1 Surgical Anatomy of the Male External Genitalia

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Introduction

As with all surgical procedures, an understanding of the anatomy not only allows planning for reconstructive procedures, but also allows the genitourethral surgeon to revert to basic anatomic principles when faced with difficult cases, complications or revision surgery.

The perineum

The male external genital organs comprise the penis, scrotum and scrotal contents. Any detailed description of the anatomy of the external genitalia, whether in the male or in the female, would be incomplete without a preliminary consideration of the anatomy of the perineum. The perineum refers to the lowest part of the trunk. It lies immediately below the pelvic floor (levator ani) and is flanked by the inner aspect of the proximal ends of the thighs and also by the inferior parts of the buttocks. When the thighs and buttocks are parted, the perineum may be pictured as lying within the osseo-ligamentous framework of the inferior pelvic aperture. This framework has a diamond-shaped outline (Figure 1.1): the four angles of the diamond being the sub-pubic angle anteriorly (long arrow), the coccyx posteriorly (short arrow) and the right and left ischial tuberosities on either side. The four sides of the diamond are the right and left ischiopubic rami anterolaterally, and the inferior edges of the right and left sacro-tuberous ligaments posterolaterally (Figure 1.1).

A transverse line drawn between the anterior ends of the right and left ischial tuberosities is seen to divide the perineum into two triangular divisions. The anterior division is the smaller of the two and is known as the urogenital triangle (urogenital region) of the perineum, while the larger posterior division is the anal triangle (anal region) of the perineum. The anal triangle of the perineum is similar in the two sexes, and contains the centrally located anal canal flanked by the right and left ischioanal (ischiorectal) fossae.

Stretching across the width of the urogenital triangle of the perineum from the inner surface of one ischiopubic ramus to the other is a distinct fascial layer termed the perineal membrane. The perineal membrane is quadrangular in outline and is confined to the urogenital triangle of the perineum (Figure 1.2).

It serves to demarcate the two principal subdivisions of the urogenital triangle: the deep perineal pouch and superficial perineal pouch. The former lies deep to (i.e. above) the perineal membrane and contains the membranous urethra, external urethral sphincter (the voluntary, striated muscle sphincter) and the deep transverse perinei muscles. Additionally, in the male, the bulbo-urethral glands (Cowper's glands) are situated in the deep perineal pouch, posterolateral to the membranous urethra. The ducts of the bulbo-urethral glands, however, penetrate the perineal membrane and open into the bulbous urethra in the superficial perineal pouch.

The superficial perineal pouch lies superficial to (i.e. below) the perineal membrane. This demarcation into the superficial and deep perineal pouches is more apparent in the male subject (owing to the perineal membrane being a more readily demonstrable entity in the male). The male external genitalia are situated entirely in the superficial perineal pouch. The gap between the anterior edge of the perineal membrane and the inferior border

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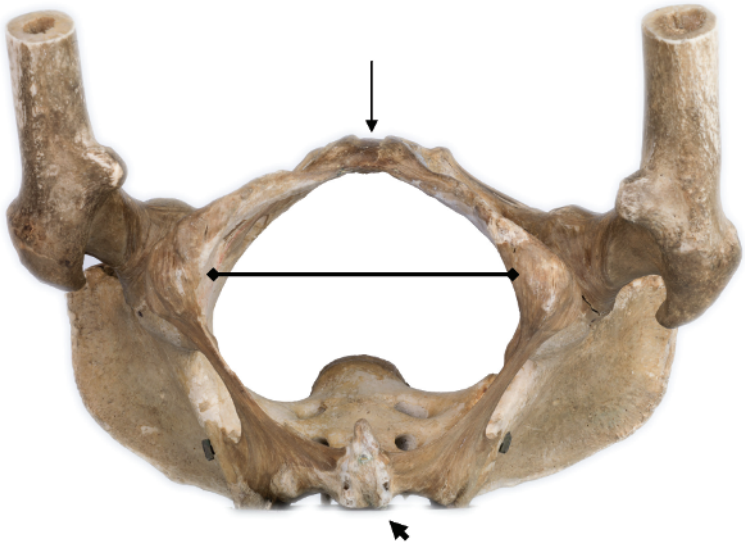

Figure 1.1 Pelvic outlet showing the urogenital and anal regions. The dividing line separates the outlet into a triangular anterior urogenital region containing the external genitalia. The anal region contains the anal canal and ischioanal fossae.

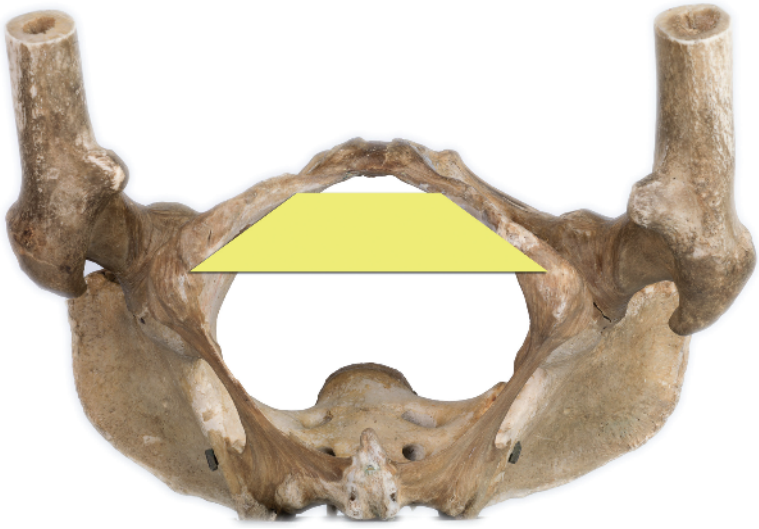

Figure 1.2 Outline of the quadrangular perineal membrane confined to the urogenital triangle of the perineum.

of the pubic symphysis transmits the deep dorsal vein of penis (or the dorsal vein of clitoris in the female).

Terminology in relation to the fascial layers in the urogenital region of the perineum

The membranous layer of superficial fascia in the anterior abdominal wall (Scarpa's fascia) is continued into the urogenital triangle of the perineum in both sexes as the superficial perineal fascia. In the male, this superficial perineal fascial layer is prolonged into the scrotum as the dartos fascia (tunica dartos) and contains smooth muscle on its surface. The prolongation of the superficial perineal fascia over the penile shaft is termed the superficial penile fascia, while the remainder of the superficial perineal fascia is attached to the posterior edge of the perineal membrane and to the outer margins of the everted ischiopubic rami and is termed Colles' fascia. The superficial

perineal pouch is the space between the perineal membrane and the overlying superficial perineal fascia. In the male it contains the root of the penis and the associated muscles. As the superficial perineal fascia is continued into the scrotum and around the penile shaft, the superficial perineal pouch may be said to include also the scrotal contents and the penile shaft.

Deep to the superficial penile fascia is a distinct fascial layer which encircles the erectile columns (i.e. the fused corpora cavernosa and corpus spongiosum) in the penile shaft. This is the deep fascia of the penis, known also as Buck's fascia. Traced proximally, Buck's fascia is seen to be continuous with the deep fascia that covers the muscles that overlie the root of the penis, termed Gallaudet's fascia.

The principal blood supply to the perineum is derived from the right and left deep internal pudendal arteries, each being a terminal branch of the corresponding internal iliac artery's anterior division. Venous drainage is to the ipsilateral internal pudendal vein which in turn drains to the internal iliac vein. The motor innervation of all the voluntary muscles in the perineum as well as the cutaneous innervation of much of the perineum is a function of the right and left pudendal nerves. The pudendal nerve is a branch of the sacral plexus and has a root value of S2, S3 and S4.

The internal pudendal artery and pudendal nerve may therefore be spoken of as the artery and nerve of the perineum, respectively. Both these structures originate in the pelvic cavity (i.e. above the pelvic floor). They leave the pelvic cavity through the ipsilateral greater sciatic foramen (a large opening in the posterolateral aspect of the pelvic wall). Turning sharply around the tip of the ischial spine, the nerve, artery (and companion vein) run forwards *below* the pelvic floor to enter a fascial sleeve (the pudendal canal) within the obturator fascia in the lateral wall of the perineum.

The scrotum and scrotal contents

The scrotum is a pendulous, cutaneous sac that contains the testes, epididymes and the lower ends of the spermatic cords with their associated coverings. The scrotum is, in effect, an extension of skin and subcutaneous tissue of the anterior abdominal wall into the urogenital part of the perineum. It is suspended below the pubic arch and lies postero-inferior to the root of the penis.

The skin of the scrotum is hair-bearing and relatively thin and is generally more pigmented than the adjacent skin of the thigh and pubic region. It contains numerous sweat glands and sebaceous glands. The scrotum is devoid of subcutaneous fat; a feature that is thought to play a significant part in maintaining the intrascrotal temperature somewhat below the core temperature which is required for normal spermatogenesis. The rugosity of the scrotal skin is due to the contraction of the underlying dartos muscle.

A median septum within the scrotum divides the scrotum into right and left compartments. The septum is essentially an infolding of the dartos layer of the scrotum. The left hemiscrotum typically hangs somewhat lower than the right. The position of the intrascrotal septum is indicated on the surface by a narrow, midline ridge termed the median scrotal raphe. This raphe is continuous anteriorly with the penile raphe (on the undersurface of the penis), and posteriorly with the perineal raphe (which extends backwards almost to the anterior margin of the anal verge). Immediately deep to the dartos fascia and within each hemiscrotum are the three fascial coverings of the spermatic cord, concentrically arranged and closely applied to each other. From outside in they are the external spermatic fascia, cremasteric fascia and internal spermatic fascia. Within the latter is the tunica vaginalis testis, a thin-walled, double-layered serous membrane containing a film of fluid between the two layers. The tunica is applied to the front and sides of the testis and epididymis.

The testis is an ovoid, firm organ with its long axis vertically orientated. It is enveloped in a thick, pale fibrous covering termed the tunica albuginea. The tunica sends multiple septa into the testicular substance, breaking up the latter into numerous lobules each containing two to three highly convoluted seminiferous tubules. The seminiferous tubules from the various lobules converge posteriorly upon the rete testis, a plexiform structure. From the rete testis 12–15 ducts (vasa efferentia) penetrate the tunica albuginea and empty into the head of the epididymis. The epididymis is a firm structure but softer to the feel than the testis. It serves as a receptacle for the storage and maturation of spermatozoa. The epididymis is applied to the posterolateral aspect of the testis, and appreciation of this topographic relationship is of importance in the clinical diagnosis of testicular and epididymal conditions. The testis is supplied by the testicular artery, a direct branch of the abdominal aorta. Running down the posterior abdominal wall, the testicular artery enters the inguinal canal through the deep inguinal ring and emerges at the superficial inguinal ring to enter the spermatic cord along with the other contents of the

spermatic cord (testicular lymphatics, vas deferens, artery to the vas, pampiniform plexus/testicular veins, sympathetic nerve fibers, cremasteric artery, genital branch of the genitofemoral nerve).

The large, upper end of the epididymis is the head (or globus major) and the narrow, lower pole is the tail (or globus minor). The intervening part is termed the body of the epididymis. Apart from the vasa efferentia, which run from the rete testis to the head of the epididymis, there is no direct physical connection between the testis and epididymis. The narrow slit-like space between the two is termed the sinus of the epididymis. The blood supply of the epididymis is from the testicular artery.

The vas deferens is the direct continuation of the tail of the epididymis. It runs upwards medial to the epididymis and so enters the spermatic cord. The blood supply of the vas is from the artery to the vas, a branch of the inferior vesical artery.

Blood supply, lymphatic drainage and cutaneous innervation of the scrotum

The anterior surface of the scrotal wall derives its blood supply from the superficial and deep external pudendal arteries bilaterally. Both arteries are early branches of the (common) femoral artery. They arise from the latter just below the level of the inguinal ligament, run medially and supply the anterior aspect of the scrotum of their side. The posterior aspect of the scrotal wall obtains its blood supply from the posterior scrotal arteries which are branches of the perineal artery, in turn a branch of the internal pudendal artery. Arteries in the anterior scrotal wall tend to run transversely, while those supplying the posterior aspect of the scrotal wall run longitudinally. Flaps can therefore be harvested from the well-vascularized scrotal skin and transferred to the urethra, penile shaft and the inguinal region.

Venous drainage from the wall of the scrotum is predominantly via the superficial and deep external pudendal veins, on each side, to the ipsilateral great saphenous vein. However, the midline of the scrotum drains medially and not laterally which is an important consideration when faced with conditions such as scrotal lymphedema.

Lymphatic drainage from the scrotal wall is to the ipsilateral superficial inguinal lymph nodes. Lymphatic drainage of the scrotal contents, however, is different. Lymphatics from the testis run within the spermatic cord and eventually drain to the para-aortic lymph nodes near the origin of the gonadal arteries (at approximately L2 vertebral level). Lymphatics from the epididymis drain principally to the ipsilateral internal iliac lymph nodes.

Cutaneous innervation of the anterior aspect of the scrotum is by the right and left ilioinguinal nerves (L1). Each nerve innervates the anterior third of the corresponding hemiscrotum. The genital branch of the genitofemoral nerve makes a minor contribution. The posterior scrotal skin is innervated by the scrotal branches of the perineal nerve (branch of the pudendal nerve) with an additional contribution from the perineal branch of the posterior femoral cutaneous nerve. The posterior scrotal skin corresponds to the S3 dermatome.

The dartos muscle in the scrotal wall is innervated by sympathetic fibers conveyed by the genital branch of the genitofemoral nerve.

The penis

The penis is the male copulatory organ and conveys the entire length of the spongiose urethra (the spongiose urethra, in turn, being divided into the bulbar, pendulous or penile and glanular segments). The glanular portion of the urethra has recently been also divided into two portions, the fossa navicularis and the meatus. The non-tumescent penis hangs below the pubic symphysis and in front of the scrotum, overlapping the median scrotal raphe. The dorsal surface of the penis is the surface that faces the anterior abdominal wall when the penis is erect. Thus, when the penis is flaccid, the dorsal surface faces anteriorly and the ventral surface faces posteriorly.

The penis consists of three parts: the root (radix), the shaft (body or corpus) and glans. The root of the penis is the proximal end of the organ, and is firmly attached to the inferior surface of the perineal membrane and to the inner aspects of the ischiopubic rami. It is made up of three somewhat elongated masses of erectile tissue: two crura (one on either side) and a centrally situated bulb of the penis (Figure 1.3).

Each crus is attached to the inner surface of the ischiopubic ramus of its side immediately in front of the ischial tuberosity, and in part also to the inferior surface of the adjacent perineal membrane, while the bulb is attached, in its entirety, to the inferior surface of the perineal membrane. Each crus is covered by the corresponding ischiocavernosus muscle while the bulb is covered by the bulbospongiosus muscle. The correct nomenclature for this is the midline fusion of the ischiocavernosus muscle. Distally, the three elements of the

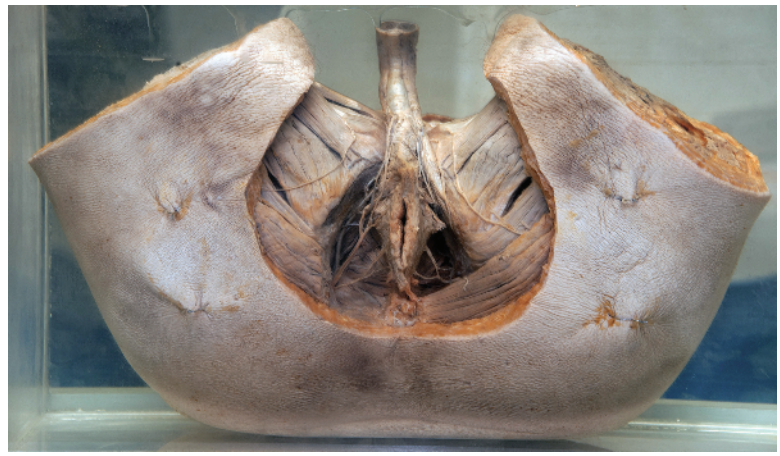

Figure 1.3 Cadaveric dissection demonstrating the origins of the root of the penis and the vascular supply.

Figure 1.4 Cadaveric dissection showing the three components of the root of the penis as they continue to form the penile shaft.

penile root (the two crura and the bulb) converge towards each other at the proximal end of the penile shaft, whence the two crura are prolonged within the penile shaft as the corpora cavernosa, and the bulb is continued as the corpus spongiosum. The muscles (ischiocavernosi and bulbospongiosus) are not prolonged into the penile shaft (Figure 1.4).

The shaft of the penis is made up of three columns of erectile tissue: the right and left corpora cavernosa, and the median corpus spongiosum. The two corpora cavernosa lying side by side are situated dorsal to the midline corpus spongiosum, the latter lying in a longitudinal groove between the apposed corpora cavernosa. The crura, bulb and corresponding corpora are each made up of spongy connective tissue comprising an interconnected network of highly vascular sinusoids.

The corpus spongiosum and the two corpora cavernosa are each contained within a dense fibrous sheath termed the tunica albuginea. The fibrous sheaths of the two corpora cavernosa are fused with each other to form the median septum of the penis and on the ventral aspect these sheaths are fused with that of the corpus spongiosum. These sheaths are collectively enveloped by the deep penile fascia (Buck's fascia). The median septum is incomplete in places, thereby allowing the cavernosal erectile tissue of the two sides to communicate with each other. There is a varying relationship of the corpus cavernosum to the corpus spongiosum, whereby it is dorsally displaced

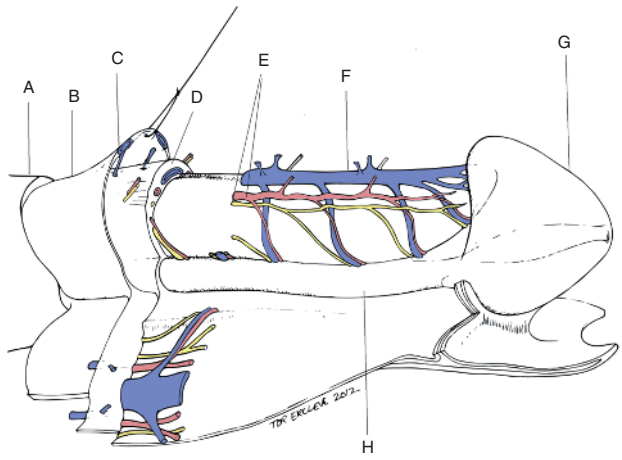

Figure 1.5 The skin and fascial layers of the penis and the location of the neurovascular bundle. A, skin; B, loose areolar tissue and dartos layer; C, superficial dorsal vein; D, Buck's fascia; E, deep dorsal artery and nerve; F, deep dorsal vein; G, glans; H, corpus spongiosum. (Source: Tor Ercleve. Reproduced with permission of Tor Ercleve.)

in the proximal aspect, centrally placed in the pendulous part, and ventrally displaced in relationship to the erectile tissue of the glans (Figure 1.5).

The glans penis is the somewhat conical (acorn-like) distal end of the penis. It is in effect a continuation of the corpus spongiosum. It is demarcated from the penile shaft by a shallow, obliquely orientated circumferential groove termed the neck of the penis. The base of the glans has a rounded edge which partially overhangs the neck of the penis, and is termed the corona of the glans (corona glandis).

The penile skin is thin, dark, hairless (except at the very proximal end of the shaft) and fairly freely mobile. From the neck of the penis, the skin extends distally as the prepuce or foreskin, a circumferential, double-layered, mobile retractable hood over the glans. The extent to which the prepuce covers the glans varies between individuals. The preputial frenulum is a median fold of skin that passes from the inner layer of the prepuce to the ventral surface of the glans adjacent to the external urethral orifice.

Blood supply, lymphatic drainage and innervation of the penis

The penis derives its arterial supply exclusively from the right and left deep internal pudendal arteries, each giving rise to the common penile artery which then divides into an artery to the bulb, a deep artery of the penis (referred to in urological literature as the cavernosal artery) and a dorsal artery of the penis (Figure 1.6).

The artery to the bulb supplies the bulb, corpus spongiosum, glans penis and the entire spongiose urethra. The deep artery supplies the ipsilateral crus of the penis and the corresponding corpus cavernosum. It enters the crus and breaks up into numerous helicine branches which supply the erectile tissue of the corpus. The dorsal artery supplies the penile skin, the dartos layer and the deeper fascial layers. The deep artery of the penis and the dorsal artery of the penis arborize distally in the erectile tissue of the glans penis and therefore provide retrograde blood flow into the corpus spongiosum.

The venous drainage of the penile skin and superficial structures is to the superficial external pudendal veins bilaterally, and thence to the right and left great saphenous veins. Venous drainage of the deeper structures including the erectile tissue is to the deep dorsal vein of the penis. This in turn runs posteriorly under the pubic symphysis to drain to the periprostatic venous plexus (of Santorini).

The lymphatic drainage of the penis is as follows. Lymph from the penile skin drains into the superficial inguinal lymph nodes bilaterally. Lymph from the glans penis and from the distal parts of the corpus spongiosum and corpora cavernosa drains into the deep inguinal lymph nodes, and thence to the external iliac lymph nodes. Lymph from the proximal parts of the erectile tissue drains into the internal iliac lymph nodes.

The cutaneous innervation of the penis is from the right and left dorsal nerves of the penis which supply the

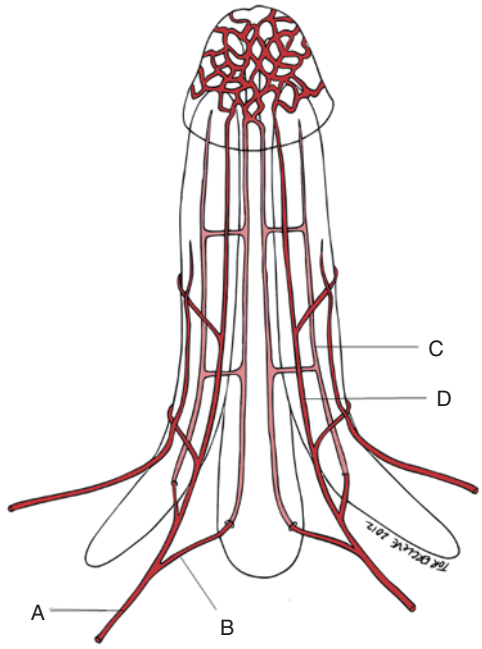

Figure 1.6 Arterial supply to the penis. A, common penile artery; B, artery to bulb; C, deep artery of the penis (cavernosal artery); D, dorsal artery of penis. (Source: Tor Ercleve. Reproduced with permission of Tor Ercleve.)

dorsal penile skin, the glans penis and glanular urethra. Each dorsal nerve of the penis is a terminal branch of the corresponding pudendal nerve. The ventral skin of the penis is innervated by the right and left posterior scrotal nerves, in turn, branches of the corresponding perineal nerves. The dermatome represented by the penile skin is S2.

The muscles of the penile root – the bulbospongiosus and the ischiocavernosi – are striated muscles and derive their motor innervation from the right and left perineal nerves, each being a terminal branch of the corresponding pudendal nerve.

The erectile tissue comprising the corpora cavernosa and corpus spongiosum is innervated by the parasympathetic fibers in the pelvic splanchnic nerves (S2, S3 and S4).

Ligamentous support of the penis

Two so-called ligaments are attached to the dorsal aspect of the penis at the junction of the root and shaft of the penis and provide suspensory support. The more deeply placed of these is termed the suspensory (or triangular) ligament. From its attachment to the anterior aspect of the pubic symphysis it runs downwards to blend with Buck's fascia on either side of the proximal end of the penile shaft. The other ligament is termed the fundiform ligament. Arising from the lower end of the linea alba just above the pubic symphysis, it runs inferiorly and splits into left and right laminae. These laminae run one on either side of the proximal penile shaft and meet on the ventral (inferior) aspect of the penis and pass into the scrotal septum.

Injury to either of these ligamentous structures can occur in trauma to the anterior part of the pelvic ring with a resultant ventral angulation of the penile shaft when the penis is erect.