Chapter 1: Clinical anatomy of the pelvis and reproductive tract

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Introduction

This chapter aims to summarize the important aspects of the anatomy of the abdomen and the pelvis, which should be known to the Obstetric or Gynaecological specialist. Many of the investigations and treatments we order on a daily basis require good anatomical knowledge in order to be properly understood.

Surface anatomy

The anterior abdominal wall can be divided into four quadrants by lines passing horizontally and vertically through the umbilicus (Fig. 1.1). In the upper abdomen is the epigastrium, which is the area just inferior to the xiphisternum, and in the lower abdomen lie the right and left iliac fossae and the hypogastrium.

The cutaneous nerve supply of the anterior abdominal wall arises from the anterior rami of the lower thoracic and lumbar vertebrae. The dermatomes of significant
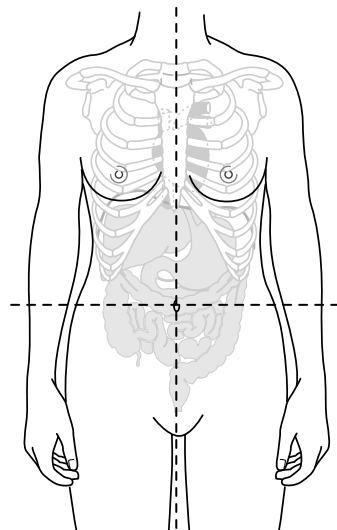

Fig. 1.1 The abdomen can be divided into quadrants.

structures on the anterior abdominal wall are:

T7   xiphisternum
T10 umbilicus
L1   symphysis pubis

The blood supply is via the superior epigastric (branch of the internal thoracic artery) and the inferior epigastric (branch of the external iliac artery) vessels. During laparoscopy, the inferior epigastric vessels can be seen between the peritoneum and rectus muscle on the anterior abdominal wall and commence their journey superiorly from approximately two thirds of the way along the inguinal ligament closer to the symphysis pubis. Care needs to be taken to avoid them while using accessory trochars during laparoscopy and to ensure that they are identified when making a Maylard incision of the abdominal wall.

The anterior abdominal wall

Beneath the skin and the fat of the superficial anterior abdominal wall lies a sheath and combination of muscles including the rectus abdominus, external and internal oblique and tranversalis muscles (Fig. 1.2). Where these muscles coalesce in the midline, the linea alba is formed. Pyramidalis muscle is present in almost all women originating on the anterior surface of the pubis and inserting into the linea alba. The exact configuration of the muscles encountered by the surgeon depends on exactly where any incision is made.

The umbilicus

The umbilicus is essentially a scar made from the remnants of the umbilical cord. It is situated in the linea alba and in a variable position depending on the obesity of the patient. However the base of the umbilicus is always the thinnest part of the anterior abdominal wall and is the commonest site of insertion of the primary port in laparoscopy. The urachus is the remains of the allantois from the fetus and runs from the apex of the bladder to the umbilicus.
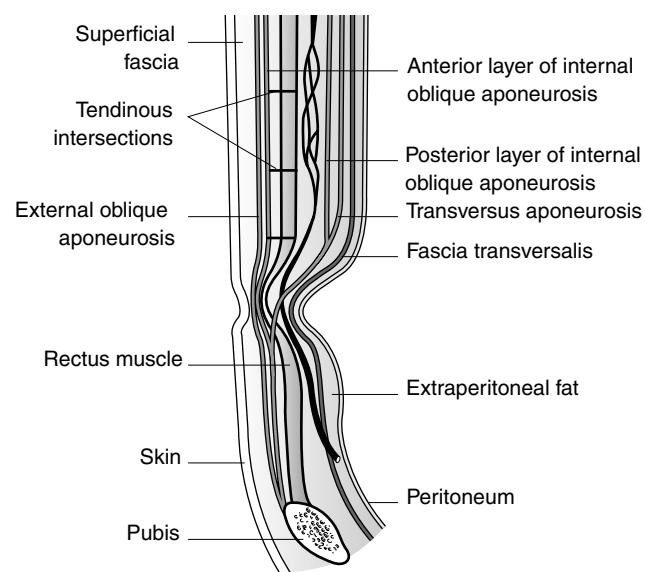
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Fig. 1.2 The layers of the anterior abdominal wall in tranverse section.
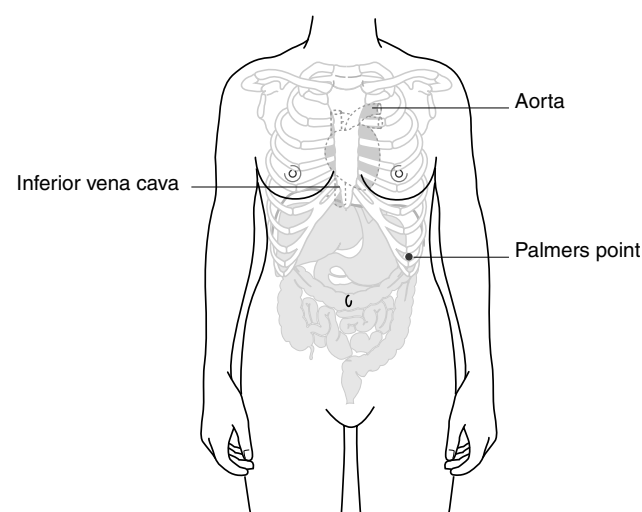

Fig. 1.3 The umbilicus in relation to the underlying vasculature in a thin patient.

Occasionally this can remain patent in newborns. In early embryological life, the vitelline duct also runs through the umbilicus from the developing midgut. Although the duct is severed long before delivery, a remnant of this structure is found in 2% of the population as a Meckels diverticulum.

The aorta divides into the common iliac arteries approximately 1–2 cm below the umbilicus in most slim women (Fig. 1.3). The common iliac veins combine to form the inferior vena cava just below this and all these structures

are a potential hazard for the laparoscopist inserting ports at the umbilicus.

Epithelium of the genital tract

The anterior abdominal wall including the vulva, vagina and perineal areas are lined with squamous epithelium. The epithelium lining the endocervix and uterine cavity is columnar and the squamocolumnar junction usually arises at the ectocervix in women of reproductive age. This is an important site as it is the area from which cervical intraepithelial neoplasia (CIN) and eventually cervical malignancy arises. The bladder is lined by transitional epithelium which becomes columnar. The anal verge is still squamous epithelium but this changes to columnar immediately inside the anus and into the rectum.

The genital tract, from the vagina, through the uterus and out through the fallopian tubes into the peritoneal cavity, is an open passage. This is an essential route for the traversing of sperm in the process of fertilization but unfortunately it also allows the transport of pathologic organisms which may result in ascending infection.

The peritoneum

The peritoneum is a thin serous membrane which lines the inside of the pelvic and abdominal cavities. In simplistic terms it is probably best to imagine a pelvis containing the bladder, uterus and rectum (Fig. 1.4) and note that the peritoneum is a layer placed over these organs in a single sheet. This complete layer is then pierced by both the fallopian tubes and the ovaries on each side. Posteriorly the rectum also pierces the peritoneum connecting to the sigmoid colon and the area between the posterior surface of the uterus and its supporting ligaments and the rectum is called the Pouch of Douglas. This particular area is important in gynaecology as the place where gravity dependent fluid collects. As a result this is where blood is found in ectopic pregnancies, pus in infections and endometriosis which has been caused by retrograde menstruation (Sampsons theory).

Vulva

The vulva is the area of the perineum including the Mons pubis, labia majora and minora and the opening into both the vagina and urethra (Fig. 1.5). The labia majora are areas of skin with underlying fat pads which bound the vagina. Medial to these are the labia minora which consist of vascular tissue which reacts to the stimulation of sexual arousal. Anteriorly they come together to form the prepuce of the clitoris and posteriorly they form the forchette.
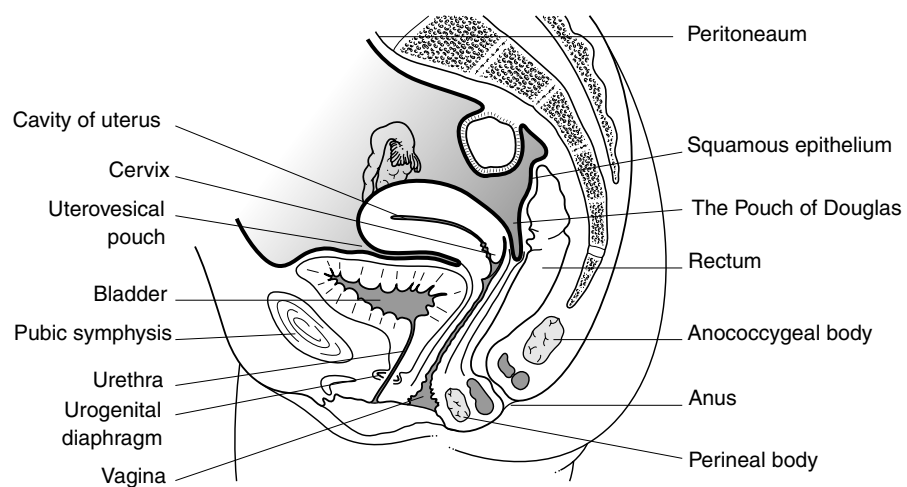
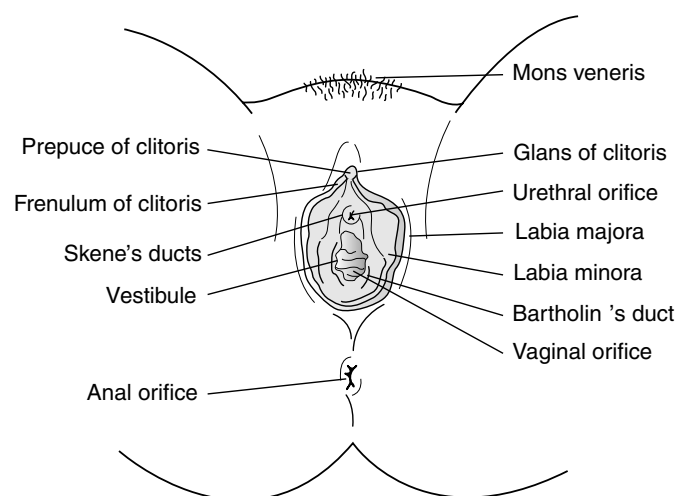**Fig. 1.4** Transverse view of the pelvic organs.

Fig. 1.5 Surface anatomy of the vulva.

The hymen is a fold of vaginal mucosa at the entrance to this organ. It usually has a small opening in virgins and is only seen as an irregular remnant in sexually active women.

To each side of the introitus are the ducts of the vestibular glands commonly known as Bartholin's glands which produce much of the lubrication at sexual intercourse.

The vulval blood supply comes from the pudendal artery and lymphatic drainage is through the inguinal lymph nodes. The nerve supply comes mostly from the pudendal nerve and pelvic plexus with branches of the perineal nerves and posterior cutaneous nerve of the thigh important in the posterior region.

The clitoris

The clitoris corresponds to the male penis consisting of the same three masses of erectile tissue (Fig. 1.6). The bulb of the vestibule is attached to the underlying urogenital diaphragm and split into two because of the presence of the vagina. The right and left crura become the corpora cavernosa and are covered by the ischiocavernosus muscles.

Bony pelvis

The bony pelvis consists of two hip bones (consisting of the ileum and ischium) which are joined together by the sacrum posteriorly and the symphysis pubis anteriorly (Figs. 1.7 and 1.8). In addition, the coccyx lies on the inferior aspect of the sacrum. A plane drawn between the sacral promontory and the superior aspect of the symphysis pubis marks the pelvic inlet and a similar plane drawn from the tip of S5 to the inferior aspect of the symphysis pubis marks the pelvic outlet.

Clinically the ischial spine is important as it can be felt vaginally and progress in labour can be measured using it as a landmark. Additionally it is an insertion point of the sacrospinous ligament which also attaches to the lower lateral part of the sacrum. Together with the sacrotuberous ligament and the bony pelvis, it forms the borders of the greater sciatic foramen (through which the sciatic nerve passes) and the lesser sciatic foramen (through which the pudenal nerve enters the pelvis).

The sacrum and ilium are joined by the very strong sacroiliac joint. This is a synovial joint and is supported by the posterior and interosseous sacroiliac ligaments. The symphysis pubis is a cartilaginous joint with a fibrocartilaginous disc separating the two bones which are firmly bound together by the supporting ligaments. There should be virtually no movement of this joint.

Pelvic floor (Figs. 1.9 and 1.10)

The obturator internus muscle sits on the medial side of the ischial bone and, together with the body of the pubis, forms a wall that supports the origins of the pelvic floor. The pelvic floor itself is a sling of various muscles which are pierced by the urethra, the vagina and the anal canal. Posterior to the vagina these muscles form the perineal body. The puborectalis muscle forms a sling around the junction of the anus and rectum and posterior to the anus, these fibres are made up by the pubococcygeus which forms the anococcygeal body in the midline (Fig. 1.9). The collection of muscles is variously referred to as the pelvic diaphragm or levator ani muscles (Fig. 1.10). These muscles support the pelvic organs, holding them in position and resisting the forces created when the intraperitoneal
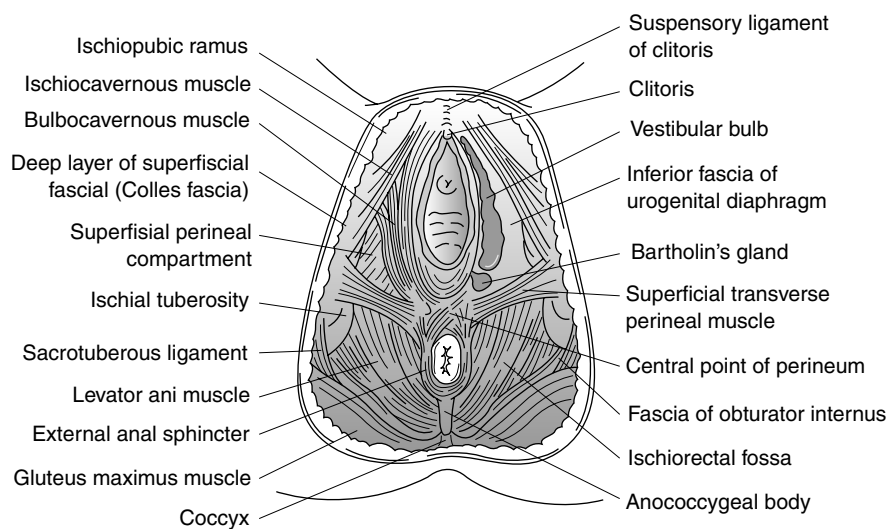

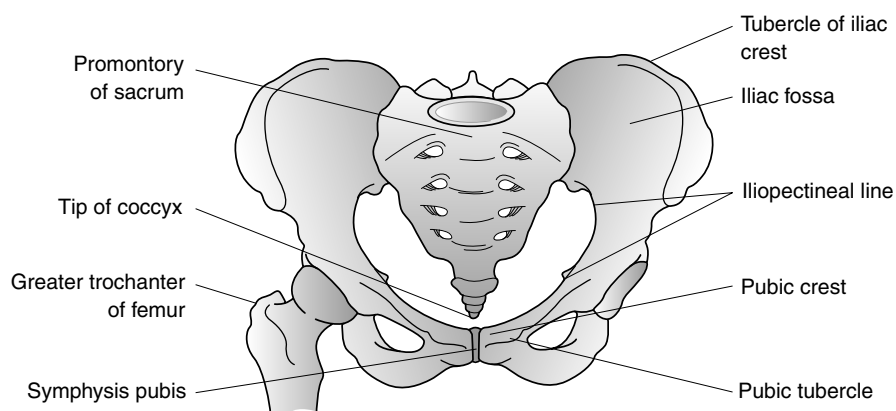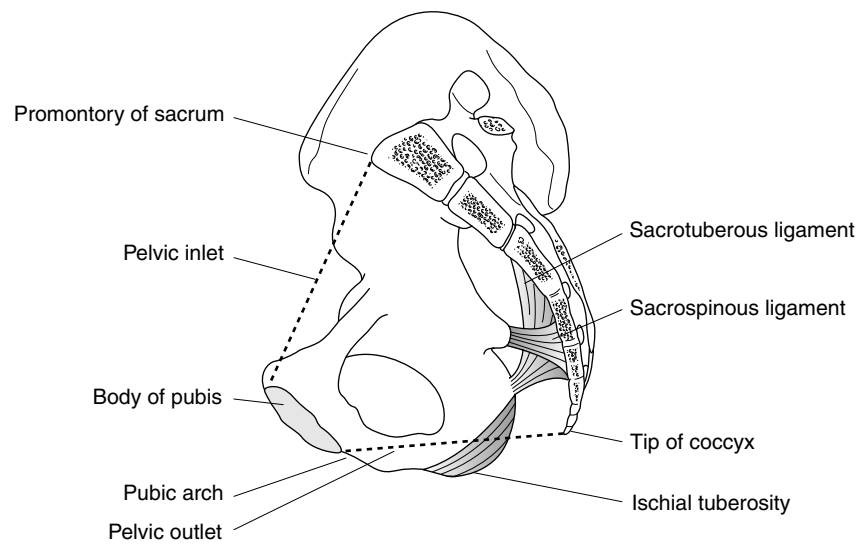**Fig. 1.6** The deeper vulval tissues.

Fig. 1.7 Bony pelvis.

Promontory of sacrum

Pelvic inlet

Body of pubis

Pubic arch

Pelvic outlet

Sacrotuberous ligament

Sacrospinous ligament

Tip of coccyx

Ischial tuberosity

Fig. 1.8 Bony pelvis.

Symphysis pubis

Levator prostate or sphincter vaginae

Puborectalis

Pubococcygeus

Anococcygeal body

Tip of coccyx

Perineal body

Junction of rectum and anal canal

Iliococcygeus

Coccyggeus

Fig. 1.9 Pelvic floor muscles.

Sacrotuberous ligament

Ischial spine

Linear thickening of fascia covering obturator internus muscle

Uterine wall

Obturator canal
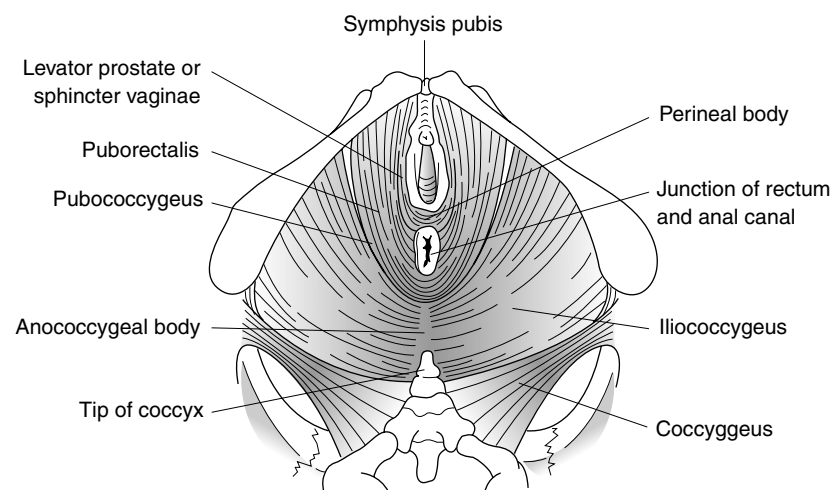
Obturator internus muscle

Coccyx
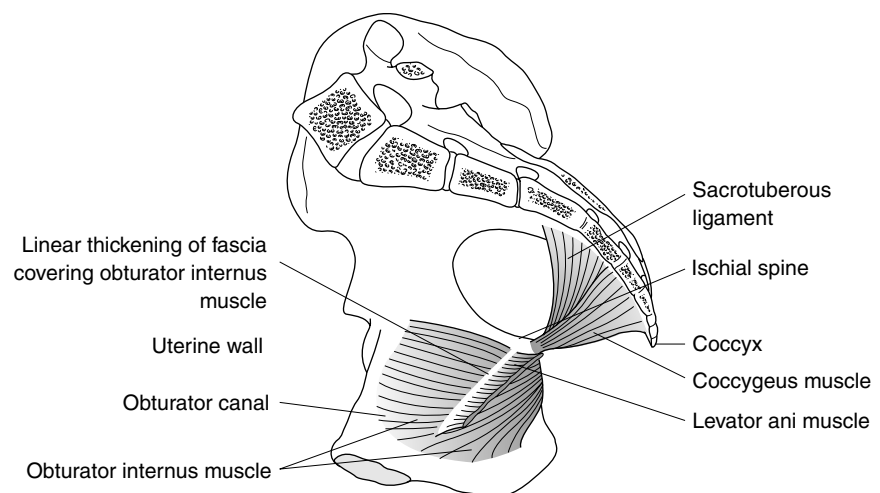
Coccygeus muscle

Levator ani muscle

Fig. 1.10 Transverse view of the pelvic floor muscles.

Fig. 1.11 MRI of the pelvis.

pressure is raised as in coughing or straining. The nerve supply is from the fourth sacral nerve and pudendal nerve.

Pelvic organs (Fig. 1.11)

Vagina

The vagina is a distensible muscular tube which passes from the introitus to the cervix. It pierces the pelvic floor and then lies flat on its posterior surface using it as support. It is approximately 8 cm long and the anterior and posterior walls oppose each other. Anatomical text books can give a confusing impression when showing this structure as an open tube with a lumen. However, on imaging, the normal vagina should not be distended and does not contain air. Projecting into the top of the vagina is the uterine cervix. The areas of the vagina which border the cervix are referred to as the fornices and are labelled as anterior, posterior, right or left.

The vaginal wall consists of outer and inner circular layers of muscles which cannot be distinguished from each other. The epithelium contains no glands but is rich in glycogen in the premenopausal woman. The normal commensal, Doderleins bacillus, breaks down this glycogen to create an acid environment.

Uterus

The uterus is approximately the size and shape of a pear with a central cavity and thick muscular walls (Fig. 1.12).

The serosal surface is the closely applied peritoneum beneath which is the myometrium which is a smooth muscle supported by connective tissue. The myometrium is made up of three layers of muscle, external, intermediate and internal layers. Clinically this is important as fibroids leave the layers intact and removal through a superficial incision leaves the three layers intact. The three layers run in complimentary directions which encourage vascular occlusion during contraction, an important aspect of menstrual blood loss and postpartum haemostasis. The mucous membrane overlying the myometrium to line the cavity is the endometrium. Glands of the endometrium pierce the myometrium and a single layer of columnar epithelium on the surface changes cyclically in response to the menstrual cycle.

The uterus consists of a fundus superiorly, a body, an isthmus (internal os) and inferiorly the cervix (external os). The cervix is a cylindrical structure which is muscular in its upper portions but this gives way to fibrous connective tissue as the cervix sits at the top of the vagina. The cervix is lined by columnar epithelium, which secretes alkaline mucus neutralizing the effects of vaginal acidity.

The cervix and uterus do not always sit in the same plane and when the uterine body rotates anteriorly it is referred to as anteflexed and posteriorly as retroflexed. The axis of the entire uterus can be anteverted or retroverted in relation to the axis of the vagina (Fig. 1.13).

The uterus is supported by the muscles of the pelvic floor together with three supporting condensations of connective tissue. The pubocervical ligaments run from the cervix anteriorly to the pubis, the cardinal ligaments pass laterally from the cervix and upper vagina to the lateral pelvic side walls and the uterosacral ligaments from the cervix and upper vagina to the sacrum. These uterosacral ligaments can be clearly seen posterior to the uterus in the Pouch of Douglas and are a common site for superficial and deep infiltrating endometriosis.

The uterine blood supply is derived mainly from the uterine artery, a branch of the anterior division of the internal iliac artery. An anastamosis occurs with the blood supply delivered through the ovarian ligament and derived direct from the ovarian artery.

The round ligament is the remains of the gubernaculum and extends from the uterus laterally to the pelvic side wall and then into the inguinal canal before passing down into the labia majora. It holds the uterus in anteversion, although it is a highly distensible structure in pregnancy. It is usually the first structure divided at hysterectomy allowing the surgeon to open the overlying folds of peritoneum known as the broad ligament.
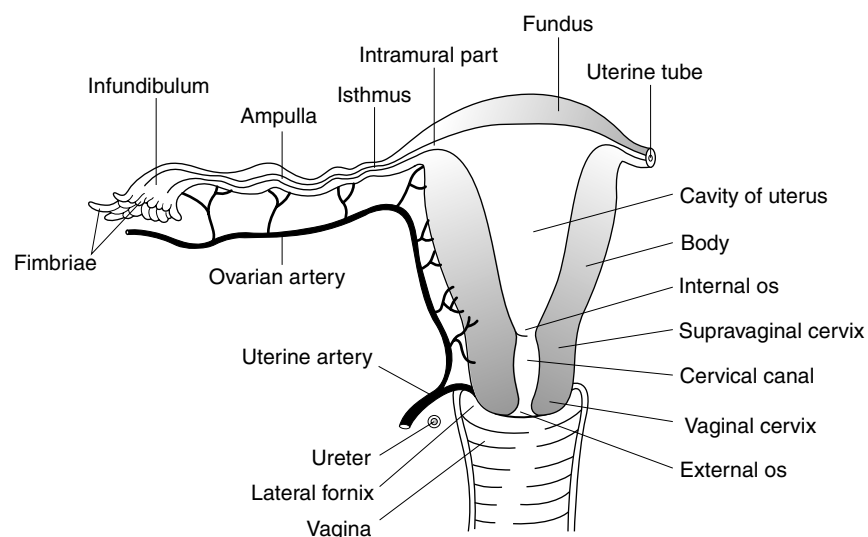
Fig. 1.12 Uterus and fallopian tubes.

Fallopian tubes

The fallopian tubes are delicate tubular structures which carry the ovum or sperm between the ovary and uterine cavity. The tubes are divided into named regions, most medially the cornu and interstial portion within the uterine wall, then the isthmus followed by the infundibulum, ampulla and finally fimbrial ends. They are lined by columnar epithelium and cilia which together with the peristaltic action of the surrounding smooth muscle propel the fertilized ovum towards the uterine cavity. The blood supply of the fallopian tubes arises from both the uterine and ovarian arteries through the mesosalpinx which is covered by peritoneum.

Ovaries

The ovaries vary in size depending on age and their function. They are approximately $2 \times 4\,\text{cm}^2$ with the long axis running vertically and are attached to the posterior leaf of the broad ligament by the mesovarium. In addition they are fixed in position by the ovarian ligament (to the uterus medially) and the infundibulopelvic ligament which contains the ovarian blood supply direct from the aorta. Venous drainage is to the ovarian veins which drain direct into the inferior vena cava on the right and into the renal vein on the left. The aortic nerve plexus also accompanies the ovary in its descent from around the level of the first lumbar vertebra.

The lateral pelvic side wall is covered by peritoneum which is folded to form the ovarian fossa. Pathological adhesions around the ovary will often cause it to be
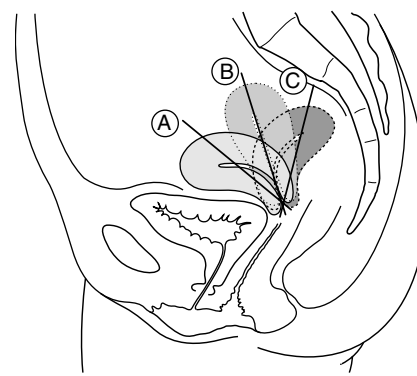

Fig. 1.13 The axis of the uterus in relation to the vagina.

fixed into the ovarian fossa causing cyclical pain or dyspareunia.

The ovary is not covered by peritoneum but is surrounded by a thin membranous capsule, the tunica albuginea, which in turn is covered by the germinal epithelium.

Bladder

The urinary bladder is situated immediately behind the pubic bone and anterior to the uterine cervix and upper vagina. It has a strong muscular wall consisting of three layers of interlacing fibres which are known together as the detrusor muscles (Fig. 1.14). The trigone is the only smooth part of the bladder as it is fixed to the underlying muscle. At the superior margins of the trigone lie the ureteric openings and at the inferior aspect the urethra.
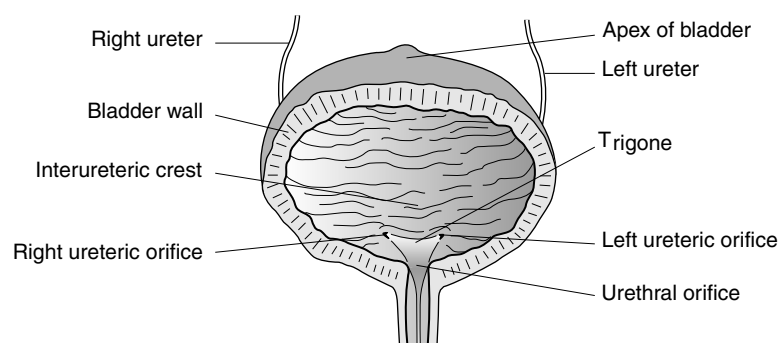
Fig. 1.14 The bladder.

An interureteric ridge can often be visualized horizontally between the ureters at cystoscopy and is useful for orientation.

The rest of the bladder is highly distensible ensuring that as it is expanded the pressure of its contents remains the same.

The bladder receives its blood supply from the superior and inferior vesical arteries which originate from the internal iliac artery. The nerve supply is from the inferior hypogastric plexus. Sympathetic nerves arise in the first and second lumbar ganglia and the parasympathetic supply from the splanchnic nerves of the second, third and fourth sacral nerves.

URETHRA

The urethra is approximately 4 cm long in the female adult starting at the internal meatus of the bladder and passing through the pelvic floor to the vestibule. The epithelium is squamous near the external meatus and changes to transitional epithelium about two thirds of the way to the bladder. The deeper tissue is muscular and this maintains the urethral tone. There are no anatomical sphincters but the muscle fibres of the bladder at the internal meatus act as an 'internal sphincter' and the pelvic floor as a voluntary external sphincter.

URETERS

The ureters run from the renal hilum to the trigone of the bladder and are approximately 30 cm in length. They enter the pelvis by passing over the common iliac bifurcation at the pelvic brim. They then pass along the lateral pelvic side wall before passing anteriorly and medially under the uterine artery as it originates from the internal iliac artery and into the base of the bladder. The ureter comes close to the ovarian artery and vein and can be adherent to these vessels or the overlying ovary in pathological

cases. By passing close to the uterine artery it can be mistakenly clamped and divided as a rare complication of hysterectomy.

The ureters are muscular tubes lined by transitional epithelium. The blood supply varies during its course but small vessels along the surface of the ureter require careful preservation when dissecting it free from other structures.

Rectum

The rectum is approximately 12 cm in length and starts at the level of S3 as a continuation of the sigmoid colon. The puborectalis part of the pelvic floor forms a sling around the lower end at the junction with the anal canal. The rectum is commonly depicted in anatomic drawing as being dilated, causing the other pelvic organs to be pushed forward. This is because the original drawings were taken from cadavers but in the live patient the rectum is often empty allowing the other structures to lie supported on the pelvic floor.

The mucosa of the rectum is columnar and this is surrounded by inner circular and outer longitudinal fibres of smooth muscle. The serosal surface is covered by peritoneum.

The blood supply is from the superior rectal artery from the inferior mesenteric artery, and the middle and inferior rectal arteries arise from the posterior division of the internal iliac artery. The nerve supply is from the inferior hypogastric plexus and ensures the rectum is sensitive to stretch only.

Conclusion

A clear knowledge of anatomy is required for many gynaecological diagnoses and certainly for surgery. Many clinicians do not gain a full understanding of pelvic anatomy until they start operating and then

rarely refer back to anatomical textbooks. The advent of more sophisticated pelvic floor surgery and especially minimal access surgery has modified the skills required of a gynaecological surgeon which necessitates the need for greater practical anatomical knowledge.

Further reading

Shah Farthing & Richardson Lennard (2003) *The Interactive Pelvis & Perineum: Female*. Primal Pitures Ltd, www.primalpictures.com

Snell R. *Clinical Anatomy for Medical Students*. London: Little Brown & Co.