

# **A Description of the Planes of Fascia of the Human Body**

**With Special Reference to the Fascia of the  
Abdomen, Pelvis and Perineum**

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## **Preface**

This description is based on actual dissection by myself of thirty-four adult human bodies, equally divided between the sexes, during the years 1913-1930 inclusive. This dissection was supplemented by work with the students on the bodies in the general dissecting room, during and before the same period. Also a number of frozen sections (frontal, sagittal etc.) especially those of the abdomen, pelvis and perineum, were made but were not satisfactory.

These are the three regions the fascial planes (or fasciae) of which are in my opinion inadequately described in our standard English and American textbooks; and this inadequacy is the reason for my attempting to give a somewhat different description.

As to the other regions of the body, viz., head and neck, thorax and the extremities, although the fasciae of these are fairly well described regionally in the text books, this description fails to make clear or to emphasize the fact that planes of fascia in one region of the body are directly continuous with the same planes in all other regions. In other words the law of continuity of fascial planes is not stressed.

These proposed corrections will be made in the following description which will be at first general, then systemic, and then regional. Considerable portions of the description will of course conform to the text of any standard work in English on anatomy.

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## General Considerations

The fascial planes or fasciae really constitute, in the non-dissected condition, a sheet of connective tissue varying in thickness and density according to locality. This covers and invests all the so-called higher structures; i.e., muscles and tendons, bursae, vessels, lymph nodes, nerves, viscera, ligaments, joints, and even cartilage and bones, these last by close adhesion to perichondrium and periosteum between the attachments of the muscles.

This plane of fascia, from a gross anatomical viewpoint, does not include connective tissue which closely surrounds or belongs to, any of the higher structures above mentioned. Thus, the epimysium of muscle and tendon, the epineurium of nerves, capsules of glands etc., are not to be regarded as parts of this fascia, although of course more or less closely adherent to it. This adherence is actually effected by innumerable minute trabeculae demonstrable while the fascia is being dissected off. After this dissection the epimysium, the epineurium etc., are intact. As to the vessels, the sheath of these is a derivative of the fascia but must not be confounded with the tunica adventitia (or externa) which is an integral element of vascular make-up.

Furthermore, for purposes of description, the following structures should also be excluded from this common plane of fascia: (1) sheets of delicate areolar tissue found in certain potential spaces, e.g., the retropharyngeal space; (2) certain deposits of fatty tissue which lie deep to or between, secondary laminae of the common plane, e.g., the buccal pad, the pad anterior to the temporal muscle, the orbital fat, irregular patches or masses situated close to muscles and other deep structures, particularly in the neck and extremities; (3) the subdural areolar tissue. These areolar and fatty structures are also connected by trabeculae with the overlying fascia and, although well marked in fat subjects, may occur in otherwise lean subjects.

This common plane of fascia will now be considered, first systemically, and then regionally.

## The Systemic Fasciae

There are grossly, two principle planes or sheets, each of which may be considered a system of fascia. Each system lies deep to or away from one or the other of those two surfaces of the body known respectively as the cutaneous surface and the serous surface.

Thus, the systems of fascia are (1) the subcutaneous system and (2) the subserous system. Although for the most part these systems are entirely distinct from each other, portions of each are directly continuous one with the other. This continuity occurs through the superior aperture of the thorax and certain openings (to be specified) in the abdominal wall and pelvis.

### *The Subcutaneous System*

This fascia consists of two layers, the superficial and the deep, separable by careful dissection. These layers are adherent to each other by interfascial trabeculae.

*The superficial subcutaneous layer.* This is described as being subdivided into two layers: (1) the superficial layer of the superficial fascia, and (2) the deep layer of the superficial fascia.

(1) The superficial layer is the fatty layer. It contains most of the fat; i.e., it constitutes the main fatty tissue of the outer surface of the body and may be more than an inch in thickness. This layer is also called the tela adiposa or the panniculus adiposus, and when thick may easily be split into several laminae. When thin it is almost impossible to separate it from the deep layer of superficial fascia without tearing holes in both layers. However, there is a natural plane of cleavage between these layers which is made by the superficial arteries, veins, nerves, lymphatic vessels and nodes, some of the bursae and the mammary gland. Nevertheless, when the superficial layer of fascia has been properly dissected off, these structures are seen, each one, to be invested with

a delicate film of tissue still connected with the deep layer, its connection with the superficial layer having been severed during the dissection.

For this reason the statement that these structures run through one layer of superficial fascia would seem at least more accurate than the usual statement that these structures run between the two layers of the superficial fascia. It is, of course, understood that these superficial vessels and nerves are branches of deep vessels and nerves (see below) and must, therefore, pierce overlying fascia (deep fascia and deep layer of superficial fascia) in order to reach this interfascial situation, while branches of these which are finally destined for the skin, pierce the topmost fascial layer.

(2) The deep layer of the superficial fascia lies immediately over or on top of the deep fascia, from which it may be distinguished, especially on the head, neck and extremities, by the greater density of the latter. This deep layer of the superficial fascia is a thin gray membrane which in well-conditioned subjects is said to be devoid of fat. In even moderately fatty subjects, however, it does seem to have some fat of its own, even after a most careful removal of the fatty superficial layer along the plane of the intervening vessels and nerves.

Although the adhesion between this layer and the deep fascia is close there are certain lines or edges along which this adhesion is especially close. These edges may be a sharp border of bone, the free edge of a tendon or the edge formed by the splitting of a layer of deep fascia into two or more layers (see below).

*The deep subcutaneous layer.* This is called simply the deep fascia of the region where situated, e.g., deep cervical fascia, deep perineal fascia, etc.

This fascia, although forming a continuous layer all over the body, varies in density according to the region in which it is found. Thus it is most dense on the extremities, less so on the head and neck, and even thin on the thorax, abdomen and perineum, where it often appears to be more delicate than the

overlying deep layer of the superficial fascia.

This fascia covers (1) all the muscles (except the superficial muscles of the head and neck, and the palmaris brevis), (2) all the large blood vessels, (3) all the large nerves, (4) the deep lymphatics and nodes, and (5) certain glands. Besides covering, it also invests these structures.

The term invest means that a layer of this fascia when traced in any direction (e.g., vertically or transversely, etc.) on meeting any one of the structures above mentioned, splits into laminae which surround the structure and then reunite. This investment is grossly often called the sheath of these structures, properly so as regards arteries and veins, but not to be confused with the epimysium and epineurium, (already spoken of) when, as is frequently the case, these are also called sheaths.

A layer of this fascia may also split to enclose a potential space. Finally a layer of this fascia may meet several superimposed strata of other structures (muscles, viscera, etc.) in which case it splits into as many layers as may be necessary to invest each stratum.

This investiture might be regarded as the phenomenon of splitting, to be taken up more specifically under regions. Conversely, any two or more of these layers if traced away from the structures they have invested will reunite into one plane. This might be called the phenomenon of reunion.

This fascia also exhibits the phenomenon of very close adhesion along certain edges previously referred to under "deep layer of the superficial fascia" (q.v.). It is understood that while this adhesion along edges affects both layers of fascia, each may be separated from the other, and the deep fascia from the edge itself, by careful dissection (see regions).

Fusion may occur. A layer may be so closely adherent to another layer, either over it or under it, as to form practically a single new layer. This occurs in the

scalp and perineum.

### *The Subserous System*

This is limited to the thoracic and abdominal cavities, and the surface is the serous membrane lining these cavities and enveloping or covering the contents of each. The thoracic serous membrane is the pleura (including in the embryo the serous layer of the pericardium); and the abdominal serous membrane is the peritoneum. That portion of each serous membrane which lines its respective cavity is called the parietal layer, e.g., parietal pleura, parietal peritoneum; while the portion which envelops the contents of such cavity is called the visceral layer, e.g., visceral pleura, visceral peritoneum. Inasmuch as the visceral and parietal layers, in each case, are continuous, they face each other and form a closed sac with a potential space between often known as a cavity, e.g., pleural or peritoneal cavity, which contains nothing and must not be confounded with the thoracic or abdominal cavity respectively. There are two pleural sacs and one peritoneal sac.

The subserous fascia, like the subcutaneous, has two layers, (1) the superficial subserous fascia which lies next to the pleura or peritoneum, and (2) the deep subserous fascia.

*The superficial subserous fascia.* This, unlike the corresponding subcutaneous fascia, cannot be split into regular layers. It contains the fat or is the fatty tissue of the inner surface of the thorax and abdomen. Inasmuch as it follows or lies next to pleura or peritoneum, like them it must and does have two portions, the sub-visceral and the sub-parietal. The former are direct prolongations to the viscera of the latter.

*The deep subserous fascia.* This is a grayish fairly substantial membrane greatly resembling certain portions of the deep subcutaneous fascia and shows many, if not all, of its phenomena (see above). This layer lies deep to the parietal portion of the superficial subserous layer and does not send any prolon-

gations onto the viscera with the exception of the prostate gland (q.v.). Subserous fasciae will be further considered under regions.

Reconsidering the subserous fascia as a whole: this entire system is almost completely divided by the diaphragm into two regions, intrathoracic and intra-abdominal.

In the thorax, the superficial subserous layer is called the subpleural fascia (or areolar tissue) and the deep subserous layer is known as the endothoracic fascia.

In the abdomen the corresponding layers are called respectively the subperitoneal fascia (or areolar tissue) and the transversalis fascia.

## **Regional Fasciae Fasciae of the Abdomen**

These are (1) subcutaneous and (2) subserous. The abdomen is a cavity bounded by a wall. Part of this cavity is the pelvic cavity. The wall of this entire cavity is made up of muscles, their tendons, and bones. The bones are the lumbar vertebrae, sacrum, coccyx, ilium, ischium and pubis. The muscles are the diaphragm above and behind, the levator ani and coccygeus below including the sacro-coccygeus ant. and uro-genital diaphragm (q.v.); also those issuing from the pelvis and the broad ventro and dorso-lateral sheets including the quadratus lumborum. The levator ani and coccygeus constitute the muscles of the pelvic diaphragm, (q.v.), which structure thus shuts off or isolates the extreme lower portions of the pelvic cavity, which are known as the ischio-rectal fossae (q.v.).

This wall is covered on its outer surface by the subcutaneous abdominal fas-

cia and on its inner surface by the subserous abdominal fascia. In other words, the wall of the abdomen lies everywhere between these two planes of fascia. It will be more convenient to call the first extra-abdominal and the other intra-abdominal fascia.

### *The Extra-abdominal Fascia*

This fascia covers those portions of the external oblique and latissimus dorsi which form the outside layer of the abdominal wall. Furthermore, it covers both the muscular part of these muscles as well as their tendons.

Traced upward this fascia becomes, i.e. is directly continuous with, the subcutaneous (extrathoracic) thoracic fascia. The boundary line extends on each side from the ensiform cartilage along the lower edges of the seventh to the twelfth costal cartilages and then slightly upward to the spinous process of the twelfth thoracic vertebra. Over the edges of the cartilages some degree of adhesion is noticeable.

Traced downward, this fascia is directly continuous with, or becomes the subcutaneous fascia of: (1) the lower extremity; (2) the scrotum (or labia majora) and spermatic cord (genetic cord); (3) penis (or clitoris); and (4) perineum.

Traced backward, this fascia passes completely around the body from the linea alba to the spinous processes of the vertebrae, from the twelfth thoracic to tip of coccyx, being very adherent along these ventral and dorsal midlines.

This fascia, including the corresponding area of the abdominal wall, is now for convenience subdivided into two districts by a line drawn upward from the anterior superior iliac spine to the costal arch (about the ninth cartilage). Behind this line is the dorso-lateral, and in front of it the ventral district. This line also indicates fairly accurately where the muscle part of the external oblique ends and becomes the broad flat tendon of the same, spoken of in most text books as the aponeurosis, which term is certainly misleading and is invariably mis-

taken by students for fascia. (See also lat. dorsi.)

The term aponeurosis has two definitions, viz: (1) a thickened strip or portion of the ordinary deep fascia, and (2) a broad thin expanded tendon of a muscle. The latter certainly applies to the broad ventral muscles of the abdominal wall.

### *The Ventral District*

Before proceeding with the fascia, that part of the tendon of the external oblique which occupies this district will be considered.

This tendon starts from behind at the line already indicated. The upper border follows the edge of the costal cartilages to the ensiform cartilage. Above this edge the tendon lies on the thorax.

The anterior border extends downward from the ensiform cartilage to just lateral to the top of the symphysis pubis, then downward and backward just lateral to the margin of the symphysis (extreme inner area of the body of pubis), to the subpubic (arcuate) ligament. This entire border closely decussates with the same border of the tendon of the opposite side. Along the front of the symphysis these decussations, together with the narrow part of the tendon immediately lateral to them, are almost inseparably united by their deep surface to downward extensions of the conjoined tendons, pyramidalis muscles and the rectus abdominalis tendons, which in their turn by close approximation of their inner edges cover the anterior pubic ligament. Between the ensiform cartilage and the top of the symphysis these decussations form a raphe known as the linea alba, which is also contributed to by fibers from the tendons of the internal oblique and transversus abdominalis.

The lower border would run as follows, assuming for the present the nonexistence of the subcutaneous inguinal ring (superficial abdominal ring): (1) From the ant. sup. iliac spine to the pubic tubercle (or spine) this is the inguinal lig-

ament [Poupart's]; (2) medially along the pubic crest nearly to the top of the symphysis across which the decussation occurs; (3) downward and backward on the body of the pubis to the subpubic ligament just lateral to the midline. This portion of the lower border, which really looks laterally, is in close contact with the line of attachment to the body of the pubis of the gracilis and adductor longus muscles. Thus between this line and the midline (symphysis) is a narrow ribbon-like strip of the tendon itself.

The inguinal ligament is a free edge. Although planes of fascia are closely attached to it above, below, in front and behind, it itself is not continuous with any of these planes, as is intimated in some textbooks. Approximately the outer two thirds is flattened and curved backward. The inner third is rounded.

The lacunar ligament (Gimbernat's) is a thin expansion from, and a part of, the inguinal ligament. It is triangular with the apex at the pubic tubercle. Of the three borders, two are attached and one is free. The attached borders are, each one, a little less than an inch long. The upper blends with the inguinal ligament; the lower is attached to about the medial half of the pectineal line, the inward prolongation of the iliopectineal line, (linea terminalis, linea arcuata). The free border is curved, concavity directed laterally, and is the inner margin of the femoral ring.

The subcutaneous inguinal ring is an opening or hiatus in the tendon of the external oblique, which has just been described as if this opening did not exist. We can now "make" this opening by cutting away and removing a triangular strip of this tendon. The base of the ring is the lateral three-fourths or so of the pubic crest (the size of the ring varies in different individuals). The inner or upper edge begins along the medial fourth or so of the pubic crest and at the top of the symphysis whence it runs upward and outward to the apex. Here it joins the outer or lower edge which passes, in its turn, downward and forward to the pubic tubercle. In fact this lower edge is the medial part of the inguinal ligament. These edges are known as the pillars or crura of the ring, the inner being somewhat the longer of the two. The distance from the apex to middle

of the base averages a little less than an inch.

Intercolumnar or intercrural fibers are to be considered as part of the structure of the main tendon. They must not be confounded with the intercolumnar or intercrural fascia (q.v.).

The triangular or reflected inguinal ligament (of Colles) is a delicate sheet of fibers seemingly prolonged from the extreme lower part of the external oblique tendon (i.e., just above the symphysis) of the opposite side. It is attached for a short distance along the pectineal line close to the deep (superior) surface of the lacunar ligament, or it may fuse with it. In my experience it is rarely demonstrable and then only in a very muscular subject. It lies behind or deep to the spermatic cord and "superficial" to the conjoined tendon (q.v.). In some subjects it seems to form a sort of floor of the ring and thus to be attached also to the pubic crest.

#### *Fascia of the Ventral District*

The superficial layer of this fascia is fairly easily subdivided into two layers, of which the superficial is commonly known as Camper's fascia and the deep as Scarpa's fascia. Traced downward along and over the inguinal ligament, Camper's fascia becomes the superficial layer of the superficial fascia of the thigh, while Scarpa's fascia becomes the deep layer of the same, which may be called the cribriform fascia, named from that part of it which passes over or fills in the fossa ovalis (saphenous opening.)

Traced downward under the skin of the scrotum and under the skin of the penis, Camper's and Scarpa's fascia fuse into one layer blended in which is a considerable amount of smooth muscle. This fused fascia and muscle is the dartos of scrotum and penis. The dartos is thin and delicate because, in fusing, Camper's fascia has lost practically all of its fat. It is well to bear in mind in tracing this fascia and dartos that it must be done, not only downward, but also upward almost to where it started from. In other words we have a fascial

bag inside a skin bag which, like the latter, completely surrounds the testicle and cord, so that Scarpa's fascia is behind the spermatic cord as well as in front of it. Similarly on the penis there is a fascial tube inside a skin tube (see also scrotum, spermatic cord, perineum and penis).

As Scarpa's fascia passes downward over the inguinal ligament it is closely adherent to the corresponding underlying portion of the deep fascia (see below).

The deep layer of fascia of the ventral district is practically ignored in the text books as a distinct plane of tissue, whereas its direct extension on the thorax, in the neck and on the extremities is carefully described. Its extension in the perineum is also ignored.

This layer is distinct from the extremely delicate sheath proper (epimysium) of the external oblique muscle. This distinction can be quite readily demonstrated over the muscle part of the muscle. Over the tendon great care in the dissection is required.

Traced downward, this deep fascia (fascia innominata because hitherto unnamed), together with the overlying Scarpa's fascia, is strongly adherent along the whole length of the inguinal ligament, and is then continuous with or becomes the fascia lata (deep fascia) of the thigh (Fig. 1). However, after passing over, or leaving, the extreme medial end of the inguinal ligament, i.e., the lower or lateral pillar of the ring, the fascia passes obliquely backward, covering the under surface of the lacunar ligament, and then downward over the pectineus muscle (pubic or pectineal portion of the fascia lata).

Along the boundaries of the subcutaneous inguinal ring (q.v.) this fascia is attached, and is then prolonged as a tubular investment over, i.e., superficial to, three other tubular investments of the vas deferens (ductus efferens), to be discussed later.

This tubular prolongation lies deep to (within) the dartos and is known vari-

ously as the external spermatic fascia, the intercolumnar fascia or the intercrural fascia. From the line of attachment of this tube to the lower boundary (pubic crest) of the ring, this same fascia is reflected downward to the subpubic ligament, thus covering the narrow area of the extreme lower part of the tendon of the external oblique muscle (q.v.). The attachment to the pubic crest is fairly close while there is no attachment, along this line, of Scarpa's fascia similar to that already mentioned along the inguinal ligament.

This downward reflection of the external spermatic fascia is continuous across the midline with the corresponding reflection of the fascia of the opposite side. Traced laterally, on each side, this lamina of fascia becomes the fascia lata. It does so after passing over and being adherent to the ridges which are the lines of attachment to the bodies of the pubic bones of the adductor longus and gracilis muscles. Furthermore Scarpa's fascia along these ridges is attached to the deep fascia.

Below, on reaching the subpubic ligament, this fascia undergoes another tubular prolongation over and around the penis (q.v.) and then becomes the inferior perineal fascia (see perineum).

## The Dorso-lateral District

The anterior boundary is the posterior boundary of the ventral district already described. The other boundaries are: above, a line running backwards from about the ninth to the twelfth costal cartilage and then along the twelfth rib to the spinous process of the twelfth thoracic vertebra; behind, a line passing over the spinous processes of all the vertebrae from the twelfth thoracic to the end of the sacrum and tip of the coccyx; below, a line which is quite irregular and indicates not only an inferior, but also a lateral, boundary. This begins at the anterior superior iliac spine. It then follows the outer lip of the crest of the ilium and the attachments of the gluteus maximus to the sacrum and coccyx.

The superficial muscles of this district comprise portions of the external oblique, lat. dorsi and a small extent of the int. obl., viz., the floor of Petit's triangle. This portion of the ext. obl. is muscle, but also comprises most of its posterior tendon. The attachments of this portion of the tendon, behind and below, are practically the same as the corresponding boundaries just described of the dorsolateral district. This tendon covers the sacrospinalis muscle and then is closely adherent along a very narrow vertical line to the posterior tendon of the transversus abd. muscle, the larger part of which arises from the tips of the transverse processes of the lumbar vertebrae. This posterior tendon of the lat. dorsi is called in all the textbooks by one or other of the following names: lumbosacral aponeurosis, posterior layer of the lumbar fascia, posterior layer of the lumbodorsal fascia.

The real fascia of this district has already been mentioned and will be referred to again. Of the names just mentioned, the one most commonly used is posterior layer of the lumbodorsal fascia. The lumbodorsal fascia is described as having three layers: (1) the posterior is the posterior tendon of the lat. dorsi already described; (2) the middle layer is the posterior tendon of the trans. abd. muscle (see above) of which the anterior tendon forms part of the sheath of the rectus abd.

Out to the line of adhesion between them, already mentioned, these posterior tendons enclose the sacrospinalis muscle. Slightly lateral to this line of adhesion, numerous muscular fibers of the int. obl. muscle are attached to or take origin from the tendon of the trans. abd.

(3) The anterior layer of the lumbodorsal fascia is simply that portion of the transversalis fascia (intra-abdominal fascia, q.v.) which covers the ventral surface of the quadratus lumb. muscle, of which the dorsal surface is in contact with the tendon of the trans. abd. muscle, just described (Fig. 2). It would thus seem that there is no such anatomical entity or unit as the lumbodorsal fascia. Hence the abolition of this term and its synonyms together with its layers would be advisable.

The extra-abdominal fascia which occupies this dorso lateral district could properly be called the lumbodorsal fascia. There is a deep and a superficial layer, the latter corresponding to, and continuous with, Camper's and Scarpa's fascia of the ventral district. Superiorly this fascia is continuous with corresponding layers of back and thorax while inferiorly it passes into continuity with the fascia of the lower extremity and, from the coccyx, with the fascia of the perineum (q.v.).

Along the irregular line of the inferior boundary, we have intimate adhesion of the deep fascia and of Scarpa's fascia. After crossing this line, the deep fascia becomes the fascia lata (gluteal portion) of the thigh, while Scarpa's fascia becomes the same layer as the cribriform fascia anteriorly, previously mentioned.

There are certain deep lying strata or laminae of the deep layer of the extra-abdominal fascia which require brief mention. They are limited to the trunk and are derivatives of the main lamina of deep fascia being examples of splitting when the main lamina meets free edges of muscles, or other higher structures.

Examples of such edges are those of ext. obl. and lat. dorsi; trapezius, rect. abd. and pectoral muscles on the thorax; trap., sterno-mast., vertebral and hyoid muscles in the neck, including pharynx, oesophagus, larynx, trachea, thyroid etc. These strata of thorax and neck link up with the deep fascia of the upper extremity at the apex of the axilla and superior aperture of the thorax.

The vertebral aponeurosis may be mentioned. It is fascia, one of the deep-lying strata just mentioned, and covers the entire sacrospinalis muscle. It lies deep to the tendons of the lat. dorsi and trapezius muscles and also to the two serratus posterior muscles, many of the fibers of which take origin from it.

#### *The Intra-abdominal Fascia*

As already stated, under systemic fasciae, there are two layers, the subperi-

toneal (or subserous) areolar tissue or superficial intra-abdominal fasciae, and the deep intra-abdominal fascia commonly called the transversalis fascia. Inasmuch as the pelvis or pelvic cavity is regarded as part of the abdomen or abdominal cavity, the intra-abdominal fascia (both layers) must be and is continued into the pelvis. Here both layers constitute the pelvic fascia, i.e., the superficial pelvic fascia and the deep pelvic fascia, the former of which, of course, lies immediately under, or next to, the pelvic peritoneum.

With this distinction between the abdomen and pelvis, we may consider the transversalis fascia as that part of the deep intra-abdominal fascia which lies above the brim of the pelvis, (linea arcuata, linea terminalis, and ileopectineal line). This line crosses the sacrum at a level just below the promontory.

#### *The Transversalis Fascia*

This lines the abdominal cavity. It is really a sort of bag, with its outside surface in contact with the abdominal wall and its inside surface in contact with the parietal portion of the subperitoneal areolar tissue. The transversalis fascia covers the muscles and invests the nerves, the aorta, post cava and lumbar vessels, thus splitting as previously described. It is fairly closely adherent along the pelvic brim except the sacral portion of the brim, an example of adhesion to edges already referred to.

It has certain prolongations, one of which is a regular tubular examination, beginning at the upper end of the inguinal canal (see below) and continuing down through the canal and superficial ring, covering the ductus efferens and the testicle. This evagination is called the infundibuliform fascia or the internal spermatic fascia (see Cord and Testicle). In the canal this tubular evagination lies against (in front of) the main lamina of transversalis fascia from which it is derived.

The upper end of the inguinal canal is halfway between the pubic tubercle and anterior superior iliac spine. Between these points the floor of the canal is

formed by the adhesion to the inguinal ligament of the main lamina of transversalis fascia just referred to. This adhesion continues up to the iliac spine. Then the transversalis fascia curves backward and upward, covering the iliopsoas muscle, etc.

The entire line of this adhesion, however, is continuous with the fascia lata beneath (deep to) the inguinal ligament; while above (superficial to) this ligament the fascia lata is continuous with the fascia innominata (see above). This is an example, tracing it upward, of one layer of fascia splitting into three layers along a sharp edge (inguinal ligament, Fig. 1).

The sheath of the femoral vessels is another downward prolongation. The other prolongations pass upward. Each may be considered an example of splitting and investing. There are two groups, (1) passing through and (2) passing behind, the diaphragm.

*Group 1.* These layers pass through the openings in the diaphragm for the aorta (which strictly speaking passes behind the diaphragm), the oesophagus, azygos veins, splanchnic nerves and sympathetic cord. In this way there is a link up with the endothoracic fascia (Fig. 3). There is no upward prolongation for the inf. vena cava. As this vessel passes through its opening in the tendon of the diaphragm, the fascia spreads out under the diaphragm, i.e., becomes the main layer. Furthermore, this fascia as a gross structure is not present on the vena cava where this vessel is in contact with the liver.

*Group 2.* Prolongations passing behind the diaphragm. Before speaking of these specifically, we will trace the fascia laterally, i.e., around the inside of the abdominal wall, the level being anywhere between the last rib and the lilac crest, beginning at the ventral midline, where it is continuous, of course, with the fascia of the opposite side. The transversalis fascia now covers the inner surface of the trans. abd. muscle, first its anterior tendon, then the muscular part and then the posterior tendon as far as the outer edge of the quad. lumb. muscle. It now covers the anterior surface of the quad. lumb. (where it is quite

substantial and is the anterior layer of the lumbodorsal fascia of the textbooks), the psoas (magnus and parvus) and then invests the aorta, vena cava and sympathetic nerve trunks (Fig. 2). As it lies over the quad. lumb. and psoas, it also covers and invests the twelfth thoracic nerve (ant. ramus) and the descending branches of the lumbar plexus. This portion, furthermore, passes behind the kidneys, adrenals, oesophagus, pancreas and duodenum. At the anterior edge of the quad lumb. it sends off a very delicate lamina which goes behind the muscle, i.e., between it and the posterior tendon of the trans. abd.

Before tracing upward those portions of the transversalis fascia which cover the psoas and quad lumb. muscles, the following will be in order. Each crus of the diaphragm has a narrow median border of tendon which unites with the one of the opposite side across (ventral to) the aorta forming the middle arcuate ligament from which some of the muscular fibers of the diaphragm arise. From this tendinous edge of each crus, at about the level of the disc between the first and second lumbar vertebrae, is prolonged laterally another narrow tendinous edge which curves across the psoas (the latter going up behind it), to be attached close to the tip of the transverse process of the first lumbar vertebrae. This is the medial lumbocostal arch, from which also muscular fibers of the diaphragm arise.

Another similar tendinous edge arises from where the first one ends and crosses the quad. lumb. to be attached to the twelfth rib just beyond the line of attachment to this rib of the quad. lumb. This is the lateral lumbocostal arch and it also gives origin to muscular fibers of the diaphragm. These lumbocostal arches are also called medial and lateral arcuate ligaments. Counting with them the middle one, the five make a continuous edge to the diaphragm like the selvage of a piece of cloth.

Tracing the transversalis fascia upward: this narrow tendinous edge is held closely to the quad. lumb. psoas and aorta by the transversalis fascia which not only becomes more substantial along this edge, but splits into two layers, one becoming the layer on the under surface of the diaphragm and the other, Group

(2) of upward prolongations, passing up behind it to blend or become continuous with the endothoracic fascia (Fig. 3). Occasionally a few delicate fibers of the psoas arise from the inner end of the medial lumbocostal arch.

The transversalis fascia is extremely delicate in three districts, viz: on the under surface of the tendon of the diaphragm, and behind the anterior tendon of each trans. abd. muscle where the latter passes, together with the posterior lamina of the tendon of the int. obl., behind the rectus abd., i.e., as far down as the semicircular line (fold of Douglas). Below this, now directly in contact with the rectus, it resumes its normal consistency. In these districts it is so thin that it is often impossible to separate it (without tearing) from the subperitoneal areolar tissue lying between it and the peritoneum. The iliac fascia is merely an unnecessary name for that portion of the transversalis fascia which covers the iliacus muscle (fig. 1).

#### *The Superficial Intra-abdominal Fascia*

Synonyms: Tela subserosa, subperitoneal (or subserous) areolar tissue. Below the pelvic brim it is (or becomes) the superficial pelvic fascia. Situated in or running through this superficial subserous fascia are all arteries and veins (except the aorta, inferior vena cava and lumbar vessels), the viscera and ducts, lymphatics and nodes, and sympathetic nerve fibers to viscera.

This fascia, as before stated, contains the fat. In very thin subjects it is a very delicate sheet of areolar tissue connecting and supporting the blood vessels etc. This fascia also sends direct prolongations to those viscera which have mesenteries. In each case these prolongations run between the layers of the corresponding mesentery, and carry the blood-vascular, lymphatic and nerve supply. On actually reaching the viscus toward which it runs, each prolongation ceases as fascia (a gross structure) and blends with the proper structure of the organ, i.e., the fibro-elastic stroma of the tunica serosa (peritoneum) of the intestines, or with the capsule of the liver. These are intraperitoneal viscera. The mesenteries of course include the omenta and in fat subjects are

seemingly mere masses of fat covered on both sides by a glistening surface, the peritoneum.

In the case of the extraperitoneal viscera (also known as sub or retroperitoneal), a delicate layer of fascia is found on stripping off the peritoneum. This covers the organ (front and back), e.g., the duodenum, except the proximal portion which is always intraperitoneal, as is also the terminal portion when there is a retroduodenal fossa; and the pancreas.

As regards the kidneys, the above arrangement is very marked. Thus, the superficial intra-abdominal fascia, a little below the lower pole of the kidney, splits into two layers which pass upward one in front of the other behind the organ, including the adrenal. These layers unite above and along the margins of the kidney. From the union along the medial border, especially at the hilum, processes are sent outward into the sinus and inward toward the aorta and vena cava, thus investing the renal and adrenal vessels, nerves etc. At their origins from aorta and cava these vascular branches necessarily pierce this fascia in order to become invested by it.

We thus have a sort of pocket in which the kidney and adrenal are lodged. The above holds good for very thin subjects. In most subjects, however, especially in fat ones, there are found special deposits or pads of fat located as follows: (1) Between the two layers, often extending up onto the kidney; (2) in front of the anterior layer, i.e., between this and the peritoneum; (3) behind the posterior layer, i.e., between it and the transversalis fascia.

This entire arrangement is called the perirenal fascia or the fatty capsule of the kidney, not to be confounded with the true capsule of the kidney, which is part of the kidney structure proper.

Along the inguinal canal there is a tubular evagination of this superficial intra-abdominal fascia, precisely like that of the deep fascia (see above). It is very thin and lies close to the vas (round ligament in the female), and testicle, the

tunica vaginalis of the latter being immediately deep to it. It carries the vascular supply of the testicle, vas and cremaster. It may be called the deepest spermatic fascia or the vascular layer of the cord (q.v.). It may contain a superabundance of fat, which in some cases is so marked as to constitute what is called lipoma of the cord (see also labium majus).

#### *The Pelvic Fascia*

This fascia is that portion of the intra-abdominal fascia which lies below the brim of the pelvis, and similarly has two divisions: superficial pelvic fascia, and deep pelvic fascia.

#### *The Deep Pelvic Fascia*

This is the continuation into the pelvis of the transversalis fascia.

In considering the deep pelvic fascia it will be necessary to make preliminary reference to the perineum and perineal fascia, owing to the close connection between the two fasciae. The brim of the pelvis is also called the pelvic inlet.

*The Pelvic Outlet.* Its boundaries, outlining a rhomboid, are: anteriorly, the mid-point of the subpubic (arcuate) ligament; from here, outward and backward, the rami of pubis and ischium to the ischial tuberosities; then the sacrotuberous ligaments to the side of sacrum and first two pieces of the coccyx; the tip of the latter being the midpoint posteriorly. The pelvic outlet is practically the same area as the perineum, using this term in its broader meaning (see below). A transverse line between the anterior ends (tips) of the ischial tuberosities, and passing in front of the anus, gives us two triangles. The anterior triangle is known as the urogenital triangle and the posterior one as the rectal triangle. The anterior triangle in the fresh state is also called the urethral triangle, the urethral perineum or simply the perineum (in its narrower meaning, see above). Hereafter the word perineum will always be used in its narrower meaning. In the female, however, perineum is applied also to the skin surface

between the front of the anus and the back of the vagina (rarely so in the male). This surface is really the base of the perineal body (see perineum).

The posterior of these two triangles is also called the anal perineum. A better name is the ischiorectal triangle because (in the fresh state) it contains on each side the ischiorectal fossa between which is the lower part of the rectum (anal canal) and the anus. Hence the pelvic outlet comprises the urogenital triangle, (or perineum) and the ischiorectal triangle. (Many textbooks use the Greek word trigone or trigonum instead of triangle).

The diaphragms of the pelvic outlet: (1) *The urogenital diaphragm*. This stretches across between the lateral and anterior boundaries of the urogenital triangle. It consists of a muscle sheet lying between two layers (upper and lower) of fascia which together are known as the triangular ligament of the perineum (q.v.). Posteriorly these two layers unite. This diaphragm lies between two other musculofascial strata (see levator ani and perineum), all three of which really constitute the diaphragm.

(2) *The pelvic diaphragm*. This consists of the levator ani and coccygeus muscles together with the fascia covering them above and below, that above being the deep pelvic fascia (supra-anal fascia; or the superior layer of the pelvic diaphragmatic fascia); and that below, the infra-anal fascia (see below).

To resume: the deep pelvic fascia will be traced at different levels and in different directions, beginning at the pelvic diaphragm.

The muscles of the pelvic diaphragm: The coccygeus. This extends from the ischial spine to the sides of the lower part of the sacrum and upper part of the coccyx, including the lower margin and inner third of the sacrotuberous ligament to which it is attached. Thus the deep pelvic fascia covers this district evenly from one ischial spine to the other, overlying the two coccygeus muscles, the intervening bones and nerves, and passing behind the rectum. It is the posterior portion of what is called the superior layer of the pelvic diaphragmatic

fascia (see above and below).

*The levator ani*. It is unnecessary to describe its various subdivisions. Each muscle is a curved (convexity outward and downward) sheet of fibers radiating outward, upward and forward from a common origin behind and below. This common origin is: (1) the sides of the lower part of the coccyx and its tip; and (2) the ano-coccygeal raphe (ligament) which runs between the tip of the coccyx and the back of the anus.

From this origin: (1) The posterior fibers run outward to the ischial spine, close to and parallel with the lower border of the coccygeus, receiving on their upper surface a prolongation of the deep pelvic fascia covering that muscle to be known as the supra-anal fascia (see above and below). (2) The anterior (or medial) fibers including those from the tip of the coccyx are the longest and run forward, something like an old fashioned hammock, to the back of the body of the pubis to a point halfway between its upper and lower borders, and halfway between the symphysis and median border of the obturator foramen. For brevity this point will hereafter be called the pubic point. (3) The intermediate fibers, or ilio-coccygeus muscle, spray outward, upward and slightly forward and end, if all fascia is removed, in a free edge, slightly curved, concavity upward, which extends from just lateral to the pubic point to the ischial spine.

The free edges or borders of the lev. ani muscle: We have already noted two, viz. (1) parallel to the coccygeus and (2) the one just mentioned. There is a third free edge. Considering again the anterior or medial fibers: These run from coccyx and anococcygeal raphe lying, along this line, above or deep to the ilio-coccygeus, to the pubic point. These fibers are called the pubococcygeus muscle. On leaving the anterior end of the anococcygeal raphe each pubococcygeus muscle, encircles half of the lower part of the rectum (anal canal) just lateral to the ext. sphincter ani, and then, after a mutual exchange of a few fibers in front of the anal canal, proceeds, independently of the other to the pubic point, now uncovered below by the ilio-coccygeus. Thus each muscle has a free medial edge with an appreciable interval between them (hiatus geni-

talis). By removing the anal canal and sphincter ani, this interval would be extended back to the anterior end of the anococcygeal raphe.

We will now consider that part of the deep pelvic fascia which lies below the upper edges and on the upper surfaces of the lev. ani muscles. It is part of the superior layer of the pelvic diaphragmatic fascia; or preferably known as the supra-anal fascia already mentioned (see post, fibers of lev. ani).

This supra-anal fascia continued from behind, forward from the coccygei muscles (see above), covers the entire inner (upper) surface of both lev. ani muscles. Traced from side to side beginning at the upper free edge (see above), it sweeps across the raphe behind the anal canal, blends with the anal canal, and in front of this passes from the upper surface and edge of one pubococcygeus muscle to that of the other, thus filling in the hiatus genitalis (see above). Since in part of this interval is the lower portion of the back of the symphysis and a narrow area of bone on each side, this same fascia traced forward and upward would cover this bone interval and at its upper margin become the transversalis fascia. In thus covering this bone interval, it is well to state now that this fascia really has between itself and the bone interval the upward prolongation of the upper (deep) layer of the triangular ligament of the perineum. This layer joins with the supra-anal fascia to form the transversalis fascia just below the upper margin of this bone interval (Fig. 4).

Hence most of the under surfaces of the pubococcygeus muscles, together with the fascia (just referred to) between their edges lies immediately over and on the upper surface of the deep layer of the triangular ligament of the perineum. Thus this musculofascial plane forms a superstratum of the urogenital diaphragm (q.v.). Thus this pubococcygeal portion of the levator ani lies between the supra-anal fascia above and the superior (deep) layer of the triangular ligament of the perineum below (Fig. 5).

This inter-pubococcygeal interval, bridged over by supra-anal fascia, has just been described as if no organs (except the anal canal) existed in this interval.

As a matter of fact certain organs or rather parts of them are so situated.

Thus in the male: The prostate gland (lower surface) lies in this interval; and the supra-anal fascia invests the gland, i.e., splits and surrounds it, forming its capsule, which is to be distinguished from its sheath which is part of the superficial pelvic fascia (q.v.). Inasmuch as the capsule cannot be dissected off from the gland without causing the gland substances to spill out, it would be better from a gross point of view to say that the supra-anal fascia blends with the capsule.

Considering the above arrangement more in detail and assuming entire absence of the superficial pelvic fascia:

The prostate has five surfaces: two lateral, one superior, one inferior and one posterior, and an apex directed upward and forward owing to the concavity (upward) of the superior (vesical) surface on which is the bladder. The posterior (rectal) surface is convex up and down and slightly concave from side to side. The lateral surfaces are convex from before backward, and from below upward. The inferior surface is also convex (downward) from before backward. All surfaces except the rectal converge to and from the apex, a blunt conical projection looking toward and fairly close to the lower part of the symphysis, and which is free.

The inferior surface may be divided by the junction of the urethra with the membranous urethra (between the two layers of the triangular ligament) into a pubic surface (free) and a perineal surface, of which the former is merely part of the apex. Similarly the concave vesical surface is prolonged on to the apex. Thus there is a slight interval between the apex and the bladder. The lateral surfaces of course begin at the tip of the apex.

The perineal surface: This occupies, from side to side, perhaps a little more than the middle third of the triangular ligament. Posteriorly this surface does not extend quite to the free edge of the triangular ligament, but curves upward to

blend imperceptibly with the rectal surface. There is thus an interval or cleft between the gland and the triangular ligament. The supra-anal fascia running forward from the anal canal runs over the triangular ligament (more or less adherent to it) into this cleft and then backward and upward on the gland as part of its capsule. Along the lateral margins of the perineal surface the supra-anal fascia is similarly attached, i.e., blends with, or becomes continuous with, that part of the capsule which is reflected up over the lateral surfaces (Fig. 5).

The perineal surface itself is covered by a fusion of supra-anal fascia with the upper layer of the triangular ligament, which combination of course fuses with, as it surrounds, the urethra; while anterior to the urethra the apex is entirely surrounded by capsule.

The capsule on the rounded under surface of the apex, followed backward to the urethra, makes an angle with and is continuous with the forward and upward continuation of the supra-anal fascia (already described) to the back of the symphysis and to the two pubic points. This particular area of the supra-anal fascia is often specially thickened and forms what is called the puboprostatic ligament. Sometimes this thickening is confined to three strands, a middle (from the symphysis), and two lateral (one from each pubic point) puboprostatic ligaments. Each of the two latter is a prolongation of the white line (see below).

The vesical surface of the prostate is very closely united to the bladder by a fusion of the capsule with a thin but condensed layer of superficial pelvic fascia (q.v.).

In the female: The vagina and urethra are situated in this interval or more accurately the extreme lower ends of the pelvic portions of these structures. (It should be recalled that both vagina and female urethra have three divisions, pelvic, membranous and vestibular: The first extending to the triangular ligament; the second lying between the layers of the triangular ligament; and the third situated in the vestibule of the vulva).

As they lie in this pubococcygeal interval, the supra-anal fascia blends with them, i.e., with their extreme lower ends.

From the closely approximated inner margins of the pubo-coccygeus, muscular fibers, difficult to dissect grossly, run to and blend with all these interval structures, and these have received special names: to the anal canal (rectum), pubo-rectalis, rectococcygeus; to the vagina, pubo-vaginalis (not to be confounded with the deep or urogenital sphincter); the pubo-urethralis or levator urethrae (in both sexes); and the levator prostatae (prostate gland).

The pubo-urethral ligaments are slight thickenings of the supra-anal fascia which are attached to the lower end of the (female) pelvic urethra. They correspond to the pubo-prostatic ligaments in the male.

Returning to the upper free edge of the lev. ani already mentioned: This edge runs, usually as a gentle curve, concavity upward, between the ischial spine and pubic point. It lies against the inner surface of the obt. int. muscle, about two thirds or less of this surface being above this edge. From the ischial spine inward this edge is in line with the upper margin of the coccygeus.

Now it is along this line, i.e., the upper edges of the coccygeus and lev. ani that the deep pelvic fascia splits when traced downward from the pelvic brim.

Considering first the free edge of the levator ani: This is held quite firmly against the obturator internus by the split just referred to. This split of the original lamina covering the inner surface of the obt. int. is in three layers. Of these three layers, two invest the lev. ani; i.e., one lies on each surface of the muscle and the third covers the lower third of the obt. int. Between the last named, laterally, and that covering the outer (under) surface of the lev. ani, medially, is a space, the ischio-rectal fossa. The curved line along which the fascia splits is thickened and shows as a distinct white line also called the white line or arcus tendineus of the lev. ani (Fig. 6).

Exactly the same thing occurs along the upper margin of the coccygeus except (1) for the absence of a white line, and (2) that the original lamina covers the pyriformis muscle, i.e., traced downward from its upper border.

Thus the upper surfaces of coccygeus and lev. ani are covered by the same layer of fascia, a fact already spoken of, and the same is true for their lower surfaces; while, considering the coccygeus alone, the third layer is simply the extreme back part of the layer already mentioned as covering the obt. int. muscle, i.e., where that muscle narrows to its tendon just at its emergence through the lesser ischiatic foramen. Nomenclature: Before further tracing the deep pelvic fascia, a few names may be considered. (The reader may be reminded that so far the superficial pelvic fascia has not been described beyond a few casual references; to which fascia many names are also attached.)

From the pelvic brim to the white line is called by some the obturator fascia. This continues down (under the same name) over the lower third of the muscle. In this case the obturator fascia, at the white line would send off the two layers, investing the levator ani (supra- and infra-anal fasciae).

These two investing layers (upper and lower) are called, by some, respectively the superior layer of the pelvic diaphragmatic fascia and the inferior layer of the pelvic diaphragmatic fascia. These names, however accurate, are cumbersome. Furthermore, it is not made clear by the users of these names that the respective fasciae also cover the coccygeus in an exactly similar manner. For clearness, therefore, we have already designated the upper one of the two layers as the supra-anal fascia, and shall call the lower, the infra-anal fascia. This latter has, for years in the so-called old nomenclature, been called the anal fascia. These names indicate antero-inferiorly the general trend of these fasciae. The supra-anal fascia is called by some authorities the parietal layer of the pelvic fascia.

To sum up, using the author's nomenclature: Traced from the pelvic brim to the upper borders of the coccygeus and lev. ani, the fascia is the deep pelvic

fascia, which along these borders splits into three layers: supra-anal fascia, infra-anal fascia and obturator fascia (Fig. 6).

Before taking up these layers separately, attention should be called to the perineal ramus, i.e., the descending ramus of the pubis and the ramus of the ischium. This shaft of bone has three borders: (1) superolateral, part of the boundary of the obturator foramen; (2) inferolateral; (3) medial. The first two are sharp, the third is rounded. For brevity the first and second may be named respectively "lateral" and "inferior." Of these three borders the inferior and medial are of present interest.

*The infra-anal and obturator fasciae.* These have already been traced from above downward. Between the upper portion of the former and the obturator fascia is a space, the ischiorectal fossa. Tracing these fasciae backward and inward, they meet and unite along the upper border of the coccygeus and the lower edge of the sacrospinous ligament, to which edge they are attached. This attachment also holds the coccygeus onto and along the same edge. This angle of junction between these fasciae is the extreme posterior limit of the ischiorectal fossa, but it is overhung by a small part of the lower border of the glut. max. which is covered in its turn by a fascial prolongation from this same junction. Thus a pocket of the fossa is formed.

Tracing this upper portion of the infra-anal, and obturator, fascia toward the perineum, they meet and unite along the whole length of the medial border of the perineal ramus. This particular tracing is along a horizontal plane. After meeting and uniting, these layers split in two and continue right across the urogenital triangle forming, together with the constrictor urethrae muscle between them, the middle stratum of the urogenital diaphragm; while the fascial layers themselves are known as the triangular ligament of the perineum, the upper (deep) layer of which may be regarded as the prolongation of the infra-anal fascia from side to side; the lower layer is similarly a prolongation from side to side of the obturator fascia. Posteriorly these layers unite along a line drawn transversely between the front ends of the ischial tuberosities. This ligament,

together with the lower portion of the infra-anal fascia, will be further considered under perineum.

The supra-anal fascia has already been described, i.e., below the white line and the upper edge of the coccygeus muscle.

From the pelvic brim down to the upper margin of lev. ani and coccygeus: The deep pelvic fascia traced from above downward or from side to side covers the upper part of the obt. int., the pyriformis, the sacral and pudendal plexuses and the mid-region of the sacrum; and of course passes behind the rectum. The pyriformis: The deep pelvic fascia really splits along the upper border: The front layer has just been mentioned. The back layer, now extrapelvic, covers the posterior surface of the muscle, links up with the front layer along its lower border and becomes part of the deep fascia (fascia lata system) of the gluteal region.

*The obt. int.* A similar splitting of the fascia occurs along that margin of the muscle, above the ischial spine, which looks toward the sacrum. This margin and a portion of the lateral surface of the muscle anterior to it are free so that the secondary split or lamina goes around the margin and on to this surface and fuses with the obturator membrane. The extreme lower part of this lamina goes out of the pelvis with (and investing) the muscle through the lesser sciatic notch and, becoming extrapelvic, covers the gemelli. A prolongation of the original layer accompanies the obturator nerve and vessels through the obturator canal. Another prolongation roofs in Alcock's canal.

#### *The Superficial Pelvic Fascia*

This is the continuation of the superficial intra-abdominal fascia into the pelvis, and similarly, is subperitoneal or sub-serous. Hence it may also be called the subperitoneal or subserous pelvic fascia.

It is of fatty consistency speaking generally and from a gross point of view. In

lean subjects the fatty consistency is scarcely apparent and the fascia becomes more like areolar tissue. In certain regions (to be specified) it is much thicker and more substantial than in others; while in other regions, low down in the pelvis, especially in the female, this fascia contains an abundance of smooth muscle fibers, "loose fatty areolar tissue, and well defined fibro-muscular and elastic bands." (Edward Martin, Berlin; quotation from article by Reginald M. Rawls, M.D., New York, N. Y., in New York State Journal of Medicine, July 1, 1929).

As a matter of gross dissection, without regard to histological elements, this fascia is a sheet of tissue which tucks into and fills up all spaces and intervals: (1) between the deep pelvic fascia and its prolongation (e.g., the supra-anal fascia), on the one hand, and the peritoneum on the other; (2) between the fascia just mentioned and the viscera; (3) between the viscera themselves; and (4) between the viscera and peritoneum.

This subserous pelvic fascia cannot be split definitely into layers e.g., Camper's and Scarpa's fascia; but it has running through it, or situated or embedded in it, all the blood vessels, lymphatics and lymph nodes of the pelvis; also nerve filaments, both sympathetic and those from lower sacral nerves to bladder; the ureter and the vas deferens (ductus efferens).

This fascia as a whole has received many names, among which are the following: tela or tunica adiposa of the pelvis; fascia endopelvina; visceral layer of the pelvic fascia; rectovesical fascia. It has even been depicted, in certain diagrams in Cunningham's Dissector, as a direct offshoot or a splitting from the deep pelvic (supra-anal) fascia. The term recto-vesical fascia is used in this article with but a very restricted meaning (see below).

Posteriorly this fascia passes behind the rectum and across the sacrum, but with the deep pelvic fascia intervening between it and the sacrum (Fig. 5). This retrorectal portion traced upward behind the rectum from the mid-point of the third sacral vertebra, where the rectum begins, becomes the beginning or low-

est part of the tissue between the layers of the mesosigmoideum (most inferior segment of the pelvic mesocolon).

The first part of the rectum extends from the point above mentioned to the ampulla (second part). It is covered by peritoneum on its sides and in front. Hence, it has on these areas, grossly, no subserous tissue or superficial pelvic fascia. On the other hand the ampulla and the upper part of the anal canal (third division of the rectum) are devoid of peritoneum and are completely invested by and imbedded in the superficial pelvic fascia, which is now quite thick and fairly dense.

From this perirectal (meaning around ampulla and upper part of anal canal) region this fascia is continued as a thick soft lamina around and between all the pelvic viscera forward to the back and top of the symphysis pubis. Laterally, below and in front, it lies closely applied to the supra-anal (deep pelvic) fascia. This mass of fascia thus briefly outlined may be considered as the lower stratum of the superficial pelvic fascia. Its upper surface in all directions is curved, concavity upward, and is covered by peritoneum. From the lateral margin of this lower stratum, the fascia is continued upward on each side as a thin lamina to the brim of the pelvis, becoming there the superficial (subserous) intra-abdominal fascia. These laminae are covered medially by peritoneum, and may be called the upper strata of the superficial pelvic fascia.

These laminae are continued around laterally and posteriorly behind the first part of the rectum, where they blend to form the retrorectal tissue already referred to. Each lamina is pierced by the obturator vessels at the beginning of the obturator canal.

*Description, more in detail: Male.* A fairly thick mass of this fascia occupies the space bounded as follows: behind by the rectum, i.e., the ampulla and beginning of the anal canal; and in front by the base (fundus) of the bladder, the ampullae of the vasa deferentia, the seminal vesicles and the posterior (rectal) surface of the prostate. This particular sheet of fascia is the recto-vesical fas-

cia. From side to side: it is wide above, corresponding to the width of the bladder and rectal ampulla, but narrow below, corresponding to the prostate and contracted rectal ampulla which here joins the anal canal. Owing to the close proximity of the rectum to the prostate, the intervening portion of the rectovesical fascia (rectoprostatic fascia) is thin but quite substantial, even more so than the supra-anal fascia underlying it. This fascia, as it covers the posterior (rectal) surface of the prostate, is really in close contact with the capsule of the prostate (see above); but its separation from the capsule by dissection is easily demonstrable. This is also true of its lateral extensions around the sides and apex of the prostate. This closely-enveloping prostatic portion of the rectovesical fascia is the sheath of the prostate, in contradistinction to its capsule. This sheath is traceable on the inferior surface of the gland but becomes very thin and blends near or at the urethra with the capsule (above) and supra-anal fascia (below).

Around the apex of the gland, this sheath is merely part of the general pubovesical fascia (see below). On the upper or vesical surface of the gland the sheath is thin but dense, and blends with the capsule. This particular lamina not only is the upper part of the prostatic sheath, but also is an inward extension of the lateral true ligaments of the bladder (see below).

To return to what has been called the rectoprostatic fascia: This particular lamina or segment of the rectovesical fascia has been called the fascia or aponeurosis of Denonvillier, also Tyrrell's fascia. It has been described and pictured as an "ill-defined fibromuscular layer" extending from (i.e., continuous with) the upper layer of the triangular ligament of the perineum. Its upper limit is not defined. This idea is not at all in accord with the present description. There is a diagram of Denonvillier's fascia in an article in *Surgery, Gynecology and Obstetrics*, February, 1927. The author of the article is Miley B. Wesson, M.D. of San Francisco. I do not agree with the anatomy of this diagram, but I have no doubt that the sheath of the prostate does limit backward extravasation of urine, as described in the article, provided the rupture of the urethra is at the junction of its prostatic and membranous portions. Another diagram of De-

nonvillier's fascia, which seems to me to be totally wrong, appears on page 461 of Gray's Anatomy (Da Costa and Spitzka) 1908.

To return to the rectovesical fascia: as stated, it lies between the rectal ampulla and the base of the bladder. Above, it is curved, concavity upward, and this concavity is covered by a layer of peritoneum, the rectovesical lamina. On each side of this concavity the fascia is raised into a curved ridge which passes backward and blends, or becomes continuous with, the perirectal and retrorectal fascia already mentioned. These curved ridges of rectovesical fascia are the so-called posterior true ligaments of the bladder. Each is covered by a fold (plica) of peritoneum continued upward from the rectovesical lamina, just mentioned. Each plica of course has a free edge of which the lateral leaflet is continued downward and backward covering the pararectal portion of the rectovesical fascia and thus forming the pararectal fossa. Both plicae are called the folds of Douglas, or the rectovesical folds or the posterior false ligaments of the bladder. These plicae are connected on and across the bladder by a fold (usually demonstrable) of peritoneum which runs across the base line of the triangular area known as the base or fundus of the bladder. Between the layers of peritoneum which make the lateral ends of this fold, runs medially the lower end of the vas just before it bends downward (now extraperitoneal) on the surface of the bladder (see above).

This fold is often considered as one structure with the plicae, viz: the genitosacral fold (homologue of the broad ligament in the female). The space bounded by the rectovesical lamina and the rectovesical folds is the rectovesical pouch, fossa, or excavation.

The rectovesical and pararectal fascia is continued forward right around the sides of the bladder into and filling up the space of Retzius between the back of the symphysis and the pubic (non-peritoneal) surface of the bladder. This is a thick layer of considerable density and usually contains fat. Its attachment to the bladder is close and it is then reflected as a thin layer over the bladder and is now covered by the peritoneum lying on the abdominal surface of the organ.

From its attachment to the bladder laterally it reaches to, and lies against the supra-anal fascia, possessing an appreciable curved (from side to side) upper surface (concavity upward) which, when covered by peritoneum, constitutes the paravesical fossa. Its attachment to the supra-anal fascia is along a line parallel with and about one-half inch or less below the white line (q.v.).

This rather substantial layer of fascia on each side is the so-called lateral true ligament of the bladder; while the layer of peritoneum over it, i.e., the floor of the paravesical fossa, is the so-called lateral false ligament of the bladder. Distension of the bladder increases the depth of the fossa.

The upper line of attachment of this fascia to the supra-anal fascia, just referred to, is considered by some to form another white line or arcus of the pelvic fascia. I could never satisfactorily, if at all, demonstrate this line. In any event it must not be confused with the true white line of the supra-anal fascia.

The pubovesical ligaments are parts of the lateral true vesical ligaments. When demonstrable there are three of these special fascial thickenings, one median and two lateral. They all run to the bladder above the apex of the prostate, the lateral from the pubic points (see above) and the median from the back of the symphysis.

*Female.* This fascia has the same general disposition as that of the male. Important modifications are due to the presence of the uterus, tubes, ovaries and vagina; and to the absence of the prostate.

What corresponds to the rectoprostatic and rectovesical fascia in the male is now the rectovaginal fascia, but a much more substantial lamina in all directions. It contains much smooth muscle tissue. This lamina above is covered by the rectovaginal fold or layer of peritoneum forming the bottom of the rectovaginal pouch (pouch of Douglas), resembling the rectovesical pouch in the male. Posteriorly this fascia extends around and behind the rectum and lies in close contact with the deep pelvic fascia covering the levator ani, coccygeus

pyriformis and sacrum.

This backward extension to rectum, etc. just mentioned has a free upper edge on each side. These edges and the fascia of which they are the edges contain much smooth muscle tissue (uterorectal muscle); while the strand to and across the sacrum is the uterosacral ligament. The edges themselves are covered by peritoneum continued upward from the rectovaginal fold. Thus are formed the uterorectal folds or plicae. Each plica at first is single but about halfway back to the rectum it very frequently splits into two folds, one going to the rectum and the other to the sacrum. This means of course a similar splitting of the underlying fascia (uterorectal muscle and uterosacral ligament). These plicae meet anteriorly and form a slight transverse ridge on the posterior surface of the supravaginal portion of the cervix.

Returning to the rectovaginal fascia: anteriorly it lies against and is closely adherent to the posterior wall of the vagina, along the lower three-quarters or four-fifths (approximately) of that portion of the latter which is above the urogenital diaphragm. At this level the rectovaginal fascia, as such, ceases but is continued as a very thin stratum up over the upper one-fourth or one-fifth of the vagina, then on the posterior surface of the supravaginal portion of the cervix uteri, and then becomes part of the parametrium (see below). This thin stratum is covered by peritoneum continued up from the rectovaginal fold. Thus these portions of cervix and vagina are covered by peritoneum. This rectovaginal fascia is often called the perineal body because its base begins in the perineum (q.v.); or the rectovaginal septum.

Without regard to the perineum, the real base of this fascia rests on the supra-anal (deep pelvic) fascia where the latter in its turn rests on the upper layer of the triangular ligament of the perineum and on a small area of the infra-anal fascia. This base is much wider sagittally and transversely than the upper part, owing to the increased distance between vagina and anal canal.

Continued forward on each side, this fascia becomes a substantial lamina in-

vesting the sides and front of the vagina, the anterior and lateral surfaces of the supravaginal portion of the cervix, the urethra, and the bladder. It finally fills in the space of Retzius, as in the male.

Where it lies between bladder and cervix, just as it bends up to become the parametrium, this fascia is covered by the uterovesical fold or layer of peritoneum forming the uterovesical pouch. The pubovesical ligaments are thickened strands of this fascia similar to those in the male (q.v.). Of these ligaments the two lateral ones are said to be continued backward to the cervix, i.e., the pubocervical ligaments. These may cause the slight ridges not infrequently seen on each side of the uterovesical pouch (uterovesical plicae).

The lateral ligaments of the bladder, the paravesical fossae and the pararectal fossae are the same as in the male and formed in the same manner. But the two fossae, on each side, are separated from each other by the lowest and narrowest portion of the broad ligaments of the uterus.

These ligaments or lateral mesenteries of the uterus each contain between their two layers of peritoneum a thin lamina of fascia prolonged directly inward and upward (disregarding the normal anteversion of the uterus) from the subserous fascia.

The shape of this lamina is the same as that of the broad ligament. It has four borders and is now considered to be spread out flat.

(1) The *lateral* border runs at first downward from a little in front of the sacroiliac joint to a little behind the spine of the ischium; and then inward to the junction of cervix with body of uterus.

(2) The *uterine* border is attached to the lateral border of the uterus, taking in a trifle of the same border of the cervix. From this attachment the fascia is reflected right around the uterus, thus becoming the parametrium already referred to, which in its turn is covered by the perimetrium (peritoneum).

(3) The *superior* border runs along with the Fallopian tube (oviduct) and invests it, covered, in its turn, of course by peritoneum.

(4) The *superolateral* border is comparatively short. It is curved, concavity upward and outward. It extends from below the attachment to the ovary of the ovarian fimbria to the upper end of the lateral border. At this point the ovarian vessels enter the broad ligament. Surmounting this border is a free edge of peritoneum (the infundibulopelvic plica or ligament). The border (fascia) itself is the suspensory ligament of the ovary.

The uterine artery runs inward through the lower part of this intra-broad ligament fascial lamina, while the ureter runs forward where this lamina comes off from the parietal part, after hooking under the artery. The ovary receives a delicate prolongation from the same lamina covered by peritoneum, the mesovarium.

*Supplementary remarks.* That portion of the superficial pelvic fascia between the vagina and urethra may be called the urethrovaginal septum. Its texture is much more delicate than that of its upward prolongation between bladder and vagina. This septum is made up entirely, or practically so, of smooth muscle tissue, according to Dr. Byron H. Goff, of New York City, who kindly showed me some slides he had prepared of this tissue. In Dr. Goff's article, "Secondary Reconstruction of Damaged Pelvic Floor," Surgery, Gynecology and Obstetrics, June, 1928, the description of the anatomy of the pelvic floor is clear and, in the main, correct.

*Exceptions.* (1) Colles' fascia is not continuous with the posterior (conjoined) margins of the triangular ligament of the perineum (q.v.) but is merely adherent to them and then passes into the ischiorectal fossa. Furthermore, between the fascia of Colles and the superficial perineal muscles is a third layer of fascia (see perineum) which is continuous, over spermatic cord (external spermatic fascia) and penis, with the fascia between the tendon of the external oblique and Scarpa's fascia, the latter being, as correctly stated, continuous

with that of Colles'.

(2) The glands of Bartholin I have found between the layers of the triangular ligament (deep perineal interspace) and not, as stated, in the superficial perineal interspace. As homologues of Cowper's glands, they should have the same situation.

The article also gives quotations from Sturmdorf and Halban. The former's description of the "pubic segments" of the levator ani is essentially the same as that already given of the pubococcygeus. The rather extensive dimensions, however, as to width and thickness which he gives, I have never noticed.

Halban (Operative Treatment of Female Genital Prolapses, Vienna, 1919) recognizes, as I do, "Two distinct fasciae in the pelvis," the "muscle fascia" (deep pelvic or supra-anal fascia) and the "fascia endopelvina" (superficial or subserous pelvic fascia). However, he says the fascia endopelvina is "composed of a parietal and visceral portion." This statement is not in accordance with the description of this fascia which I have given. Nevertheless, the "theory of Halban and Tandler that the fascia endopelvina is a fascial sheath surrounding completely the uterus, bladder and rectum" is correct.

#### *The Fascia of the Urogenital Triangle (Perineum) and Ischiorectal Triangle*

These areas have been outlined and defined. Their fasciae will now be considered, as a unit, disregarding partial descriptions previously made.

As these combined areas are the pelvic outlet their fasciae might be called collectively the FASCIA of the PELVIC OUTLET.

This fascia, like that of all other regions, has a superficial and a deep layer, the latter, similarly to deep fascia elsewhere, characterized by splitting into subsidiary layers to enclose muscles and other higher structures.

### *The Deep Fascia of the Pelvic Outlet and Perineum*

This comprises the infra-anal fascia and its three derivatives, viz; the fascia between the fascia of Colles and the superficial perineal muscles, to be called the inferior perineal fascia; and the triangular ligament (two layers) of the perineum. Also that portion of the supra-anal fascia which covers the upper surfaces of the pubococcygeus muscles and is applied to the upper surface of the deep layer of the triangular ligament, already described.

*The infra-anal fascia:* (1) The portion not covering the pubococcygeus muscle is continued up to the white line and then downward as the obturator fascia, as already described. Traced medially, this fascia reaches and is attached to the medial border of the pubo-ischial ramus along which it meets the obturator fascia. These two layers unite along this border and then immediately split and are prolonged into the two layers of the triangular ligament. Thus the inferior surface of the pubococcygeus muscle in the region of the perineum lies on top of the lateral part of the deep layer of the triangular ligament which now takes the place of the infra-anal fascia.

(2) The portion covering the pubococcygeus muscle also covers the external sphincter ani muscle. This layer is continued forward, widening as it proceeds, until it reaches the posterior borders of the superficial transverse perinei muscles. Along this line, still continuing forward, it splits into three layers: the inferior perineal fascia and the two layers of the triangular ligament. There is, however, a small shallow pocket at the extreme outer end of the sup. trans. perin. This pocket is situated above, i.e., deep to the muscle and is formed as follows: The infra-anal fascia proceeds to the anterior border of the trans. perin. muscle and then is reflected back around the muscle to become the inferior perineal fascia.

Posteriorly the infra-anal fascia is continuous with the deep fascia of the back. *The inferior perineal fascia.* This is, in general, of a triangular outline, but not so well defined as that of the triangular ligament. This fascia, in the first place,

covers the superficial (see below) perineal muscles thus forming the so-called superficial perineal pouch or interspace, of which the inferior boundary is stated erroneously by most writers to be Colles' fascia.

Continued forward, i.e., from the subpubic ligament where the perineum as a region ends and the penis begins, this fascia becomes the lower segment of the tubular deep fascia of the penis and thereby is continuous with the deep layer of the extra-abdominal fascia (q.v.; also see inferior layer of triangular ligament). Furthermore, on each side of the root of the penis this fascia, now no longer to be called inferior perineal, ascends on the body of the pubis to the pubic crest (lower margin of the ring) as part of the deep layer of the extra-abdominal fascia, and then bends sharply downward to become the posterior portion of the tubular external spermatic fascia of the spermatic cord (q.v.). Thus this bend of the fascia lies over or above a similar bend described below under Colles' fascia (Fig. 4.)

The inferior perineal fascia traced from side to side: The lateral margins are attached to the entire medial border of the pubo-ischial ramus above (deep to) the crus penis which in its turn is attached to the comparatively broad surface of the ramus which lies between the medial and inferior borders of the same. From this medial border the fascia is reflected around, i.e., below (superficial to) the ischiocavernosus muscle and the crus and then after adhering to the inferior border of the ramus becomes continuous with the deep fascia of the thigh. This line of attachment is much firmer than that along the medial border (Fig. 5).

On each side of the midline there is a muscular triangle formed by the three superficial muscles of the perineum. Thus the inferior perineal fascia not only covers these muscles but also is in contact, within the confines of this triangle, with the under surface of the inferior (superficial) layer of the triangular ligament.

The superficial (so-called in all textbooks) perineal muscles are really deep

muscles, since they lie beneath (deep to) a layer of deep fascia, i.e., the inferior perineal fascia. They are collectively the lowermost or, counting from below upward, the first muscular stratum of the perineum. The deep perineal muscles (see below) are the second stratum; and the two pubococcygeus muscles (anterior portions) are the third stratum. These three strata with their fasciae constitute the urogenital diaphragm (see above).

The muscles of the first stratum are: (1) bulbocavernosus, also called accelerator urinae (male) and sphincter vaginae (female); (2) ischiocavernosus, also called erector penis or clitoridis; (3) superficial transverse perineal (both sexes). Morphologically the external sphincter ani belongs to this group, but topographically it does not lie in the true perineum.

*The triangular ligament* of the perineum. As already stated this ligament consists of two layers of fascia, the inferior or superficial and the superior or deep. The space between them is known as the deep perineal pouch or interspace. Posteriorly these layers are united because they, together with the inferior perineal fascia, are simply splits of the infra-anal fascia, already described.

Laterally these layers join together along, and are attached to, the medial borders of the pubo-ischial rami each of which begins at the front of the ischial tuberosity (which is the meeting place of crus penis, ischio-cavernosus and trans. perin. muscles) and extends to the subpubic ligament (inferior border of symphysis).

At this point, traced forward (or upward), the two layers separate: The inferior layer passes in front of the extreme lower part of the symphysis just deep to where the corpus spongiosum (cavernous urethrae) unites with the corpora cavernosa, and then blends, around the upper ends of the bulbocavernosus and ischiocavernosus muscles, with the inferior perineal fascia to form or become the posterolateral segment of the deep fascia of the penis.

The superior layer passes behind the symphysis and at about the level of the

two pubic points (see above) blends with the deep pelvic or supra-anal fascia to become the transversalis fascia (Fig. 4).

Just below the subpubic (arcuate) ligament the deep dorsal vein of the penis (clitoris) pierces both layers of the triangular ligament and is invested by some very delicate fibers from each layer. These fibers have been named, somewhat unnecessarily (?) the "transverse pelvic ligament."

Among other structures found between these layers of the triangular ligament are: (1) The deep perineal muscles; (2) urethra (male); (3) urethra and vagina (female); (4) bulbo-urethral glands (Cowper's, male); (5) vestibular glands (Bartholin's, female).

Each of these layers blends with the wall of urethra (both sexes) and vagina where it is pierced by these structures.

*The deep perineal muscles.* These are: (1) the variously called compressor, constrictor, sphincter urethrae (male); urogenital sphincter (female); and (2) the deep transverse perineal (both sexes).

Laterally these muscles (frequently (2) is simply the back border of (1)) have a very thin edge which is tucked in between the lateral attachments of the layers of the triangular ligament. Medially these muscles are attached, from behind forward, to the central tendinous point of the perineum (perineal center, see below); the vagina (female) and urethra (both sexes), surrounding the membranous portions of these tubes.

*The perineal center.* This is an area of fused planes of fascia (see below) situated in the male, between the anus and bulb of the corpus spongiosum; in the female, between the anus and vagina. The extent, approximately, of this area in all directions is male, half an inch; female, one inch more or less. Other figures are given in the textbooks. The planes of fascia, the fusion of which forms this area, are, from below upward: (1) inferior perineal fascia; (2) both layers

of the triangular ligament i.e., the midpoint of the line of splitting of the infra-anal fascia, of which a small portion may share in the fusion; and (3) the supra-anal fascia.

To this perineal center are attached fibers of all the perineal muscles both superficial and deep, including the ext. sphinct. ani, except the ischiocavernosus.

In the female the area of the center included within the attached fibers of all these muscles is much more extensive than in the male. In the latter these fibers are very close together — so much so that the "center" is often called the "point."

Resting on and closely adherent to the upper surface of the supra-anal fascial portion of the center is the base of the rectovaginal septum, also known as the perineal body (see above.) In the male, similarly, is attached the base of the rectoprostatic and rectovesical fascia (q.v.), rarely spoken of as the "perineal body." The dimensions of this lamina of fascia, except perhaps from side to side, are considerably less than those of the rectovaginal septum. It is also less substantial than the latter.

Colles' fascia (see below) is fairly well adherent to the center. Very frequently the skin area corresponding to the region between anus and vagina is called the perineum.

Returning to the medial border of the puboischial ramus: along this entire border we find attached the following planes or layers of deep fascia: (1) inferior perineal fascia; (2) inferior layer of triangular ligament; (3) superior layer of triangular ligament; (4) infra-anal fascia; and (5) obturator fascia. The supra-anal fascia is not attached to this border because it is shifted away from it, so to speak, by the interposition of the lev. ani, where this muscle, considered as a sheet, curves medially to become the pubococcygeus, which now comes to lie between the superior layer of the triangular ligament below and the supra-anal fascia above (Fig. 5).

Thus the two pubococcygeus muscles, from a perineal point of view, constitute a third muscular stratum, considering always the medial free border of each and the intervening supra-anal fascia (previously described).

### *The Superficial Perineal Fascia*

This is continuous with the superficial extra-abdominal fascia and similarly may be split into two layers: the superficial, which has no name but which corresponds to Camper's fascia; and the deep layer, known as Colles' fascia, and which corresponds to Scarpa's fascia.

*Fascia of Colles.* This covers, i.e., lies below or superficial to, the inferior perineal fascia, and has the same lateral attachments, i.e., the medial and inferior borders of the pubo-ischial ramus, from the latter of which it continues down the thigh, on which it is the same plane of fascia as that of the cribriform fascia previously mentioned.

Posteriorly, Colles' fascia, after its adherence along the line of splitting of the infra-anal fascia (see above) including the perineal center, follows everywhere the infra-anal fascia, i.e., around the ext. sphincter ani (circumanal fascia) and up into the ischio-rectal fossa to and just under the white line, then down over the obturator fascia, and then on the posterior aspect of the thigh. The circumanal fascia simply keeps on backward and upward and becomes the deep layer of the superficial fascia of the back.

Anterosuperiorly, Colles' fascia, along the line of the sub-pubic ligament, ceases and becomes Scarpa's fascia. In the midline, this part of Scarpa's fascia, together with Camper's fascia, after blending with the scrotal septum (see below), covers the penis posteriorly and is part of the dartos (see penis and extra-abdominal fascia). Just lateral to this mid-line, Colles' fascia becomes that portion of Scarpa's fascia which ascends to a line somewhat below the lower border of the subcutaneous inguinal ring (pubic crest) and then bends rather sharply downward behind the spermatic cord (q.v.) to form, together with

Camper's fascia, the back of the dartos of the scrotum (q.v.).

The superficial layer of the superficial perineal fascia (corresponding to Camper's fascia on the abdomen) simply covers and follows Colles' fascia in all directions. On entering the ischiorectal fossa, it becomes a pad of fat which completely fills the fossa.

## Special Regions

### *The Inguinal Canal*

The inguinal canal is a slit, morphologically, between the ext. and int. obi. muscles, in which lies the spermatic cord (genetic cord in female). Its upper end is halfway between ant. sup. iliac spine and pubic tubercle; its lower end is the subcutaneous inguinal ring (often referred to as the "ring"). This canal will be described in two portions: the annular, and the intermuscular.

(1) *Intermuscular portion.* This is the slit above mentioned. Its floor is a slight groove formed by the adhesion of the transversalis fascia to that portion of the inguinal ligament which is antero-inferior to the upper end of the canal. Postero-superior to this end, there is no slit or canal because from all along this portion of the inguinal ligament arise those downwardly curving fibers of the int. obi. and trans. abd. muscles which unite into a common (conjoined) tendon which is inserted into the pubic crest.

These curved fibers and conjoined tendon have a lower free curved edge which lies close to the cord. Of this free edge, the upper two-thirds, on an average, is muscle, the rest, tendon. This free edge is the roof of the canal. Not infrequently this edge is tucked down behind the cord, without being attached to the inguinal ligament, in which case the int. obi. is said to be the posterior wall of the canal. The real posterior wall, however, is the transversalis fascia.

Returning to the floor: The adhesion to the inguinal ligament of the transversalis fascia, already spoken of, begins below, at the pubic tubercle. This means that the downward reflection of the fascia from the outer pillar of the ring would lie against the upper surface of the lacunar ligament (q.v.) and thus exclude the latter from any share in the formation of the floor of the inguinal canal. Such share is stated to exist in some text books. The anterior wall of the canal is the tendon of the ext. obl. immediately superior to the inguinal ligament.

(2) *The annular or ring portion* of the inguinal canal. Anteriorly is simply the superficial ring previously described. The floor is the pubic crest.

The posterior wall, as a whole attached to the crest, has against or in front of it the cord (spermatic or genetic) and is made up of two elements. These are from before backward: (1) the reflected inguinal ligament, already described (rarely observed); (2) the conjoined tendon (reflected inguinal falx). This has just been mentioned. Its chief and constant insertion is into the pubic crest. In some cases there is a thin prolongation (reflection) from this tendon, for a variable distance along the pectineal line, which with difficulty can be differentiated from the transversalis fascia behind it. This occasional reflection has been thought of sufficient importance to warrant the change of name as above indicated, the necessity for which I fail to see.

Behind the conjoined tendon are the pyramidalis and tendon of the rectus abd. muscle; and then the transversalis fascia.

*The spermatic cord.* This, aside from vessels and nerves, is made up of the vas deferens and at first three and then four tubular evaginations of fascia which completely surround it (see scrotum and dartos). Speaking generally, these evaginations are caused by the descent of the testicle from its original intra-abdominal position. Lower down these tubes widen so as to surround the testicle also, including the vas where it lies against the epididymis (see ligamentum scroti). The cord, as such, ends at the top of the testicle. The downward continuation of its fasciae surrounding the testicle, taken together, is called the tu-

nica vaginalis communis. Between the inner surface of the latter and the testicle is a serous sac, the tunica vaginalis propria. The parietal layer of this sac lines the inner surface of the communis and is then reflected, along the line of apposition of vas to epididymis, over the latter and the testicle as the visceral layer. This cannot be peeled off from the testicle and must not be confused with the capsule of the latter, viz., the tunica albuginea.

The cord lies in the inguinal canal and emerges through the ring. In the canal the vas has three of the investments referred to, while after emergence through the ring it has four.

These investments are: (1) The external spermatic or intercolumnar fascia. This has been referred to previously under deep layer of the extra-abdominal fascia (fascia innominata) and perineum. It may be repeated that after its posterior and inferior attachment to the lower border (pubic crest) of the ring it passes downward to the level of the subpubic ligament where it becomes or is continuous with the inferior perineal fascia (q.v.).

This lamina lies behind a similar downward prolongation of Scarpa's fascia (see scrotum and dartos). Medially each tubular external spermatic fascia is connected with the other by a lamina which, as it crosses the midline, blends with and forms part of the suspensory ligament of the penis (q.v.). From above downward this lamina is simply the lower part of the fascia innominata (deep extra-abdominal fascia).

(2) The cremasteric or middle spermatic fascia is the tubular evagination from the int. obi. and trans. abd. muscles. It consists of a series of loops of muscle (cremaster muscle) connected by delicate fascia. Postero-superiorly it is attached to the inguinal ligament.

(3) The internal spermatic or infundibuliform fascia is the evagination from the transversalis fascia (deep intra-abdominal) already outlined.

(4) This covering of the vas is not definitely spoken of in the textbooks. It lies next to the vas, hence is deep to (3). It is evaginated from the superficial (subserous) intra-abdominal fascia (q.v.). It may be called the vascular (or innermost) spermatic fascia, because it carries the vascular supply of the testicle and cord. Ordinarily it is very thin and can be shown only if the vessels are well injected. This is because the usual fat in the subserous fascia ceases as a rule where the evagination begins. Lipoma of the cord is excessive fat in this fascia.

All these fascial envelopes are closely united with each other and the innermost one with the vas by innumerable fine trabeculae. Between the circumference of the cord as a whole and the superficial fascia (dartos) of the scrotum (q.v.) surrounding it there are also connecting trabeculae which are readily demonstrable owing to the greater interval between cord and dartos.

*Processus vaginalis.* This is the tubular evagination of peritoneum which is continuous with the tunica vaginalis propria of the testicle, during and after descent of the latter. The communication between the peritoneal cavity and that of the tunica by means of this process is done away with by obliteration of the latter, which normally occurs within a year or two after birth.

The so-called vestigial strand of the processus vaginalis, I have never been able to find.

The genetic cord corresponds, in the female, to the male spermatic cord. The main structure, however, is the ligamentum teres (round ligament) of the uterus, around which are the same fascial envelopes as those of the vas in the male. They must be named, however, "genetic" instead of "spermatic." These fasciae terminate distally by blending with the superficial fascia of the labium majus (q.v.), the skin of which is said to receive the end of the round ligament now divided into several small filaments practically impossible to dissect grossly. Many textbooks call the genetic cord "the round ligament," thus causing confusion to the student. The round ligament is the homologue of the gu-

bernaculum testis which latter finally shrinks to become the ligamentum scroti (see scrotum).

### *The Abdominal (or Deep) Inguinal Ring*

In the sense that the subcutaneous (superficial) ring is a ring, i.e., a hole in a tendon (previously described), this deep ring does not exist. It is really the shallow-funnel-shaped aperture between the great bag of transversalis fascia and the tubular evagination from the latter known as the infundibuliform or internal spermatic fascia. Regarded from in front, this aperture is placed at the beginning (upper end) of the inguinal canal. Regarded from behind, this aperture, lined by the beginning of the innermost spermatic fascia and peritoneum, forms the lateral inguinal fovea or fossa; just medial to which, (its medial boundary), is the inferior (deep) epigastric artery covered posteriorly by a fold of peritoneum, the plica epigastrica. The vas (in female, round ligament of the uterus) hooks around this artery laterally in order to enter the inguinal canal.

*Interfovealar ligament.* This is a delicate strand of tissue lying immediately behind and somewhat to the inner side of, but wider than, the deep epigastric artery, giving support, as it were, to the latter against the pressure of the vas and the spermatic vessels. The name is derived from its position between two fossae, the lateral just mentioned, and the medial inguinal fovea of which in its turn the medial boundary is the umbilical (obliterated hypogastric) artery covered by the plica hypogastrica. A direct inguinal hernia begins to extrude in this fossa, while an indirect or oblique inguinal hernia starts in the lateral fossa.

The interfovealar ligament is often known as the ligament of Hesselbach. Around its lateral margin are evaginated all the fasciae of the cord except the external spermatic fascia. This ligament is not at all easily demonstrable. In the great majority of subjects it appears to be merely a thickening of the transversalis fascia.

In some subjects, however, this ligament is evidently derived from the upper

part of the lower free edge of the conjoined tendon (q.v.) and runs downward to be attached to the inguinal ligament. It would thus be tendinous in nature.

It is suggested that this ligament is the vestigial inner boundary of the primordial true abdominal inguinal ring, i.e., a hole in the conjoined tendon, at a period when the lower free edge of the latter and of its muscles was presumably attached along the entire length of the inguinal ligament. The future canal and two rings would be formed around the still more primitive genito-inguinal ligament, ancestor of the gubernaculum testis and the round ligament of the uterus. Then absorption of the tissue of the conjoined tendon would occur, both lateral and medial to the primordial ring, resulting in the adult condition; and in the survival in some cases of a fairly well-defined Hesselbach's ligament. Varying degrees of absorption medially would account for the reflected portion of the conjoined tendon previously described.

The scrotum and dartos (see also superficial fascia of abdomen and perineum). Developmentally each half of the scrotum is distinct from the other, homologue of the labium majus. These two skin bags, each lined with a fascial bag (dartos), then coalesce along their medial surfaces, the skin element being completely absorbed. Thus a permanent septum is formed by the coalescence of the medial surface of each dartos with that of the other, and the scrotal bag is divided into two, marked by a skin raphe front and back.

The bag idea, however, applies only to the larger part of the scrotum, i.e., that which hangs down from between the under surface of the root of the penis in front and the anterior limit of the perineum behind.

Above, i.e., from the side of the root of the penis up to the level of the subcutaneous inguinal ring, each half of the scrotum is distinct from the other.

It diverges from the common bag below. It resembles in a general way the labium majus. It may form a slight elevation; or if not, it may be pinched up, when the cord will be felt. Laterally the skin passes into continuity with that of

the thigh. Medially the skin passes across the midline to be in continuity with the skin of the opposite scrotum. Below, this lamina of skin covers the penis above, and is continuous around the reflection of the prepuce with the skin of the penile under surface and then with the skin of the anterior surface of the scrotal bag. The opening of the urethra must be allowed for.

Although this upper part of the skin of the scrotum is not a tube, the dartos (Scarpa's and Camper's fascia) is a tube, and surrounds the cord. Medially from this tubular dartos is derived a lamina which crosses the midline to join the dartos of the opposite side. In crossing the midline this lamina blends with and is part of the suspensory ligament of the penis (q.v.).

From above downward this lamina is simply the lowermost portion of Scarpa's and Camper's fascia (q.v.).

Furthermore, the posterior segment of this tubular dartos lies against, i.e., in front of, its own downward reflection from just below the line of the pubic crest, this reflected lamina continuing into or becoming the superficial perineal fascia at the level of the subpubic ligament. Thus a sort of edge is formed, over which hooks downward the external spermatic fascia (q.v.) from along the pubic crest (Fig. 4). This edge or sharp bend, circumferentially traced, is continuous with a much blunter bend in front where the up-and-down plane of the superficial abdominal fascia changes to the plane of the scrotum. Thus a sort of circular margin exists (around the cord) which is doubtless the third inguinal ring named and described from a somewhat different point of view, by A. Lee McGregor, M.B. (Edin.) etc. Johannesburg, South Africa, in an article in Surgery, Gynecology and Obstetrics, September, 1929, kindly loaned me by Dr. Carnes Weeks of the Department of Anatomy.

The subject of the article is chiefly surgical, i.e., ectopic testicle; and the fascia of this region is described with the view of explaining the occurrence of this abnormality in various situations. The fascial descriptions are based on original dissections which apparently have been most carefully made. Sometimes,

however, undue stress as well as unnecessary names have been given to minute "structures," e.g. a certain thickened strand of fibers in Scarpa's fascia is called "Scarpa's ligament," etc.

On the other hand, to be noted with entire agreement, are two statements: (1) That there is a layer of "deep fascia of the perineum, covering the superficial perineal muscles," which is deep to Colles' fascia; (2) that Scarpa's fascia passes around behind the spermatic cord.

*Ligamentum scroti.* This, the remains of the gubernaculum testis, is usually said to be a cord of tissue running from the lower end of the testicle, between the lines of reflection of the parietal and visceral layers of the tunica vaginalis propria (q.v.), to the skin of the scrotum, passing right through the intervening tissues, i.e., the layers of the tunica vaginalis communis (q.v.) and the dartos. I have never been able to demonstrate this cord, except for a very short bit close to the testicle. What is demonstrable, however, is a substantial, somewhat transversely placed lamina of tissue which occupies the narrow interval between lower end of testicle and skin of scrotum, and which as a whole is firmly attached to both of these structures. This lamina is a condensation and thickening, along the line of the primordial gubernaculum testis, of all the fasciae which have hitherto been described as surrounding the vas and testicle, i.e., the tunica vaginalis communis and dartos (Fig. 4).

*The penis.* This structure is the coalescence of three cylinders of cavernous tissue which takes place just at and under the subpubic ligament.

The deep fascia of the penis is of course tubular and is quite substantial. It is closely adherent to the fibrous capsules of the three cylinders above mentioned. On the glans penis (end of corpus spongiosum) it is absolutely adherent to the capsule and also to the overlying prolongation of the superficial penile fascia (dartos), in its turn very thin and almost a part of the delicate modified skin overlying it.

The formation of the deep fascia of the penis, around its base, as mentioned in previous sections of this article, is as follows: above, a layer of fascia made up of the union of the fascia innominata with the inferior layer of the triangular ligament of the perineum, just above the subpubic ligament; below, a prolongation of the inferior perineal fascia; laterally, a curved union of the upper and lower layers. The inferior perineal fascia also links up with the triangular ligament (inferior layer) by bending around behind the extreme upper end of the corpus spongiosum.

This deep fascia of the penis is essentially Buck's fascia referred to by Wesson in the same article previously mentioned under rectoprostatic fascia. The article appears to quote Buck's own description, and gives two diagrams. "A membranous sheath" is Buck's name for this fascia.

The description is, as of a local structure, essentially the same as that I have given. There is some confusion as to identity of fascial planes around the root of the penis, both in text and diagrams. "A transverse septum" between corpora cavernosa and corpus spongiosum does exist.

*The suspensory ligament of the penis.* This it seems to me is a single structure (see below). It is triangular, base upward, and extends from a variable distance above the symphysis to the root of the penis. It is simply a circumscribed thickening and condensation of the three layers of the extra-abdominal fascia, deep (innominate) and superficial (Scarpa's and Camper's). At the root of the penis the first named of these fasciae becomes the deep fascia of the penis, and the other two run into and become the dartos of the same.

At this level a split can be made by dissecting from below upwards when it will be seen that the deeper lamina is the more substantial, while the superficial one as a rule is mostly fat. However, many authorities, including McGregor (already quoted), divide this ligament into two parts: (1) the fundiform or superficial suspensory ligament; (2) the deep suspensory ligament.

The superficial fascia or dartos of the penis has been sufficiently described. However, two points might be noted: (1) The narrow area of dartos corresponding to the raphe on the skin of the penis is continued into the septum of the scrotum (q.v.); (2) The prepuce contains between its two layers of skin a prolongation of the dartos.

*The labium majus.* The arrangement of its skin is like that of the upper part of the scrotum (q.v.) viz., it is not a tube or bag. From the subcutaneous inguinal ring down to the upper end of the labium, the genetic cord may be demonstrated grossly by dissecting off the overlying superficial fascia (Scarpa's and Camper's), just as may be done for the spermatic cord in the male. These fasciae likewise surround the genetic cord. In the labium they also form a sort of capsule, anteriorly lining the skin of the labium and posteriorly resting against its own fascia which passes downward from near the pubic crest (see spermatic cord). Anteriorly this capsule can be split into two layers, of which the superficial contains considerable fat. However, in the lowest part of the labium these layers blend into a dartos.

All the tissues of the genetic cord, including the round ligament except one modification (see below), as they enter the labium break up into slender strands which penetrate and lose themselves by blending with the capsule above mentioned.

The terminal filaments of the round ligament are stated to extend even to the skin.

These strands and filaments cannot of course be demonstrated grossly.

*The modification* (just spoken of). What may be called the core of the labium majus is a distinct pad of fat about equal to the labium in length. It lies within the capsule just described, from which it may be readily shelled out. Its light yellow shade of color and more delicate texture differentiate it quite distinctly from the surrounding capsule. This core is the enlarged lower end of the innermost

fascia of the genetic cord (q.v. also spermatic cord). In only very fat subjects can this connection be grossly demonstrated. To quote from Piersol's Anatomy: "The center of the labium is occupied by a fairly well defined mass of fat (corpus adiposum) that is connected with the adipose tissue within the inguinal canal continuous with the subperitoneal tissue and is therefore of different derivation from that of the subcutaneous fat, from which it is separated by a delicate fascia." This "delicate fascia," from the wording presumably a distinct structure, I have never been able to demonstrate. It might be a part of the corpus adiposum itself or a thin slice from the under surface of Scarpa's fascia.

Repetition of description of various fascial structures in this article is noticeable. This is due to the necessity, in the writer's opinion, of describing these structures from different points of view.

For example, the various fascial layers of the spermatic cord should be considered not only collectively as making up the cord but also individually, each as a derivative from its own great plane of fascia; also, the infra-anal fascia is part of the deep pelvic fascia, as well as of the fascia of the pelvic outlet and perineum.

\* \* \* \* \*

## Figures

1. Horizontal section (lumbar region)
2. Transverse vertical section (schematic) of pelvis
3. Sagittal section just medial to right ant. sup. iliac spine
4. Sagittal section to right of midline through body of pubis, inguinal ring, scrotum, and testicle
5. Horizontal section (schematic) of pelvis
6. Frontal section (aorta)

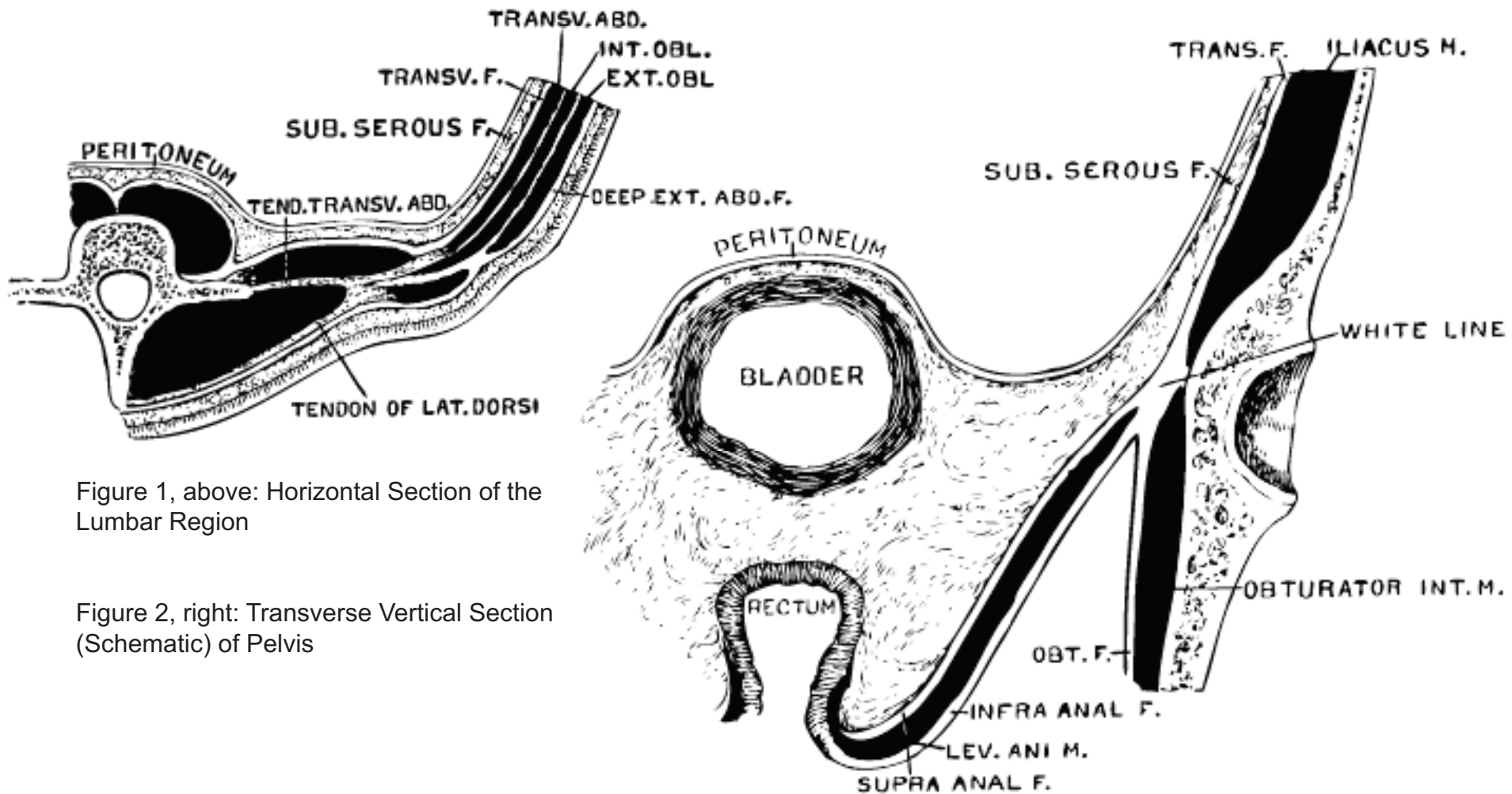


Figure 1, above: Horizontal Section of the Lumbar Region

Figure 2, right: Transverse Vertical Section (Schematic) of Pelvis

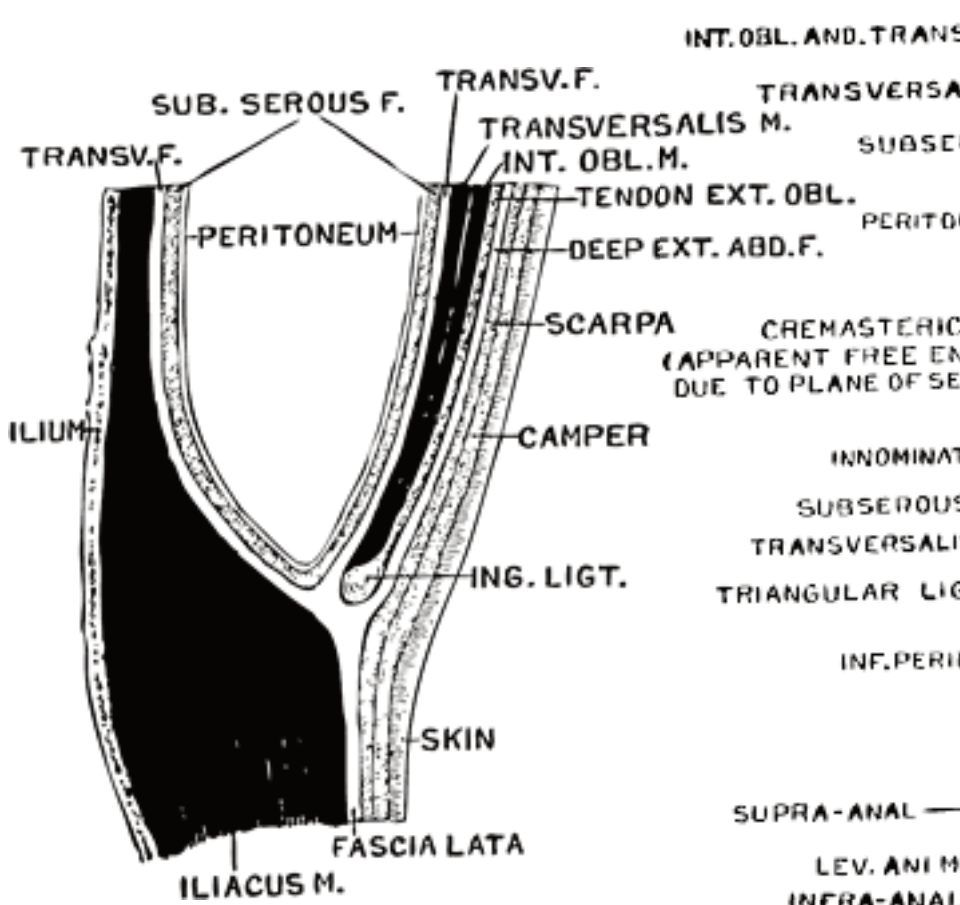


Figure 3: Sagittal Section Just Medial to Right Ant. Sup. Iliac Spine

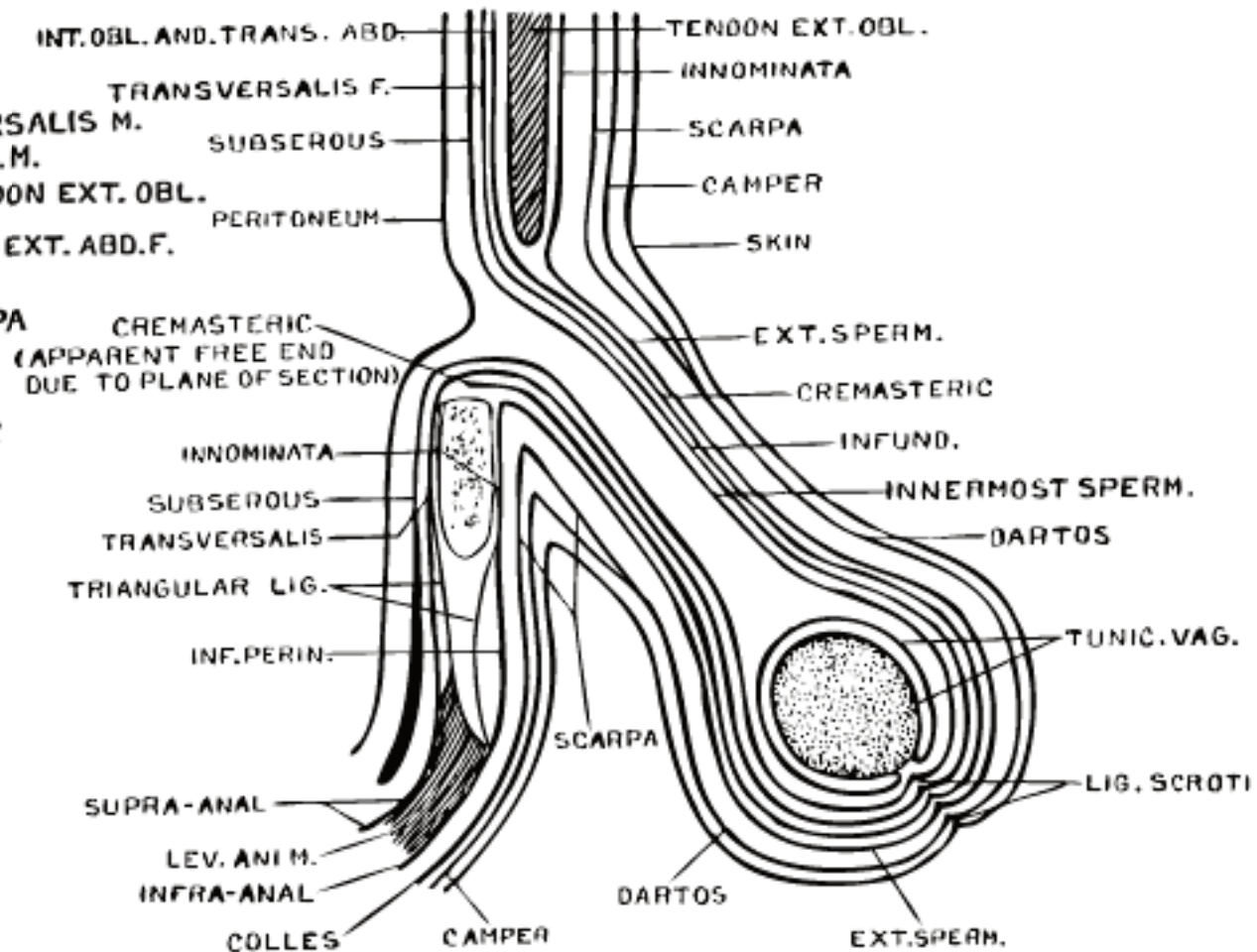


Figure 4: Sagittal Section to Right of Midline Through Body of Pubis, Inguinal Ring, Scrotum, and Testicle

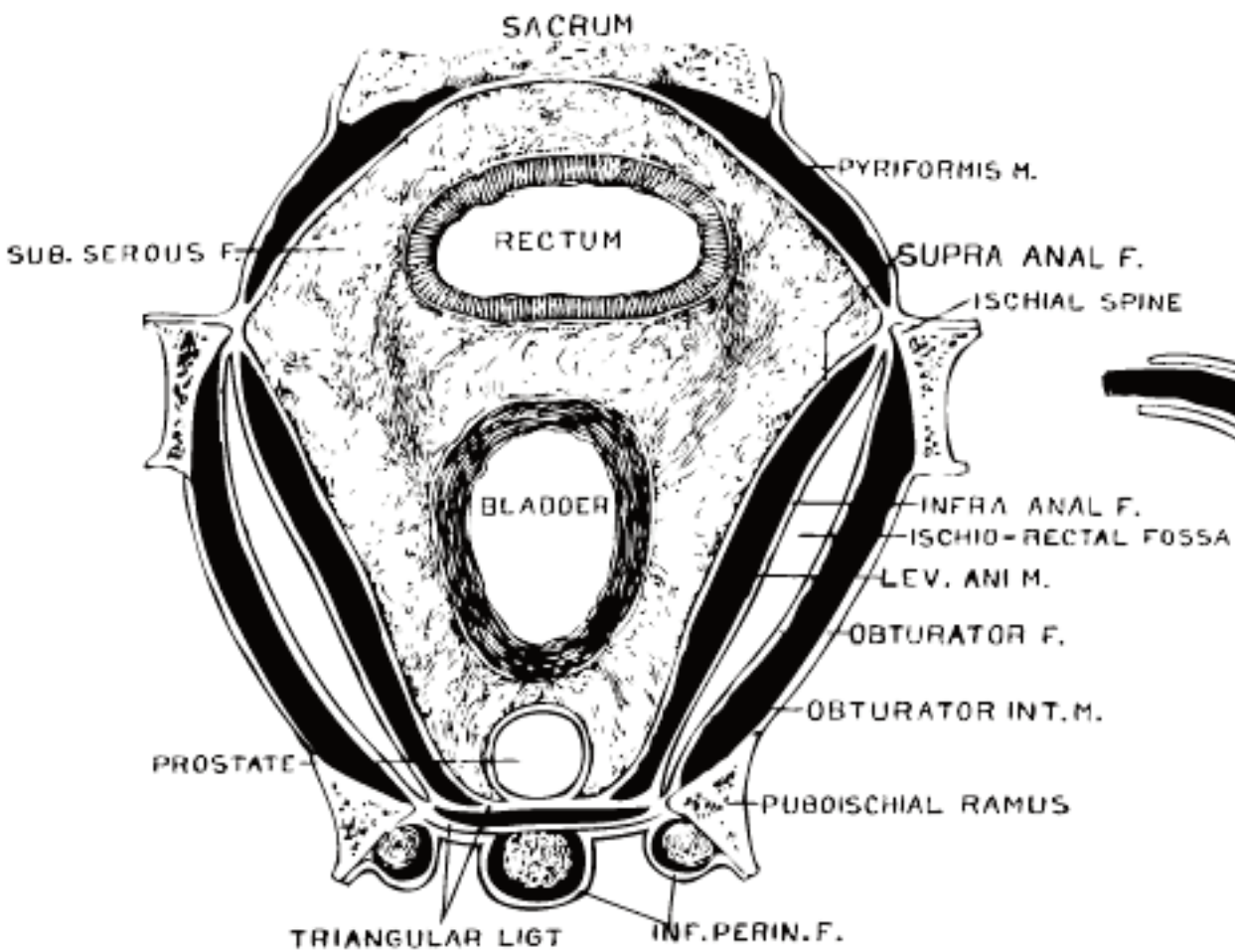


Figure 5: Horizontal Section (Schematic) of Pelvis

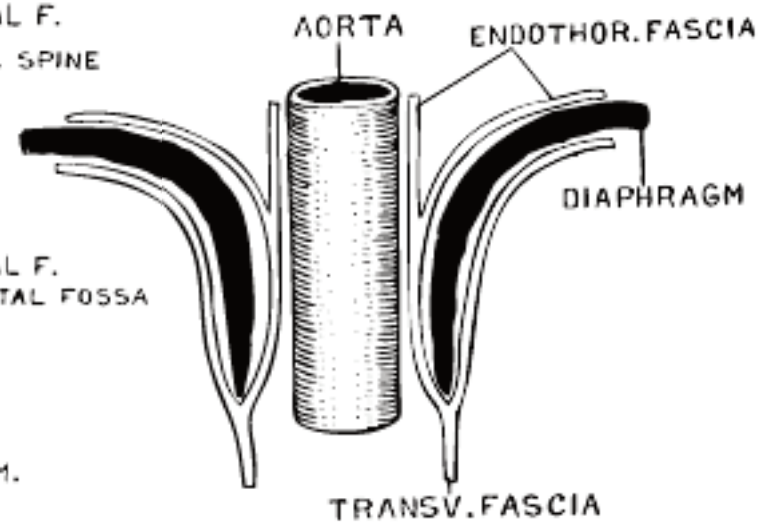


Figure 6: Frontal Section