ABDOMINAL CAVITY

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.

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.

The abdominal cavity is much more extensive than the impression gained from examination of the anterior abdominal wall. Much of it lies under cover of the lower ribs, for the domes of the diaphragm arch high above the costal margin. Hidden by the lower ribs are the whole of the liver and spleen, much of the stomach, and the upper poles of the kidneys and both suprarenals. The volume of the thoracic cavity is, correspondingly, much less than examination of the bony thorax would suggest. Furthermore, an appreciable amount of the abdominal cavity projects backwards into the pelvis, just in front of the buttocks. A perforating wound of the buttock can easily involve the pelvic cavity.

The abdominal cavity contains the digestive and urogenital viscera.

The pelvic cavity accommodates not only its own pelvic organs, rectum, uterus and bladder, but also a goodly volume of intestine, sigmoid colon and ileum.

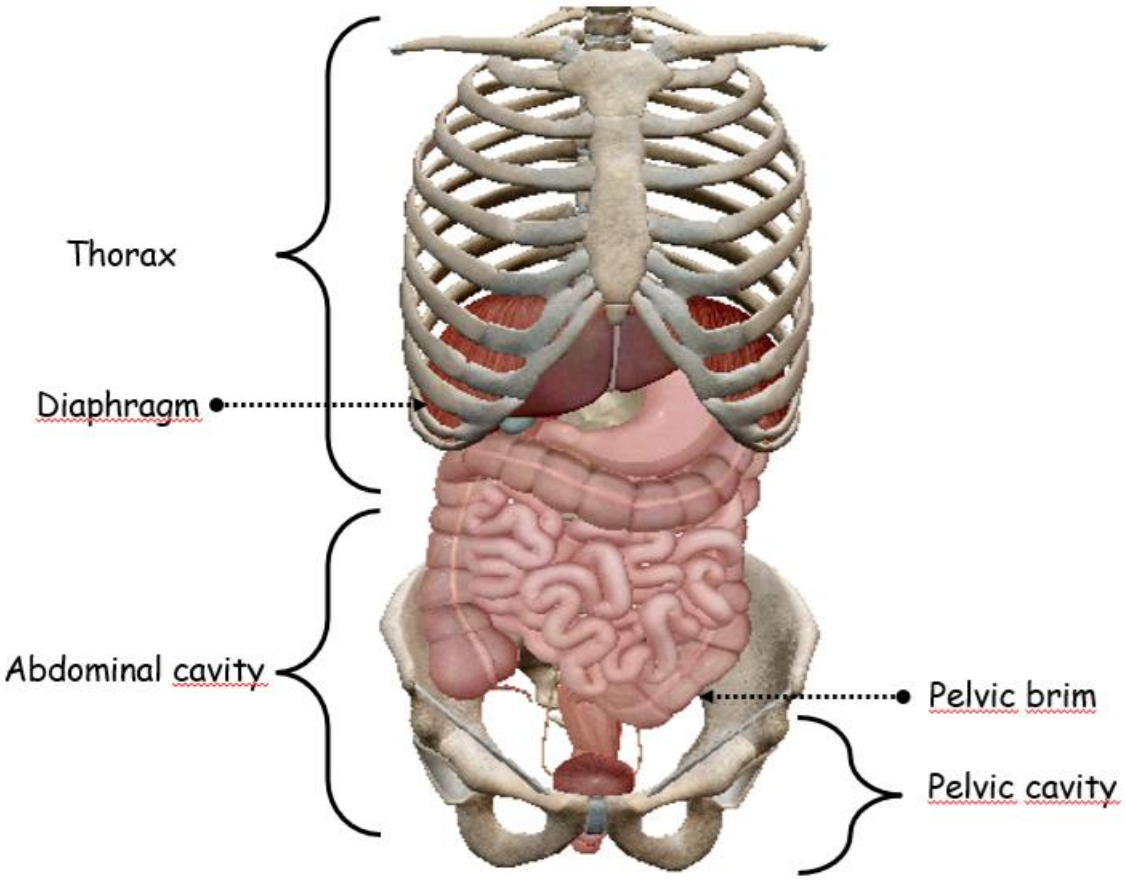

Figure 1: Anterior view of the trunk

II. GENERAL TOPOGRAPHY OF THE ABDOMEN

The alimentary canal and its two chief derivatives, the liver and pancreas and also the spleen, are developed in fetal mesenteries which later alter their disposition as a result of fusion of adjacent leaves of peritoneum. The liver and spleen remain invested in peritoneum, but the pancreas becomes retroperitoneal.

The alimentary canal is invested unevenly. Parts of it are free to swing on peritoneal folds, mesenteries; other parts become plastered down to the posterior abdominal wall. The

stomach is fixed at its two ends but elsewhere swings free on mesenteries. The duodenum is plastered down to the posterior abdominal wall, while the whole length of small intestine swings free on its own mesentery. The ascending and descending colon are both adherent to the posterior abdominal wall, but between the colic flexures the transverse colon is mobile on its own mesentery, the transverse mesocolon. The sigmoid colon swings free on a mesentery while, lastly, the rectum is plastered by peritoneum to the hollow of the sacrum.

The suprarenals, kidneys and ureters lie behind the peritoneum and possess no serous coat. The aorta and inferior vena cava also lie behind the peritoneum. The intestinal vessels run through the mesenteries to reach the gut.

The division of the abdominal cavity into regions by vertical and horizontal planes is useful but gives no aid in understanding abdominal topography. By far the most useful plane is the transpyloric plane, and if the structures lying at this level are appreciated the topography of the rest of the abdominal organs becomes clear. (Figure 2)

The peritoneal cavity is enclosed in men whereas it communicates with the canal of the uterine tube through its abdominal os.

The declining points of the peritoneal cavity vary according to position of the body. Standing up, the declining point is the rectovesical pouch in men and the rectouterine pouch in women. Lying down, they are situated in the pelvis in front of the sacrum, the lesser sac and the paracolic gutters.

The transpyloric plane bisects the body between the jugular notch and the pubic symphysis. But the plane need not be defined with geometrical accuracy and it is sufficient to mark it as passing through a point midway between the xiphisternum and the umbilicus, or about a handsbreadth below the xiphisternal joint. It cuts each costal margin at the tip of the ninth costal cartilage, which is at the lateral border of the rectus abdominis, the semilunar line; beneath this point on the right side, lies the fundus of the gall bladder, on the left is the body of the stomach. The plane passes through the lower border of the first lumbar vertebra, where the spinal cord ends at the conus medullaris.

As its name implies, the plane passes through the pylorus. It must be noted that the pylorus is free on a mesentery, and therefore mobile. In the erect posture it hangs down over the front of the head of the pancreas, so the plane passes along the head, neck and body of that gland, just above the attachment of the transverse mesocolon. The supracolic compartment containing liver, spleen and the fundus of stomach, lies above the plane, the infracolic compartment containing small intestine and colon below it. The superior mesenteric artery leaves the aorta at this level, and the splenic vein runs transversely behind the pancreas in the plane. The hilum of each kidney lies at the plane, the right just below and the left just above it, level with the tips of the ninth costal cartilages.

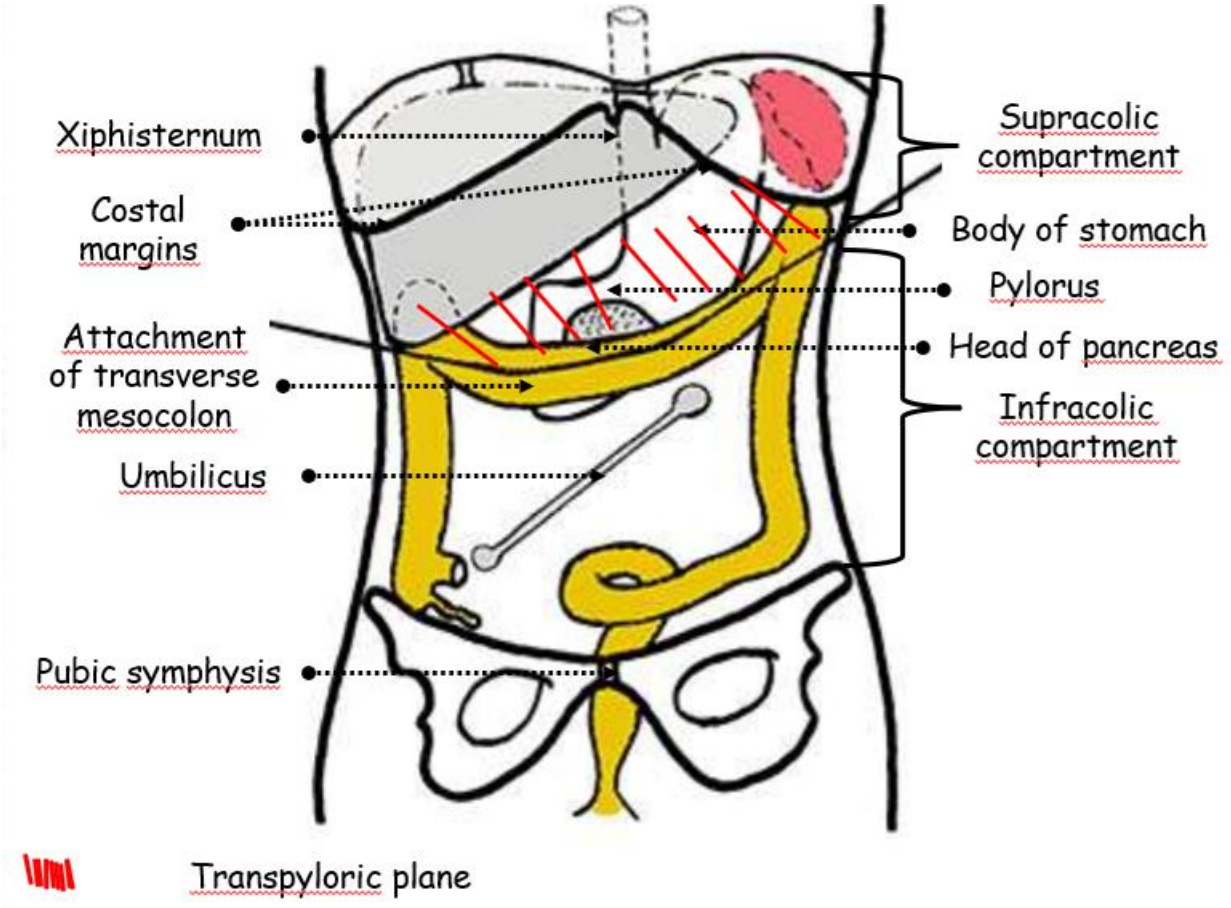

Figure 2: Schematic anterior view of the abdominall cavity showing the transpyloric plane

III. PERITONEUM

The peritoneum is a serous membrane which lines the abdominal cavity; it covers the anterior and posterior walls, the under surface of the diaphragm and the pelvic cavity. All this is the parietal peritoneum. In places it leaves the posterior abdominal wall or diaphragm to form a

partial or complete investment for viscera; this is the visceral peritoneum, which forms the serous covering for many viscera.

Peritoneum consists of a single layer of flattened cells, mesothelium, overlying areolar tissue which varies in both thickness and density in different places. Over expansile parts this areolar tissue is loose and cellular, beneath the transversalis fascia on the lower anterior abdominal wall for instance, while over non-expansile parts it is often very thick, over iliac fascia, psoas fascia or parietal pelvic fascia; but loose or dense, thin or thick, these variously named fasciae are part of the one continuous extraperitoneal connective tissue lying between the parietal peritoneum and the walls of the abdominal and pelvic cavities. On the posterior abdominal wall, the dense psoas and iliac fasciae and the anterior layer of the lumbar fascia serve as firm bases upon which the extraperitoneal tissue can gain attachment. The posterior surfaces of retroperitoneal structures, pancreas, duodenum, ascending and descending colon also gain a firm attachment to these fasciae. Thus, peritoneum and viscera have a firm anchorage undisturbed by the movements of contraction of the underlying muscles.

Various folds or reflexions of peritoneum connect viscera to the abdominal walls or to one another. Some of these are properly called folds, but others may be called a mesentery, omentum or ligament. (Figure 3)

The double fold supporting most of the small intestine is the mesentery; the mesenteries supporting the transverse colon, sigmoid colon and appendix are the transverse mesocolon, sigmoid mesocolon and mesoappendix. The lesser omentum connects the stomach to the liver, and the greater omentum hangs down from the lower border of the stomach. The various

ligaments associated with the liver, stomach and spleen are simply peritoneal folds and bear no relation in structure or strength to the ligaments of muscles and joints; the name as applied to peritoneum is an unfortunate one. A few of these peritoneal structures are easy to see on opening the abdomen through the anterior abdominal wall, the greater omentum and the mesentery for example, but others can only be properly appreciated when viscera are displaced or removed.

A- LIGAMENTS

On the posterior surface of the anterior abdominal wall the peritoneum is raised into six folds, one above and five below the umbilicus. Passing upwards from the umbilicus behind the linea alba towards the xiphisternum is the falciform ligament. It contains in its posterior and slightly crescentic free margin the ligamentum teres, the obliterated remains of the left umbilical vein, which enters the fissure of that name on the visceral surface of the liver. Having delivered the ligamentum to the liver, this double-layered fold continues up and to the right of the midline, between the diaphragm and the anterior and superior surfaces of the liver, where the two layers separate. For the present, note that although the lower part of the ligament is attached to the midline of the abdominal wall, the posterior free margin deviates to the right of the midline while containing the remains of the left umbilical vein.

Below the umbilicus there is a central fold with a pair on either side. Centrally is the median umbilical fold, containing the median umbilical ligament, the obliterated remains of the urachus. On each side, and also running as far as the umbilicus, is the medial umbilical fold, containing the medial umbilical ligament, the obliterated remains of the umbilical artery. Further

laterally is the lateral umbilical fold, containing the inferior epigastric vessels, which enter the rectus sheath by passing beneath the arcuate line; although called umbilical folds, this lateral pair do not reach as far as the umbilicus.

B- SACS

The serous-coated organs fill the abdominal cavity so that visceral surfaces are in contact with one another or with the parietal peritoneum. The space between them is only potential, not actual, and it contains only a few millilitres of tissue fluid which lubricates adjacent surfaces so they can glide over one another. This is the general peritoneal cavity, body cavity or coelom, and is opened up when incisions that include parietal peritoneum are made through the abdominal wall. Another name for it is the greater sac.

The lesser sac, properly called the omental bursa, is a diverticulum of the peritoneal cavity behind the stomach. It exists because of the way the liver, stomach and spleen change their positions and shapes during development, and its purpose is to provide a slippery surface for the necessary mobility of the posterior surface of the stomach. It opens into the greater sac through a slit-like aperture in front of the inferior vena cava, the epiploic foramen.

Theoretically the cavity of the lesser sac should extend down between the layers of the greater omentum, but because of the fusion of layers it rarely extends much below the stomach. The lesser omentum and stomach form the anterior wall of the sac. To the left the sac extends to the hilum of the spleen, where the peritoneum forms the lienorenal and gastrosplenic ligaments, while at its right edge is the epiploic foramen, also described below with the lesser omentum. The

sloping roof of the sac is the peritoneum covering the caudate lobe of the liver, and this is continuous with the peritoneum of the posterior wall which overlies part of the diaphragm, pancreas, left kidney and suprarenal gland. The lowest part of the posterior wall is the transverse mesocolon, attached to the lowest part of the pancreas.

A finger introduced through the epiploic foramen cannot explore the whole of the lesser sac, but some features are palpable. Behind the posterior wall to the left of the inferior vena cava is the aorta, here giving off the coeliac trunk, two of whose branches may be felt. The common hepatic artery curves down to the right behind the peritoneum and then turns up behind the first inch of the duodenum to enter the lesser omentum. It raises the pancreaticoduodenal fold, which can be felt; to the left of the fold the fingertip passes steeply downwards behind the pylorus, as if over a step. The left gastric artery runs up towards the oesophageal opening to enter the lesser omentum; on its way up it raises the palpable pancreaticogastric fold. These two folds together produce a slight hourglass constriction of the sac beyond which the cavity becomes extensive, but the examining finger cannot reach its limits.

Confirm your understanding of the lesser sac by appreciating that it can be entered and more extensively explored by incising the lesser omentum and gastrocolic omentum from the front and the transverse mesocolon from below and the gastrosplenic and lienorenal ligaments from the left.

C- OMENTA

On opening the abdomen from the front, the most obvious peritoneal structure is the greater omentum.

It hangs down like a vascular apron from the greater curvature of the stomach, overlying coils of intestine. It may be translucent or filled with fat, depending on the nutritional state of the individual. It is the most vascular part of the peritoneum and is often called the policeman of the abdomen, since it can move to a site of infection and become adherent to it, bringing to the area protective leucocytes and walling off the inflammatory region.

The greater omentum consists of two closely-applied layers of peritoneum enclosing blood vessels and lymphatics though strictly speaking it is four layers fused together. The posterior inner layer is in the lesser sac, and when traced to the left it reaches the hilum of the spleen. The anterior outer layer is in the greater sac, and when traced to the left it forms the peritoneal investment for the spleen; note that the two layers of peritoneum, one from the lesser sac and one from the greater sac, connecting the stomach and spleen form the gastro splenic ligament, and those between spleen and kidney form the lienorenal ligament. Above the spleen the greater omentum passes from the back of the stomach to the diaphragm above the kidney as the gastrophrenic ligament. These ligaments are all derivatives of the dorsal mesogastrium. The greater omentum thus has a continuous curved attachment from abdominal oesophagus to duodenum, along the greater curvature of stomach.

The part of the greater omentum immediately below the stomach overlies and fuses with the transverse mesocolon and transverse colon, and can be called the gastrocolic omentum,

but it is not a separate structure, merely the name given to this upper part of the greater omentum.

The two layers of peritoneum that extend between the liver and the upper border of the lesser curvature of stomach constitute the lesser omentum, sometimes called the gastrohepatic omentum. It can usually only be seen when the liver is lifted up, away from the stomach. Its attachment to the stomach extends from the right side of the abdominal oesophagus and along the lesser curvature to the first inch of the duodenum. The liver attachment is L-shaped, to the fissure for the ligamentum venosum and the porta hepatis. Between the duodenum and the liver it has a right free margin, where the peritoneum of the greater and lesser sacs becomes continuous. Within this fold are the portal vein at the back, with the hepatic artery in front and to the left of the vein and the bile duct to the front and right of the vein. It is here that the portal vein forms the anterior boundary of the epiploic foramen.

Traced downwards over the stomach, the two layers of the lesser omentum become greater omentum. Traced upwards, the two layers enclose the liver and then spread on to the diaphragm and posterior abdominal wall, where they are no longer called lesser omentum but form the coronary, triangular and falciform ligaments.

The epiploic foramen of Winslow or the aditus to the lesser sac is a vertical slit about two centimetres and half high, like the opening for a coin in a slot machine and can be slightly stretched to admit the tips of two fingers. Its upper boundary is the caudate process of the liver. The lower boundary is the ascending part of the duodenum; this can only be understood if it

is appreciated that this part of the duodenum runs not only towards the right but backwards as well. The posterior boundary is the inferior vena cava, here covered by the parietal peritoneum of the posterior abdominal wall which, continuing to the left through the foramen, becomes the peritoneum of the posterior wall of the lesser sac. Anteriorly the foramen is bounded by the right free margin of the lesser omentum; since the portal vein is the most posterior of these three structures, the foramen can conveniently be remembered as lying between the two great veins of the abdomen—portal and inferior vena cava.

D- COMPARTMENTS

By virtue of its attachments to the posterior abdominal wall and to various viscera, the peritoneal cavity is descriptively divided into compartments called supracolic, infracolic and pelvic. The supracolic compartment is subdivided into four, right upper and lower and left upper and lower, while the infracolic compartment has two parts, right upper and left lower.

The dividing line between the supracolic and infracolic compartments is the transpyloric plane. When an opened but otherwise undisturbed abdomen is examined, the root of the transverse mesocolon is not immediately visible. The most obvious feature in the upper abdomen is the stomach, and below it lying over coils of intestine is the greater omentum. A short distance below this curvature, the transverse colon and transverse mesocolon are adherent to the posterior surface of the greater omentum. Lift the greater omentum up over the costal margin; the stomach, transverse colon and mesocolon will be lifted upwards with it, and the posterior surface

of the mesocolon will be brought into view. By displacing coils of small intestine downwards, the attachment of the mesocolon can now be seen.

1. Supracolic compartment

The subdivisions of the supracolic compartment are defined by the attachments of the liver to the diaphragm and abdominal wall. Place the fingers of one hand above the liver to the right of the falciform ligament and push backwards. Your fingers are prevented from going further by the upper layer of the coronary ligament; your fingers are in the right subphrenic compartment. Remove the hand and place the fingers under the right side of the liver and in front of the right kidney. Your fingers are prevented from going further by the lower layer of the coronary ligament; your fingers are in the right subhepatic compartment, better known as the hepatorenal pouch of Morison. Remove the hand and now place it above the liver to the left of the falciform ligament and push backwards. Your fingers are prevented from going further by the left triangular ligament and are in the left subphrenic compartment. The fourth subdivision of the supracolic compartment is the left subhepatic compartment, a term not often used, because it is in fact the lesser sac.

When lying supine, the hepatorenal pouch is the lowest part of the peritoneal cavity with the sole exception of the pelvis and hence is an area where intraperitoneal fluid is likely to accumulate.

2. Infracolic compartment

The infracolic compartment, below the level of the transverse mesocolon, is relatively easy to examine, by lifting up the stomach and greater omentum together with the

adherent transverse mesocolon and transverse colon. The whole compartment is divided into two by the attachment of the root of the mesentery, which passes down from left to right at an angle of about 45°. It begins on the left at the duodenojejunal junction, crosses the third part of the duodenum where the superior mesenteric vessels enter between its two layers, and then continues downwards across the aorta, inferior vena cava, right psoas muscle and ureter to the right iliac fossa. This attachment is 15 centimetres long, although the intestinal border of the mesentery is greatly folded, like the hem of a very full skirt, to accommodate something like 3.5 metres of small intestine. The depth of the mesentery is about 15 centimetres.

In the retroperitoneal tissue in the region of the root of the mesentery there are numerous Pacinian corpuscles. It is well established that tension and traction on peritoneal folds in the upper abdomen produce a fall of blood pressure by undue stimulation of these encapsulated mechanoreceptors. In normal circumstances they may serve a protective function by causing reflex contraction of the abdominal wall to aid support of the heavy viscera of the upper abdomen when jarring movements tend to displace the viscera and produce undue traction on their peritoneal attachments.

If the greater omentum is lifted up and coils of small intestine pressed downwards and to the left, a triangular area of peritoneum of the posterior abdominal wall is exposed, above and to the right of the root of the mesentery. This is the upper right infracolic compartment. Its apex lies below, at the ileocaecal junction. Its right side is the ascending colon, its left side the attachment of the mesentery of the small intestine, and its base is the attachment of the transverse mesocolon. Examine the floor of the triangle, at the right end, the lower pole of the

right kidney can be seen and felt, crossed by the ascending branch of the right colic vessels. Just to the left of this the descending part of the duodenum appears, passes downwards for seven centimetres and half and turns transversely across the posterior abdominal wall for ten centimetres as the horizontal part and ends by passing upwards to the duodenojejunal flexure, at which point the gut breaks free from under the peritoneum of the posterior abdominal wall and, as the jejunum, gains a mesentery. The duodenojejunal flexure, one of the angles of the left infracolic compartment, lies to the left of the midline, over the left psoas muscle, on a level with L2 vertebra. Note that to descend from the right infracolic compartment into the pelvis it is necessary to pass forwards over the lower ileum, and contrast this with the free passage into the pelvis on the left side.

Lateral to the ascending colon is the right paracolic gutter. It can be traced upwards into the hepatorenal pouch, and downwards into the pelvis, easy pathways for the gravitation of fluid.

The lower left infracolic compartment is exposed by displacing the coils of small intestine upwards and to the right. It is larger than the right infracolic compartment and is quadrilateral in shape. It widens below to pass in a smooth sweep across the pelvic brim into the cavity of the pelvis. Its upper border is the attachment of the transverse mesocolon, between the duodenojejunal flexure to the left of the midline and the left colic flexure.

The fourth ascending part of the duodenum lies in this compartment, in the upper angle to the left of the mesentery of the small intestine and it runs up to the

commencement of the jejunum. The paraduodenal fossae lie here. At the lateral end of the upper border, the inferior pole of the left kidney can be seen and felt, in the angle between the transverse mesocolon and the splenic flexure. It is crossed by the ascending branch of the upper left colic vessels. The right border of the left infracolic compartment is provided by the attachment of the mesentery which slopes down to the right iliac fossa. The floor is shallowest in the midline, for the forward prominence of the lumbar vertebrae is here enhanced by the overlying aorta and inferior vena cava. Over the promontory of the sacrum the peritoneal floor dips down in a bold sweep to line the pelvic cavity.

Lateral to the descending colon is the left paracolic gutter. It is limited above by a small transverse fold of peritoneum between the left flexure of the colon and the diaphragm, the phrenicocolic ligament. Unless it has been removed by surgery, this helps to prevent the upward spread of infection to the left subphrenic region. Traced downwards the gutter leads to the left of the left edge of the attachment of the sigmoid mesocolon and into the pelvis.

At the lower end of the left infracolic compartment is the attachment of the sigmoid mesocolon. It is A-shaped and the two limbs diverge from each other at the bifurcation of the common iliac vessels, which point lies on the pelvic brim over the left sacroiliac joint. The lateral limb passes forwards along the pelvic brim over the external iliac vessels halfway to the inguinal ligament while the medial limb slopes down into the hollow of the sacrum, where it reaches the midline in front of S3 vertebra, at the commencement of the rectum. At the apex of the junction of these two leaves, just beneath the peritoneum and lying over the bifurcation of the

common iliac artery, lies the left ureter, thus the apex is an important landmark for identifying the position of the ureter. Throw the sigmoid colon upwards to expose this point.

E- NERVE SUPPLY

The parietal peritoneum is supplied segmentally by the spinal nerves that innervate the overlying muscles. Thus, the diaphragmatic peritoneum is supplied centrally by the phrenic nerve (C4), hence referred pain and hyperaesthesia from this area to the tip of the shoulder, and peripherally by intercostal nerves. The remainder of the parietal peritoneum is supplied segmentally by intercostal and lumbar nerves. In the pelvis the obturator nerve is the chief source of supply. The visceral peritoneum has no afferent supply as far as is known; pain from diseased viscera is due to muscle spasm, tension on mesenteric folds or involvement of the parietal peritoneum.

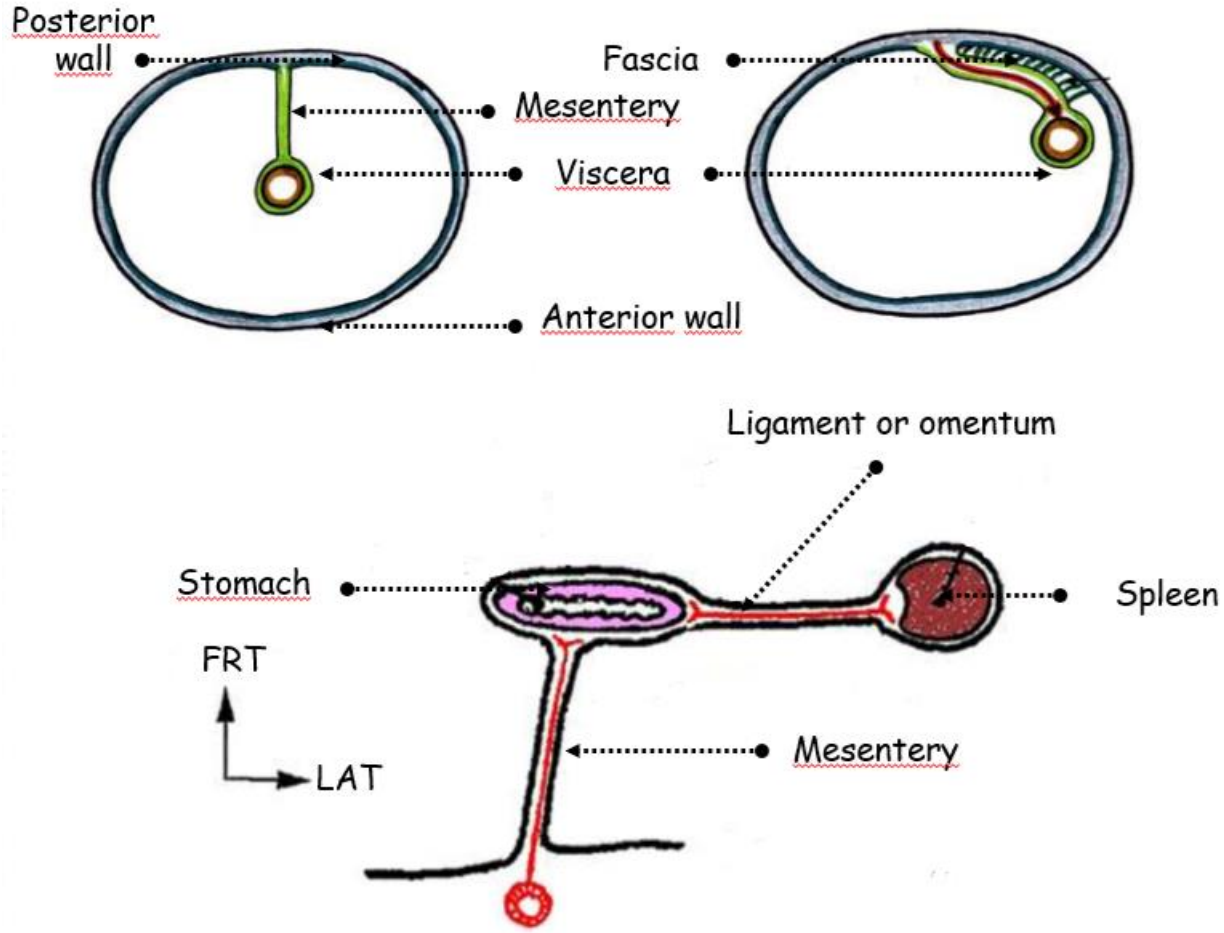

Figure 3: Schematic horizontal sections of the abdominal cavity showing peritoneal folds

IV. RETROPERITONEAL SPACE

Some major structures lie on the posterior abdominal wall behind the peritoneum. These include the aorta and inferior vena cava with a number of their branches and tributaries; the cisterna chyli, lymph nodes and vessels; nerves, mostly branches of the lumbar plexus, including the sympathetic trunks; the kidneys, ureters, pancreas, and most of the duodenum and suprarenal glands. All these can be said to lie in the retroperitoneal space, though the term is often used to

apply only to the area of the posterior abdominal wall behind the peritoneum that is not occupied by the major viscera and great vessels, over parts of psoas and other muscles for instance. It is important because haemorrhage and infection may develop in it and be trapped.

V. PELVIC PERITONEUM

The pelvic peritoneum is draped over the pelvic viscera and invests them in part with a serous coat. Between the viscera it hangs in dependent folds or pouches. These differ somewhat in the two sexes. As elsewhere, the visceral layer has no nerve supply. The parietal peritoneum, on the pelvic walls, is supplied by the obturator nerve.

A- IN THE MALE

From the margin of the pelvic brim the peritoneum descends across the pelvic walls to line the cavity, but nowhere does it descend far enough to reach the pelvic floor. (Figure 4)

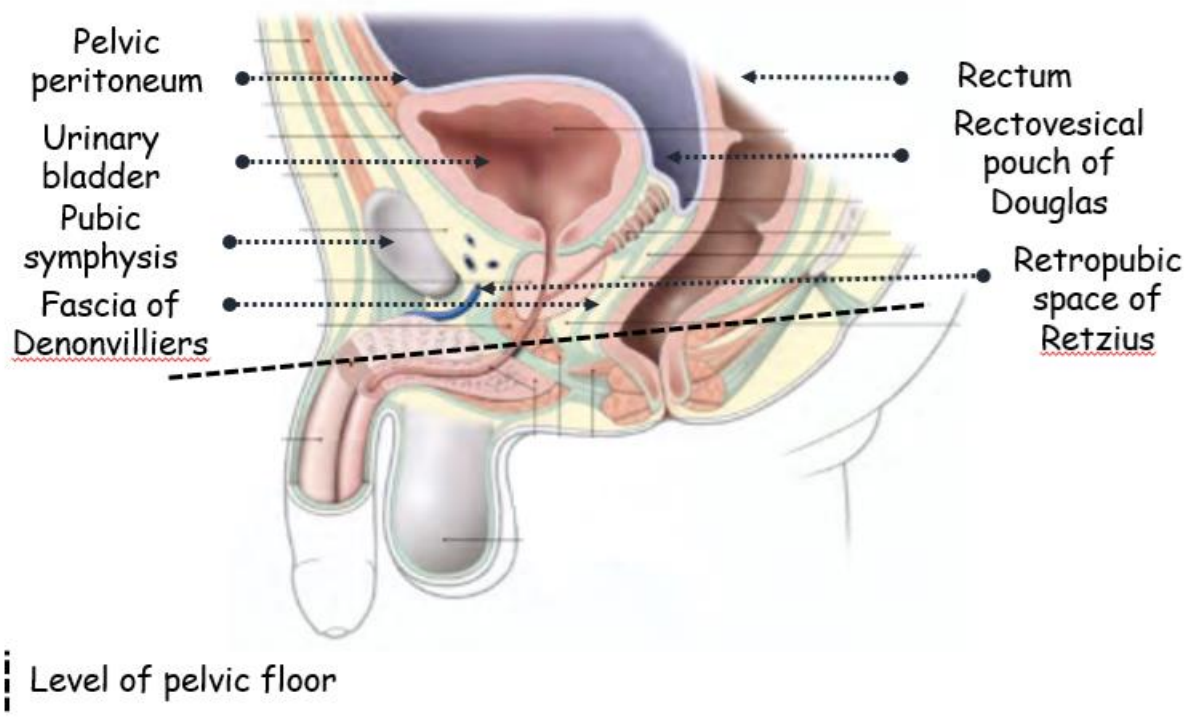

Figure 4: Sagittal section of the male pelvic cavity showing the pelvic peritoneum (from KAMINA)

Anteriorly in the midline it descends but little below the upper margin of the pubic symphysis, and then only when the bladder is empty. It passes from the lower part of the anterior abdominal wall and is reflected in a shallow fold to the upper surface of the bladder, where it is densely adherent. The fold roofs in the retropubic space of Retzius. If the bladder rises in distension above the symphysis this fold of peritoneum is stripped upwards from the anterior abdominal wall. A trocar can then be introduced through the anterior abdominal wall into the bladder below the fold; in this way extraperitoneal drainage of the bladder may be carried out as a relief measure in cases of urethral obstruction. From the back of the bladder the peritoneum descends in a fold before ascending over the rectum and the hollow of the sacrum. This fold is the rectovesical pouch. The retroperitoneal tissue, stretching from the depth of the pouch to the perineal body and passing

between the bladder and prostate in front and the rectum behind, is the rectovesical fascia of Denonvilliers.

The midline visceral peritoneum, including its folds, passes laterally in a continuous sheet to the side wall of the pelvis and becomes continuous with the parietal peritoneum of the abdominal cavity at the pelvic brim.

The pelvic peritoneal cavity is occupied by coils of the sigmoid colon and the lower part of the ileum, which lie in front of the rectum and above the bladder.

B- IN THE FEMALE

The arrangement of the peritoneum is similar to that in the male, the only difference being the presence of the uterus and the broad ligaments. From the back of the bladder the peritoneum ascends over the front of the uterus, making the vesicouterine pouch between the two viscera. The visceral peritoneum of the uterus is firmly attached to the back of that organ and to the posterior fornix of the vagina, whence it is reflected up over the rectum and sacrum. This deep pouch of peritoneum is the rectouterine pouch of Douglas. It is opened by incision through the posterior fornix, and this method is employed in draining an intraperitoneal pelvic abscess in the female.

Each side of the uterus is attached to the side wall of the pelvis by the broad ligament, which extends down towards the pelvic floor.

VI. PELVIC CAVITY

A- BONY PELVIS

When articulated the bones enclose a cavity; from the brim of the cavity the ala of each ilium projects up to form the iliac fossa, part of the posterior abdominal wall. The pelvic brim is formed in continuity by the pubic crest, pectineal line of the pubis, arcuate line of the ilium, and the ala and promontory of the sacrum. The plane of the brim is oblique, lying at 60° with the horizontal; the vagina is in the same plane. From the brim the pelvic cavity projects back to the buttocks.

Sex differences are striking and easily recognized; they are due to the two facts that the female pelvis is broader than that of the male for easier passage of the fetal head and that the female bones, including the head of the femur, are more slender than those of the male. In the male pelvis the sturdy bones make an acute subpubic angle, pointed like a Gothic arch, while in the female the slender bones make a wide subpubic angle, rounded like a Roman arch. The outline of the pelvic brim differs. In the male the sacral promontory indents the outline, and the brim is widest towards the back, a heart-shaped outline while in the female there is less indentation of the outline by the sacral promontory and the brim is widest further forwards, a transversely oval outline.

Hold an articulated pelvis in the position it occupies in the erect individual, and note the degree of tilting of the hip bone and sacrum. The anterior superior iliac spines and the upper margin of the symphysis pubis lie in the same vertical plane. Note an important horizontal plane,

the upper border of the symphysis pubis, the spine of the ischium, the tip of the coccyx, the head of the femur and the apex of the greater trochanter lie in the one plane. This plane passes through the pelvic cavity at a level with the tip of the finger of the clinician during rectal or vaginal examination. The ovaries in the female and the seminal vesicles in the male lie in this plane.

B- PELVIC WALLS

The word pelvis is Latin for a basin and, when properly tilted forwards into the anatomical position, the bony pelvis does bear some resemblance to a pudding basin but with much of the front wall missing. The deficiency is made good by the lower part of the anterior abdominal wall where the aponeuroses of all three anterolateral muscles lie in front of rectus abdominis.

The pelvic brim divides the false pelvis above the brim, part of the general abdominal cavity, from the true pelvis or pelvic cavity below.

The muscles of the pelvis are denned as obturator internus and piriformis which are also classified as lower limb muscles and levator ani and coccygeus, which, with their fellows of the opposite side, constitute the pelvic floor or pelvic diaphragm.

The side wall of the pelvis is formed by the hip bone, clad with obturator internus and its fascia. The curved posterior wall is formed by the sacrum with piriformis passing laterally into the greater sciatic foramen.

Piriformis arises from the middle three pieces of its own half of the sacrum and the adjoining lateral mass. The origin extends medially between the anterior sacral foramina, so that

the emerging sacral nerves and sacral plexus lie on the muscle. It runs transversely to the greater sciatic foramen. The pelvic surface of the muscle and the sacral plexus are covered by a strong membrane of pelvic fascia attached to the sacral periosteum at the margin of the muscle; elsewhere the sacrum presents bare bone.

The large obturator foramen contains in life a felted mass of fibrous tissue, the obturator membrane, with a gap above that converts the obturator notch into a canal for the obturator nerve and vessels. The muscle arises from the whole membrane and from the bony margins of the foramen. The origin extends posteriorly as high as the pelvic brim and across the flat surface of the ischium to the margin of the greater sciatic notch. On the ischial tuberosity the origin extends down to the falciform ridge. From this wide origin the muscle fibres converge fan-wise towards the lesser sciatic notch. Above the notch is a curved bare area of bone, with a large bursa lying on it beneath the muscle. Tendinous fibres develop on the muscle surface where it bears on the lesser sciatic notch and the bone often shows low ridges and grooves where the tendon takes a right-angled turn to pass into the buttock.

Note the extent of the upper margin of the muscle. From the pelvic brim at the sacroiliac joint the line slopes downwards along the side wall of the pelvis until anteriorly it lies below the obturator canal. Above this line lies bare bone; below it the muscle is covered with a strong membrane, the obturator fascia. This is attached to bone at the margins of the muscle down to the falciform edge of the sacrotuberous ligament on the ischial tuberosity. The white line for origin of levator ani slopes across the obturator internus fascia, the pelvic cavity is above this line, the ischioanal fossa below it. The posterior surface of the body of the pubis and of the pubic

symphysis is bare of both muscle and fascia. Do not confuse the obturator membrane in the foramen with the obturator fascia on the internal surface of the muscle.

C- PELVIC FLOOR

The pelvic floor consists of a gutter-shaped sheet of muscle, the pelvic diaphragm, slung around the midline body effluents, urethra and anal canal and, in the female, the vagina.

The muscles of the pelvic floor are called coccygeus and levator ani, but it is better to regard them as one morphological entity, ischiococcygeus, iliococcygeus and pubococcygeus from behind forwards. (Figure 5)

They arise in continuity from the spine of the ischium, from the white line over the obturator fascia, and from the body of the pubis, and are inserted into the coccyx and the anococcygeal ligament, a fibromuscular band, the deepest part of which can be called the anococcygeal raphe, being formed by interdigitating fibres of levator ani. From their origin the muscle fibres slope downwards and backwards to the midline; the pelvic floor so produced is a gutter that slopes downwards and forwards. Appreciation of this point clarifies the whole of obstetrical mechanics; the lowest part of the fetus is the first to meet this sloping gutter and during delivery is mechanically rotated to the front.

1. Coccygeus muscle

The human coccygeus is best thought of as ischiococcygeus. In the tailed animals this muscle is the agitator caudae. Man has no tail to wag and the muscle is degenerating. Its gluteal

surface is, indeed, not muscle, but fibrous tissue, and is none other than the sacrospinous ligament. It arises from the tip of the ischial spine, alongside the posterior margin of obturator internus. Its fibres fan out to be inserted into the side of the coccyx and the lowest piece of the sacrum; it lies edge to edge with the lower border of piriformis and is supplied by perineal branches of S4 and S5.

2. Levator ani muscle

Levator ani consists of two parts, iliococcygeus and pubococcygeus. Their fibres arise in continuity, from the ischial spine to the body of the pubis, across the obturator fascia. Here is a thickening, the white line or arcus tendineus. It is densely adherent to the obturator fascia and is usually described as a thickening thereof. This is not really correct; it is the property of levator ani, not of the obturator fascia.

The iliococcygeus part arises from the posterior half of the white line and the pelvic surface of the ischial spine and crossing the pelvic surface of coccygeus its fibres are inserted into the side of the coccyx and the anococcygeal ligament and raphe. This extends from the tip of the coccyx to the junction of rectum and anal canal. During defaecation, and especially during the second stage of labour, it is passively stretched.

Note that the iliococcygeus does not arise from the ilium; its name derives from its former origin on the iliac bone at the pelvic brim.

The pubococcygeus part is that part of levator ani which arises from the anterior half of the white line and from the posterior surface of the body of the pubis on a level with the lower

border of the pubic symphysis. There is often a triangular gap between the adjacent borders of this muscle and iliococcygeus. The pubococcygeus forms a flat muscle whose fibres are in different functional sets. The bulk of its posterior fibres, those arising from the white line, sweep backwards in a flat sheet on the pelvic surface of the iliococcygeus and are inserted into the tip of the coccyx and the anococcygeal ligament and raphe. These constitute the pubococcygeus muscle proper. Fibres arising more anteriorly, from the periosteum of the body of the pubis, swing more medially and more inferiorly around the anorectal junction and join with fibres of the opposite side and with the posterior fibres of the deep part of the external anal sphincter. No raphe exists here, and the muscles form a U-shaped sling which holds the anorectal junction angled forwards; this part of the muscle is called puborectalis. More medially still, a U-shaped sling of fibres passes behind the prostate into the perineal body; this part is named levator prostatae. In the female a similar muscular sling passes behind the vagina into the perineal body, as pubovaginalis. The most medial fibres are adjacent to the urethra and can exert some sphincteric action. The puboprostatic and pubovaginal slings are of fibres that interdigitate widely, between the pelvic floor and the skin of the perineum, bound together by fibrous tissue and constituting the perineal body, now called the central perineal tendon.

. The whole pelvic floor is thus seen to consist of a gutter-shaped muscular diaphragm, the fibres of which are arranged in a series of U-shaped loops sloping progressively downwards towards the midline. The fibres of the U-shaped loops are inserted progressively into the coccyx and the anococcygeal raphe from behind forwards, and when traced in this direction the anterior fibres overlap the upper or pelvic surface of the posterior fibres of the raphe.

There is a gap anteriorly between the medial edges of the levator prostatae or pubovaginalis parts. This is almost completely filled by the puboprostatic ligaments in the male and the pubovesical ligaments in the female. In the midline between these ligaments lies the deep dorsal vein of the penis or clitoris.

All parts of levator ani, including puborectalis, are supplied by the perineal branches of S3 and S4 which enter the upper pelvic surface of the muscle.

3. Action of the pelvic diaphragm

The pelvic diaphragm helps to support the pelvic viscera and retain them in their normal positions, and it is active in quiet respiration. The floor contracts to counteract increased intra-abdominal pressure, which may be momentary, as in coughing and sneezing, or more prolonged as in muscular efforts like lifting. If an expulsive effort is required, the floor relaxes. Thus in defaecation when the abdominal wall and diaphragm contract, puborectalis relaxes to straighten out the anorectal junction and the floor descends to become more funnel-shaped, rising again as the process comes to an end. The pubovaginalis fibres of levator ani may be important in assisting the urethral sphincter at the end of micturition. In parturition the floor initially directs the fetal head to the pelvic outlet, but the degree of stretching to which the muscular and fibrous parts of the floor are subjected renders it liable to damage by tearing, hence the prophylactic use of episiotomy.

D- PELVIC FASCIA

The fascia of the pelvis is usually described under the headings parietal and visceral. Its arrangement is essentially simple, and this simplicity is best appreciated by considering the pelvic fascia under the headings of the pelvic wall, pelvic floor and pelvic viscera. Two principles govern the arrangements of the fascia. The first is that over non-expansile parts the fascia is a strong membrane, while over expansile or mobile parts no membrane exists, the fascia consisting here of a loosely felted areolar tissue. The second principle is that fascia does not extend over bare bone.

The fascia of the pelvic wall is a strong membrane which covers the muscles obturator internus and piriformis and is firmly attached to the periosteum at their margins. Elsewhere the bone of the pelvic wall is bare of fascia. An exception is the fascia of Waldeyer, which sweeps downwards from its attachment in the hollow of the sacrum to the ampulla of the rectum. The spinal nerves lie external to the fascia of the pelvic wall, the vessels lie internal to it. The sacral plexus lies behind the pelvic fascia, between it and the piriformis muscle, and its branches to the buttock do not, there ore, pierce the fascia. The vessels of the buttock, superior and inferior gluteal, on the other hand have to pierce this fascia to establish continuity between pelvis and buttock.

The fascia of the pelvic floor, though usually included under the term parietal pelvic fascia, bears no possible resemblance to that of the pelvic wall. Here is no inexpansile membrane; indeed such a structure would nullify the necessary mobility of the pelvic diaphragm. The surface of levator ani is covered with no more than the epimysium, loose areolar tissue, that distinguishes muscle surfaces anywhere in the body. Between the pelvic floor and the pelvic peritoneum lie the

pelvic viscera. The extraperitoneal space between these viscera is composed of loose areolar tissue, which forms dead space for distension of bladder and rectum, and vagina too. The space allows for ready compression during the passage of the fetus in childbirth. Through this loose tissue the infection in pelvic cellulitis travels widely and fast. In the dead-space tissue are found so-called ligaments which are of two types.

First, condensations of areolar tissue surround the branches of the iliac vessels and the branches of the hypogastric plexuses to the viscera. Some of these are very strong. The lateral ligaments of the uterus and bladder and the fascia of Waldeyer are examples of ligaments that form around neurovascular bundles.

Second, certain ligaments exist in their own right, independently of neurovascular bundles. The puboprostatic and pubovesical ligaments are examples. Further examples are the round ligaments of the uterus and the uterosacral ligaments; both contain smooth muscle mingled with their fibrous tissue.

The fascia of the pelvic viscera is loose or dense in conformity with the distensibility of the organ. The non-distensible prostate is surrounded by a tough membrane of fascia; the highly distensible bladder and rectum have no membrane around their muscle walls, only a loose and cellular tissue invests them.

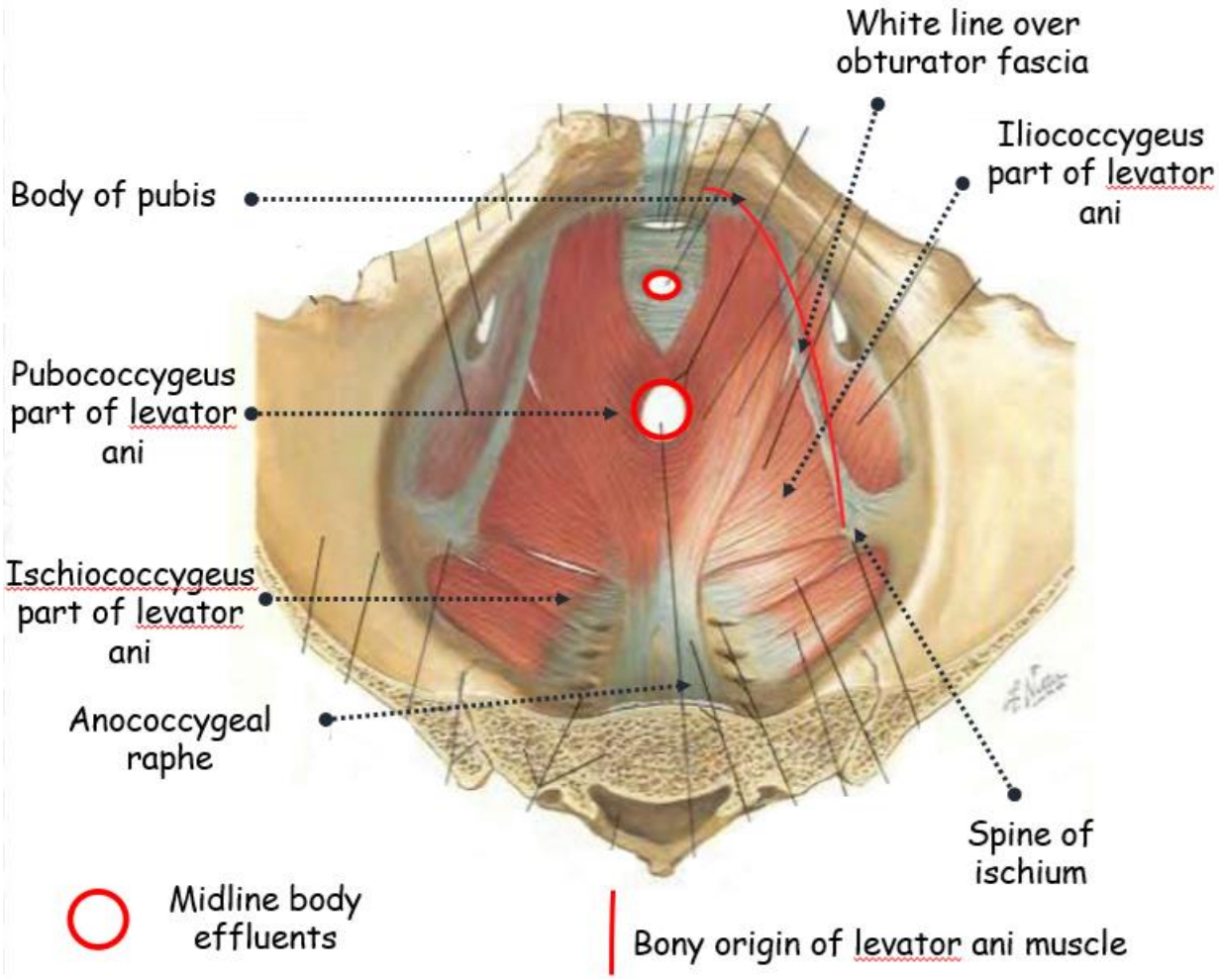

Figure 5: Superior view of the pelvic cavity showing the pelvic diaphragm (from NETTER)

VII. CONCLUSION

The great abdominal cavity extends from the thoracoabdominal diaphragm to the pelvic diaphragm. As its name implies, it is broader than it looks like. Thus, it remains mandatory to figure it out as compartments and regions, defined by peritoneal folds and extraperitoneal fasciae. The latters are mandatory to know carefully before the surgical approach of any of the abdominal and pelvic viscera.