior layer of the lumbar fascia which thickening in front passes from the first lumbar transverse process to the outer end of the twelfth rib constitutes the lateral arcuate ligament.

The quadratus lumborum muscle is depressor of the twelfth rib and abductor of the lumbar spine.

13. Psoas major muscle

The psoas major muscle lies in the gutter between the bodies and transverse processes of the lumbar vertebrae.

It has a continuous vertebral attachment to the discs above the five lumbar vertebrae, the adjoining parts of the bodies of the vertebrae, the fibrous arches that span the concavities of the sides of the upper four vertebral bodies and the lateral ends of the transverse processes of the lumbar vertebrae.

It passes downwards along the pelvic brim and then beneath the inguinal ligament into the thigh, where its tendon is attached to the lesser trochanter of the femur.

Its lateral border is straight but oblique running downwards and somewhat laterally.

Its medial border is slightly curved and just overlaps the pelvic brim.

The psoas fascia is part of the iliac fascia having the same origin as the muscle. It is attached to the iliopubic eminence at the margins of the muscle. It is not part of the lumbar fascia but the lateral edge blends with the anterior layer of that fascia over quadratus lumborum.

The medial arcuate ligament is a thickening of the psoas fascia curving obliquely from the body of L2 vertebra to the transverse process of L1, from which fibres of the diaphragm arise in continuity alongside the crus. The part of the psoas major above this ligament is in the thorax.

The psoas major muscle is lateral flexor of the vertebral column and lateral rotator of the hip.

The simultaneous action of the two psoas major produces flexion of the trunk.

14. Psoas minor muscle

The psoas minor muscle is present in only two out of every three individuals.

It is a slender muscle lying on the surface of psoas major.

It arises from T12 and L1 vertebrae and ends by a long tendon that flattens out to blend with the

psoas fascia behind the inguinal ligament and thus gains a bony attachment at the margin of

psoas major to the arcuate line and iliopubic eminence.

The psoas minor muscle is a weak flexor of the lumbar spine.

15. Iliacus muscle

The iliacus muscle arises from the hollow of the iliac fossa up to the inner lip of the

iliac crest, encroaches across the sacroiliac joint to arise also from the anterior sacroiliac ligament

overlying the ala of the sacrum.

It is triangular and converges medially towards the lateral margin of psoas, passes out of the iliac

fossa beneath the lateral part of the inguinal ligament where it is inserted into the psoas tendon

and the adjacent part of the femur below the lesser trochanter.

The iliacus muscle is flexor of the thigh and lateral rotator of the hip.

The simultaneous action of the two muscles produces the flexion of the trunk.
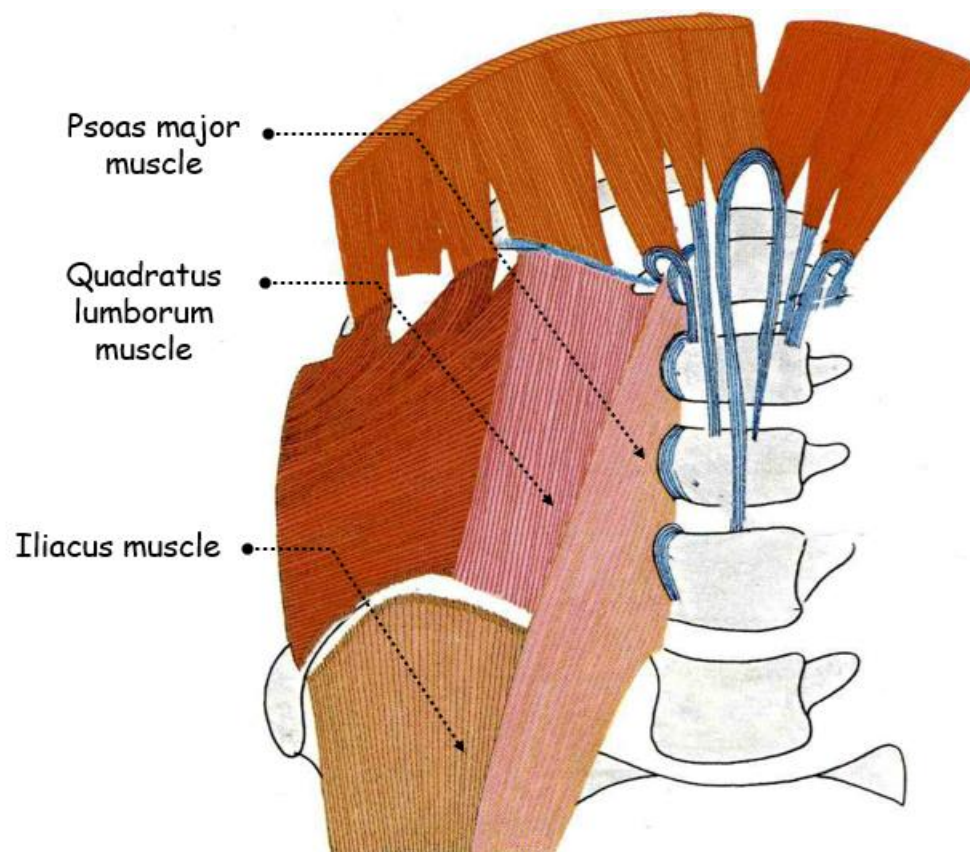
Figure 9: Anterior view of the skeleton of the abdomen
showing the proper muscles of the posterior abdominal wall

16. Iliac fascia

As each muscle of the posterior abdominal wall is covered with a dense and unyielding

fascia, the iliac fascia covers the iliacus muscle. It is strong and is attached to bone at the margins

of the muscle and to the inguinal ligament.

It constitutes the floor to the abdominal cavity and serves for the attachment of parietal

peritoneum.

It prolonges into the femoral sheath.

17. Lumbar fascia

The lumbar fascia is the lumbar part of the thoracolumbar fascia.

It consists of three layers of tough fibrous tissue enclosing two muscular compartments.

The anterior and middle layers occupy only the lumbar region.

The posterior layer extends above this to the lower part of the neck as the thoracic part of the thoracolumbar fascia and below to the dorsal surface of the sacrum.

The anterior compartment is occupied by the quadratus lumborum muscle and is continuous with the transversus abdominis muscle.

The posterior compartment is occupied by the erector spinae mass.

The anterior layer of the lumbar fascia extends from the front of the iliolumbar ligament and adjoining iliac crest to the lower border of the twelfth rib.

Medially, it is attached to the front of each lumbar transverse process near its root adjoining the attachment of the psoas fascia.

Laterally, it blends with the middle layer along the lateral border of quadratus lumborum; here transversus abdominis and internal oblique take origin.

The middle layer extends from the back of the iliolumbar ligament and adjoining iliac crest up to the twelfth rib.

Medially, it is attached to the tips of the lumbar transverse processes.

Laterally, it blends with both anterior and posterior layers.

Their line of fusion stands along the lateral borders of quadratus lumborum and erector spinae sloping in opposite obliquities crossing each other like the limbs of a very narrow X.

The posterior layer of the lumbar fascia lies over the whole erector spinae mass of muscle.

Medially, it is attached to the spinous processes and supraspinous ligaments of all the sacral,

lumbar and thoracic vertebrae.

Laterally, it extends along the transverse tubercles of the sacrum to the ridge on the posterior part of the iliac crest sloping outwards to the twelfth rib being attached across the lumbar region to the middle layer along the lateral border of iliocostalis.

This layer is particularly thick and is reinforced by fusion of the aponeurotic origin of latissimus dorsi. Its thoracic part commences above the twelfth rib.

18. Lumbar triangle of Petit

The lumbar triangle of Petit is floored in by the internal oblique muscle. It has a lower base and upper apex and is bounded by, forwards, the posterior border of external oblique muscle, backwards, the anterior border of latissimus dorsi muscle and, downwards, the iliac crest.

It is crossed by the gluteal rami of iliohypogastric nerve.

The lumbar triangle of Petit is a weakness zone of the posterior abdominal wall.
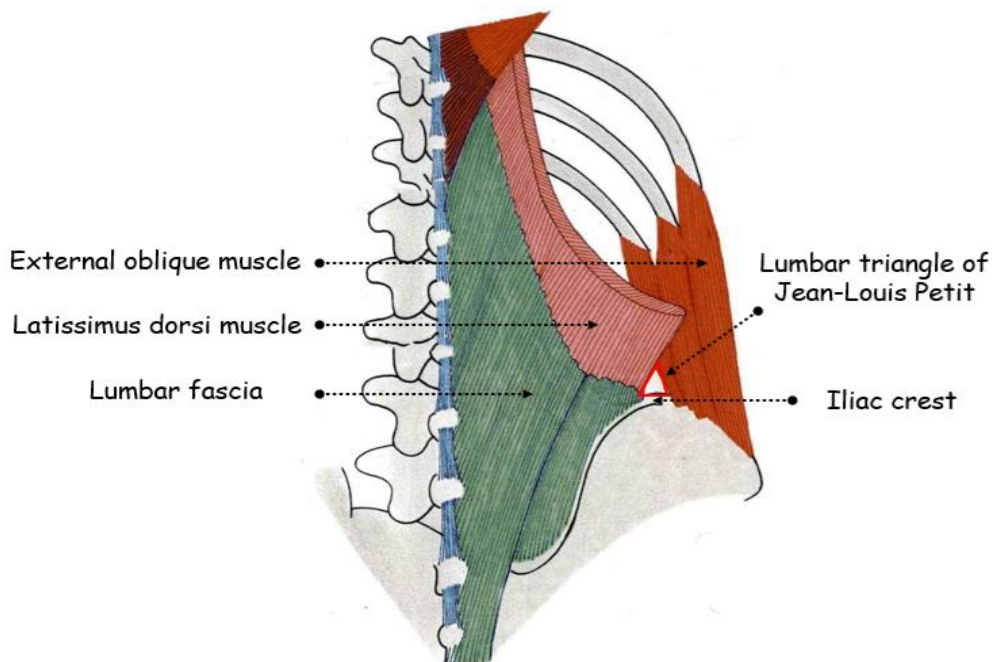

Figure 9: Posterior view of the skeleton of the abdomen showing the lumbar triangle of Petit

The lumbar triangle of Grynfeltt is variable in shape. It is floored by the iliolumbar ligament and aponeurosis of tranversus abdominis muscle and roofed by external oblique and latissimus dorsi muscles.

It is bounded by, medially, the lateral border of quadratus lumborum muscle, upwards, the tip of the twelfth rib and, laterally, the internal oblique muscle.

The lumbar triangle of Grynfeltt is a weakness zone of the posterior abdominal wall and is crossed by the subcostal vessels and nerves.
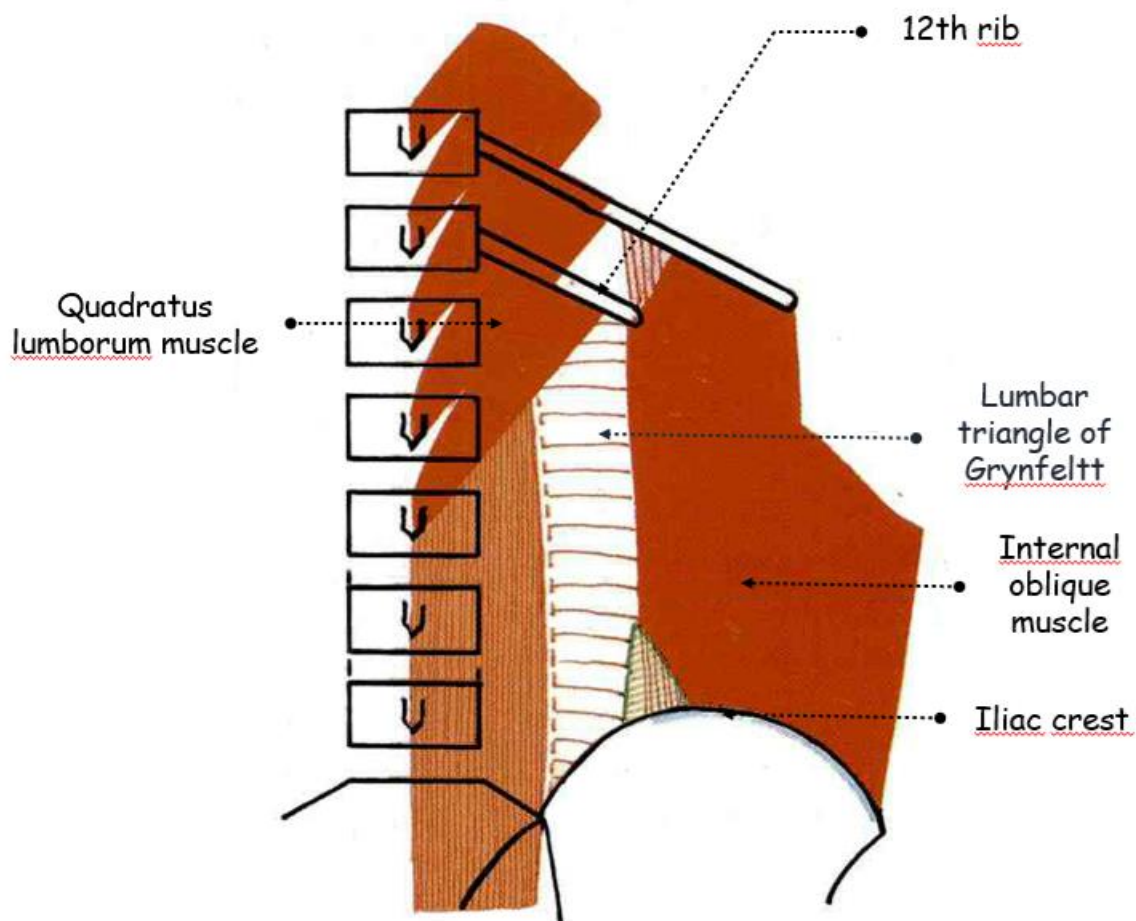

Figure 10: Posterior view of the skeleton of the abdomen showing the lumbar triangle of Grynfeltt

III.   BLOOD SUPPLY; LYMPH DRAINAGE AND NERVE SUPPLY

A- ANTERIOR ABDOMINAL WALL

The arterial supply of the anterior abdominal wall is rich.

The superior epigastric artery is the terminal branch of the internal thoracic artery. It enters the sheath by passing between the sternal and highest costal fibres of the diaphragm.
It supplies the rectus muscle and anastomoses within it with the inferior epigastric artery.

The superficial epigastric artery is the cutaneous branch of the femoral artery. It may pierce the fascia lata or emerge through the saphenous opening. It crosses the inguinal ligament and is distributed towards the umbilicus to the skin and fat of the lower abdominal wall.

The inferior epigastric artery leaves the external iliac at the inguinal ligament, passes upwards behind the conjoint tendon, slips over the semicircular fold and so enters the sheath.

The deep circumflex artery arises from the external iliac behind the inguinal ligament, it runs laterally towards the anterior superior iliac spine in a canal of tissue where the transversalis and iliac fasciae meet. Then, it continues along the inner lip of the iliac crest and anastomoses with a branch of the iliolumbar. At the anterior superior iliac spine, it gives off an ascending branch which enters the neurovascular plane to anastomose with the inferior epigastric.

The seven lower intercostal arteries arise from descending thoracic aorta. Each gives off a small collateral branch which passes around in the neurovascular plane at a lower level than the main trunk.

The lumbar arteries are four in number. They leave the abdominal aorta opposite the bodies of the upper four vertebrae and pass beneath the lumbar sympathetic trunks and the fibrous arches in the psoas. They are overlied on the right side by the inferior vena cava. Each artery gives off posterior and spinal branches. The three upper pass laterally behind quadratus lumborum muscle into the neurovascular plane between transversus abdominis and internal oblique muscles; the fourth passes in front of the lower border of quadratus lumborum, along the upper margin of the iliolumbar ligament.

The veins of the anterior abdominal wall follow the arteries. They flow into the brachiocephalic vein through the internal thoracic vein, the inferior vena cava through lumbar veins, the femoral vein through the superficial epigastric vein, the external iliac vein through inferior epigastric and deep circumflex iliac veins and the the azygos vein on the right and the hemiazygos and accessory hemiazygos on the left through posterior intercostal veins.

The anterior abdominal wall is a site of portosystemic anastomosis between the paraumbilical veins in the ligamentum teres and the inferior epigastric vein.

The lymphatics of the anterior abdominal wall are arranged in quadrants and two levels, superficial and deep.

At the deep level above the umbilicus, they pierce the diaphragm to reach mediastinal nodes. Below the umbilicus, they drain to external iliac and para-aortic nodes.

At the superficial level above the umbilicus on each side, they drain to the pectoral group of axillary nodes.

Below the umbilicus, they drain to the superficial inguinal nodes.

They are, surprinsinly, not draining to intercostal nodes.

The rectus and external oblique muscles are supplied by the lower intercostal and subcostal nerves T7–T12.

The internal oblique and transversus abdominis muscles are supplied by the latters added to ilioinguinal and iliohypogastric nerves.

The pyramidalis muscle is supplied by the subcostal nerve.

The lower intercostal and subcostal nerves T7–T12 pass from their intercostal spaces into the abdominal wall through the neurovascular plane between the internal oblique and transversus abdominis muscles. Then, they enter the rectus sheath by piercing the posterior layer of the internal oblique aponeurosis and proceed behind the rectus muscle to about its midline, pierce the muscle, supply it, and pass through the anterior layer of the sheath to become the anterior cutaneous nerves. The T7 nerve runs upwards just below the costal margin, T8 transversely and the others obliquely downwards.

Before they reach the sheath, the nerves have given off their lateral cutaneous branches, which pierce the internal and external obliques to the skin supplying the external oblique muscle.

The subcostal nerve passes from the thorax behind the lateral arcuate ligament, slopes down below the vein and artery lying parallel to the twelfth rib across the front of the anterior layer of the lumbar fascia, disappears by passing through transversus abdominis to reach the neurovascular plane and slopes down again around the anterior abdominal wall. It supplies the lower part of the anterior abdominal wall muscles and skin. Its lateral cutaneous branch pierces

the oblique muscles and descends over the iliac crest to supply the skin of the anterior part of the buttock.

The iliohypogastric nerve lies in front of quadratus lumborum at a lower level.

It arises from the anterior ramus of L1 dividing from a common stem with ilioinguinal lateral to psoas major muscle and in front of quadratus lumborum behind the anterior layer of the lumbar fascia, it gives a lateral cutaneous branch which sinks below the iliac crest to supply skin of the upper part of the buttock behind the area supplied by the subcostal nerve, then, it slopes downwards in the neurovascular plane and pierces the internal oblique above the anterior superior iliac spine, slopes down again between external and internal obliques and pierces the aponeurosis of the external oblique about two centimetres and half above the superficial inguinal ring and ends by supplying the skin over the lower part of rectus abdominis and the mons pubis.

The ilioinguinal nerve lies in front of quadratus lumborum at a lower level.

It arises from the anterior ramus of L1 dividing from a common stem with iliohypogastric lateral to psoas major muscle and in front of quadratus lumborum behind the anterior layer of the lumbar fascia. It represents the collateral branch of the iliohypogastric and, consequently, has no lateral cutaneous branch. It pierces the fascia and passes laterally to sink into transversus abdominis and run downwards and forwards, above the iliac crest, in the neurovascular plane parallel to and above iliohypogastric. It gives motor branches to those muscle fibres of internal oblique and transversus muscles which are inserted into the free edge of the conjoint tendon before piercing the lower border of internal oblique, runs downwards and medially and so enters the inguinal canal from the side, continuing behind the external oblique aponeurosis. At this point, it pierces

the external spermatic fascia at the superficial inguinal ring to become subcutaneous. It supplies the anterior one-third of the scrotum and the upper and medial part of the groin, down to the anterior axial line.

B- POSTERIOR ABDOMINAL WALL

The arteries of the posterior abdominal wall include the lumbar arteries and the iliolumbar artery.

The veins of the posterior abdominal wall are the lumbar veins, they follow the arteries.

The lymph drainage of the posterior abdominal wall is direct to the thoracic duct.

The nerves of the posterior abdominal nerves are the lumbar nerves. The latissimus dorsi muscle is supplied by some rami of the brachial plexus.

IV. SURGICAL APPROACH

The simplest abdominal incision is the midline incision, above or below the umbilicus, and passing through skin and subcutaneous tissues, the linea alba, transversalis fascia, extraperitoneal fat and peritoneum. No major vessels or nerves are involved, but a few small vessels may cross the midline of the peritoneum. Note that in the lower abdomen the linea alba is very narrow and the two rectus muscles may lie very close together; poor suture technique leads to incisional hernias. In the suprapubic region the bladder must not be damaged.

For laparoscopic surgery, the incision for insertion of the needle to induce pneumoperitoneum is usually made in the midline, just above or below the umbilicus, and the instrument is first directed down towards the pelvic cavity to avoid damaging the aorta. Separate incisions are made for other instruments, often lateral to the rectus sheath but not too low, to avoid the inferior epigastric vessels; transillumination from behind helps to avoid them. Other openings can be made above the umbilicus to the left of the midline to avoid the falciform ligament which lies increasingly towards the right, or in the midclavicular or midaxillary lines nearly level with the umbilicus. Sites below the umbilicus or at the lateral border of the rectus sheath are also used for the insertion of a trocar and cannula for drainage of peritoneal fluid paracentesis or for a peritoneal dialysis catheter.

In a paramedian incision, the anterior wall of the rectus sheath is incised vertically three centimetres from the midline and the rectus muscle either retracted laterally or split so that the posterior wall of the sheath can be incised. The tendinous intersections in the rectus muscle at and above the umbilicus may have to be dissected off the anterior wall of the sheath; they may contain vessels. Above the umbilicus on the right the falciform ligament may have to be divided. If the rectus is split instead of being retracted, the split should not be more than one centimetre from the medial border in order to avoid the intercostal nerves which pierce the muscle near its midline. The small part of the muscle medial to the split will be denervated and devascularized but this does not cause problems. The lack of a posterior wall of the sheath below a point midway between the umbilicus and pubic symphysis implies that sound healing depends on proper closure of the sheath's anterior wall.

An incision similar to the paramedian but near the lateral border of the rectus sheath, pararectal incision, was formerly popular, but has now been abandoned because of damage to the nerves entering the sheath laterally.

The right subcostal Kocher's incision is made three centimetres parallel to and below the right costal margin, from the midline to beyond the lateral border of the rectus sheath. The anterior layer of the sheath with the external oblique and the rectus muscle are divided in the line of the skin incision, with ligation of the superior epigastric vessels and or their branches. The posterior layer of the sheath is then incised, continuing laterally into the internal oblique and transversus and through to the peritoneum. The seventh intercostal nerve follows the costal margin upwards and is usually above the incision line, although the eighth or ninth nerve may have to be cut, with little effect on the rectus muscle. They should be preserved if possible but cutting more than two paralysing more of the rectus should be avoided.

The double Kocher or rooftop incision, combining subcostal incisions on both sides, gives a very wide exposure of the upper abdomen.

The gridiron McBurney's incision is a right lower oblique muscle-splitting incision, long used for appendicectomy. The skin incision is through the junction of the outer and middle thirds of a line drawn from the anterior superior iliac spine to the umbilicus and can be made either parallel to the iliac crest or transversely. The external oblique muscle and its aponeurosis are divided in the line of the muscle fibres and then the internal oblique and transversus are split transversely in the line of their own fibres. The two muscles are close and may appear as one; the transversus becomes aponeurotic at this level and adheres to the transversalis fascia. The

peritoneum can then be incised. The iliohypogastric and ilioinguinal nerves may be seen between the internal oblique and transversus and must not be damaged, to avoid weakening the protective effect that the muscles exert upon the inguinal canal. Extending the incision laterally may cut the deep circumflex iliac artery's ascending branch, which runs upwards above the anterior superior iliac spine between the internal oblique and transversus.

For cosmetic reasons the gridiron incision is often replaced by a more transverse muscle-splitting incision, starting above and medial to the anterior superior iliac spine and extending nearly to the lateral border of the rectus sheath.

Transverse muscle-cutting incisions can be made above or below the umbilicus, cutting one or both rectus sheaths and muscles and extending laterally into the obliques and transversus, or just cutting the more lateral muscles. Intercostal nerves run obliquely through the lower abdominal wall, but more than one is not likely to be cut by these transverse incisions.

The oblique muscle-cutting incision Rutherford Morison's is similar to the gridiron but after incising the external oblique in the line of its fibres the internal oblique and transversus are cut in the same line not in the line of their own fibres.

The lower abdominal transverse incision Pfannenstiel's is commonly used for approach to the pelvic organs. A slightly up-curving skin incision is made three centimetres above the pubic symphysis as far as the lateral borders of the rectus sheaths. The anterior layers of the rectus sheaths are divided in the line of the skin incision and flaps dissected off the muscles both upwards and downwards, including midline tissue and with the pyramidalis muscles included in the lower flap.

The rectus muscles which at this level lie close together are separated, and linea alba is then incised vertically to expose extraperitoneal tissue, followed by incision of the peritoneum, with care to avoid the bladder.

Transverse division of the rectus muscles gives wider exposure, and the incisions can be extended laterally into the flat muscles.

A lumbar incision is used for extraperitoneal approach to the kidney and upper ureter. The incision extends below the twelfth rib from the lateral border of erector spinae towards the anterior superior iliac spine. Latissimus dorsi and external oblique are incised and their cut edges retracted so that the internal oblique and transversus merging with the lumbar fascia can also be incised. The subcostal nerve deep to internal oblique should be preserved but the vessels can be ligated. The transversalis fascia and extraperitoneal fat in the posterior part of the incision are separated to expose the renal fascia. The peritoneal cavity is not entered. Proper identification of the twelfth rib especially when short is essential, to avoid entering the pleural cavity.

V. CONCLUSION

The abdominal cavity is bounded by a very complex wall that for learning facilities is divided into anterolateral and posterior walls. It is the surgical access to peritoneal and retroperitoneal spaces and has a major clinical importance in analysing abdominal pain. Many weakness zones are recognised in the abdominal wall, they are subjects to hernias.