

Penis and Female Urethra

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1. Embryology

1.1 Male

At about 12 weeks, the external virilization of the male fetus begins and under hormonal control, the following steps ensue:¹

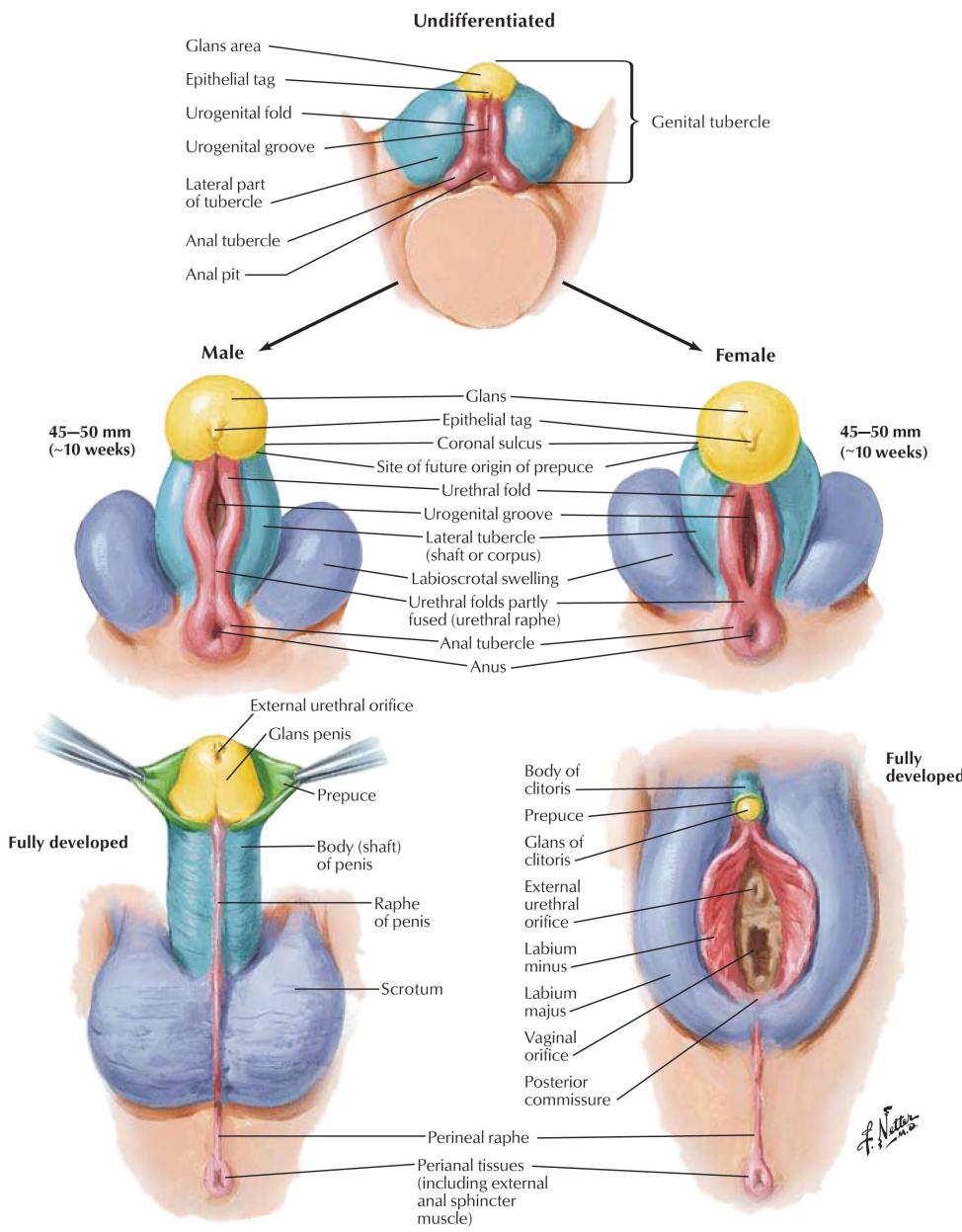
- Anogenital distance lengthens, labioscrotal swellings fuse to form scrotal raphe
- Fused tubercles grow in cylindrical shape
- Urethral groove deepens as tissue folds begin to fuse ventrally around 16 weeks
- Urethral tubularization continues and urethral slit moves out to corona
- Mesenchyme surrounds the urethra and forms the corpus spongiosum
- Glans enlarges and preputial skin grows out from either side of urethral groove
- Ingrowth of glandular ectodermal skin meets urethral slit and glans covers over ventral surface
- Given normal urethral formation, the prepuce closes ventrally

1.2 Female

The external genitalia change very little from the undifferentiated state compared to male genitalia development. Non-fusion of the urogenital folds is the main difference between male and female genital development.² Without the influence of testosterone the following steps ensue at 10-12 weeks:^{1,2}

- Enlargement of urethrovaginal folds cause disappearance of mullerian tubercle
- Genital tubercle elongates slightly to form clitoris
- Urethral folds enlarge forming labia minora, no fusion occurs
- Genital swellings form labia majora
- Separation occurs between the urogenital sinus and uterovaginal canal

Homologues of External Genitalia



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Figure 1: Homologues External Genitalia

2. Penis

2.1 Gross Structure

Three erectile bodies and the urethra are contained within the penis and continue into the perineum. The tunica albuginea surrounds the two corpora cavernosa which are located dorsally and contain erectile tissue. The inner layer of the tunica has bundles which are oriented circularly, while the outer layer bundles run longitudinally.³ The mid-line septum between the corpora cavernosa allows free

communication between the two bodies. Internally, the corpora contain erectile tissue, cavernosal arteries, venous sinusoids, nerves, smooth muscle fibers which form endothelium-lined cavernous sinuses and trabeculae arising from the tunica albuginea.⁴ Ventral to the corpora cavernosa lies the corpus spongiosum which encompasses the urethra and widens to become the glans penis distally. The corona of the glans overhangs the shaft and on the ventral surface, forms a "V", with the frenulum just proximal to the point of the "V" attaching from the glans to the penile shaft. The meatus sits ventrally at the tip of the glans and has a slit-like appearance. ⁴

2.2 Arterial Anatomy

Arising from the femoral artery, the left and right superficial external pudendal vessels traverse the femoral triangle and divide into two branches running both dorsolaterally and ventrolaterally to supply the skin of the penis. The internal pudendal artery becomes the common penile artery which has three terminal branches.^{4,5} **First branch:** The bulbourethral artery penetrates the perineal membrane and enters the spongiosum supplying the urethra, spongiosum and glans. **Second branch:** The cavernosal artery enters the corpus cavernosum at the hilum and gives off the helicine arteries which dilate with stimulation, and in conjunction with the relaxation of the sinusoidal smooth muscle, produce an erection. **Third branch:** The dorsal artery travels between the deep dorsal vein, which is medial, and the dorsal nerve, which is lateral. The circumflex arteries branch from the dorsal artery and supply both the spongiosum and the urethra.

2.3 Venous Anatomy

Superficial: Variable drainage running in dartos fascia along dorsolateral aspect of penis. These veins come together at the base forming a single superficial dorsal vein which usually drains into the left saphenous vein, but can also drain into the right saphenous vein or both. **Intermediate:** Venules from the cavernous sinuses drain into a subtunical capillary plexus giving rise to the emissary veins which follow an oblique path through the tunica and drain into the circumflex veins dorsolaterally. The subtunical venules are compressed against the tunica albuginea during erection.⁴ A network of veins drains the glans and then flows into the deep dorsal vein which passes beneath the symphysis and drains into the prostatic (Santorini's) plexus. **Deep:** The cavernosal veins in the proximal 1/3 of the penis converge into one or two veins and join into the prostatic plexus or internal pudendal veins. Also joining the internal pudendal veins are three to four small crural veins arising from each proximal crus.

2.4 Lymphatic Drainage

Skin drainage from prepuce and shaft flows into bilateral superficial inguinal nodes. The glans drains towards the frenulum and lymphatics travel beneath Buck's to the deep inguinal lymph nodes. The skin distal to a circumcision scar drains into the glans.

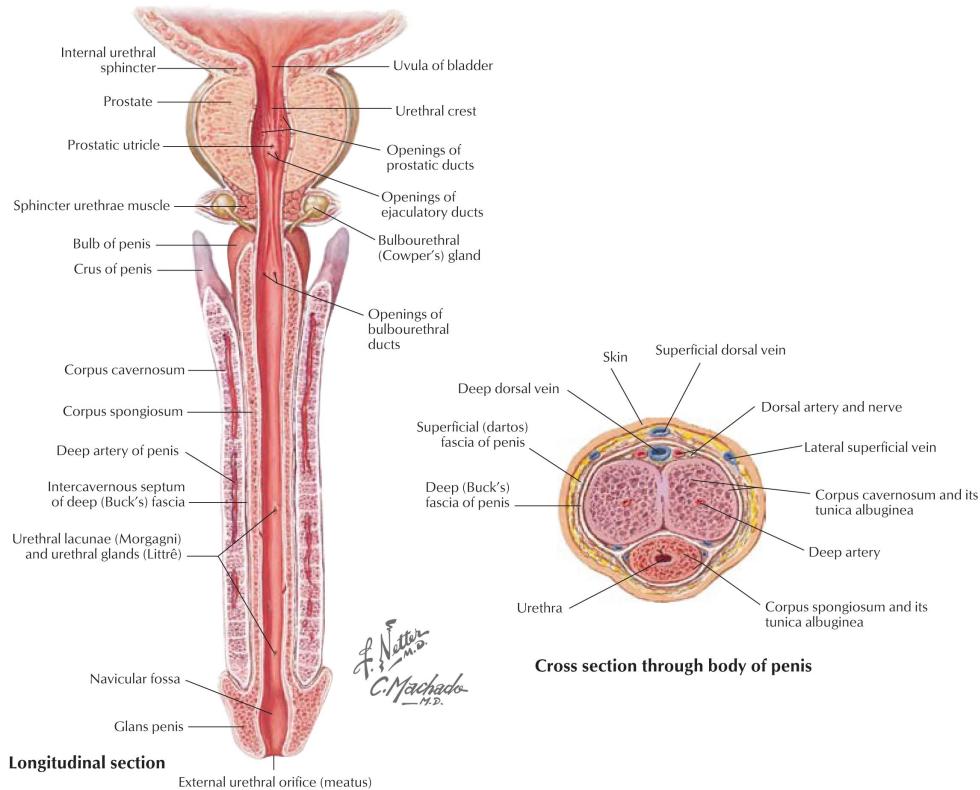
2.5 Innervation

The pudendal nerves give rise to the dorsal nerves which run lateral to the dorsal arteries and supply

somatic motor and sensory innervation. The pelvis plexus supplies the autonomic innervation; parasympathetic efferents from S2-S4 and sympathetic efferents from T11-L2, as well as visceral afferents pierce the corporal bodies and become the cavernosal nerves which lie dorsomedially to the cavernous arteries.⁴ Erection occurs with the relaxation of cavernosal smooth muscle caused by acetylcholine, nitric oxide and vasoactive intestinal polypeptide released by parasympathetic nerves.⁵

2.6 Fascial Investments

Superficial (dartos) fascia and deep (Buck's) fascia surround the three erectile bodies. The dartos fascia loosely attaches the skin to Buck's fascia and contains superficial arteries, veins and nerves of the penis. Buck's fascia surrounds the corpora cavernosa and then splits ventrally to incorporate the corpus spongiosum. Because of the distal attachment to the glans at the corona and the proximal fusing to the tunica albuginea in the perineum, a tear in the corporal bodies (penile fracture) produces ecchymosis limited to the penile shaft.



3. Female External Genitalia

3.1 Gross Structure

The vulva is made up of the labia majora, labia minora, the clitoris, the urethral meatus, the vaginal opening and the erectile tissue of the corpus spongiosum (vestibular bulbs). The hair-bearing skin of the labia majora fuses anteriorly with the mons pubis. The smaller, inner folds, the labia minora, are covered by non-hair bearing skin laterally and by vaginal mucosa medially. The anterior fusion of the two labia minora forms the clitoral hood. The clitoris is formed by two corpora cavernosa with the distal ends terminating in the glans, all of which are made of erectile tissue that becomes turgid with stimulation. The suspensory ligament of the clitoral body connects it to the mons pubis and pubic symphysis. The vestibular bulbs are two erectile organs lying in the anterior perineum, lateral to the labia minora, and covered by the bulbocavernosus muscles.²

3.2 Arterial Anatomy

The internal pudendal artery gives off branches to the vestibular bulbs and terminates in the deep artery of the clitoris and the dorsal artery of the clitoris. The external pudendal vessels supply the labial fat pads and are the basis for the Martius rotational flap repair used for a variety of reconstruction procedures.⁵

3.3 Venous Anatomy

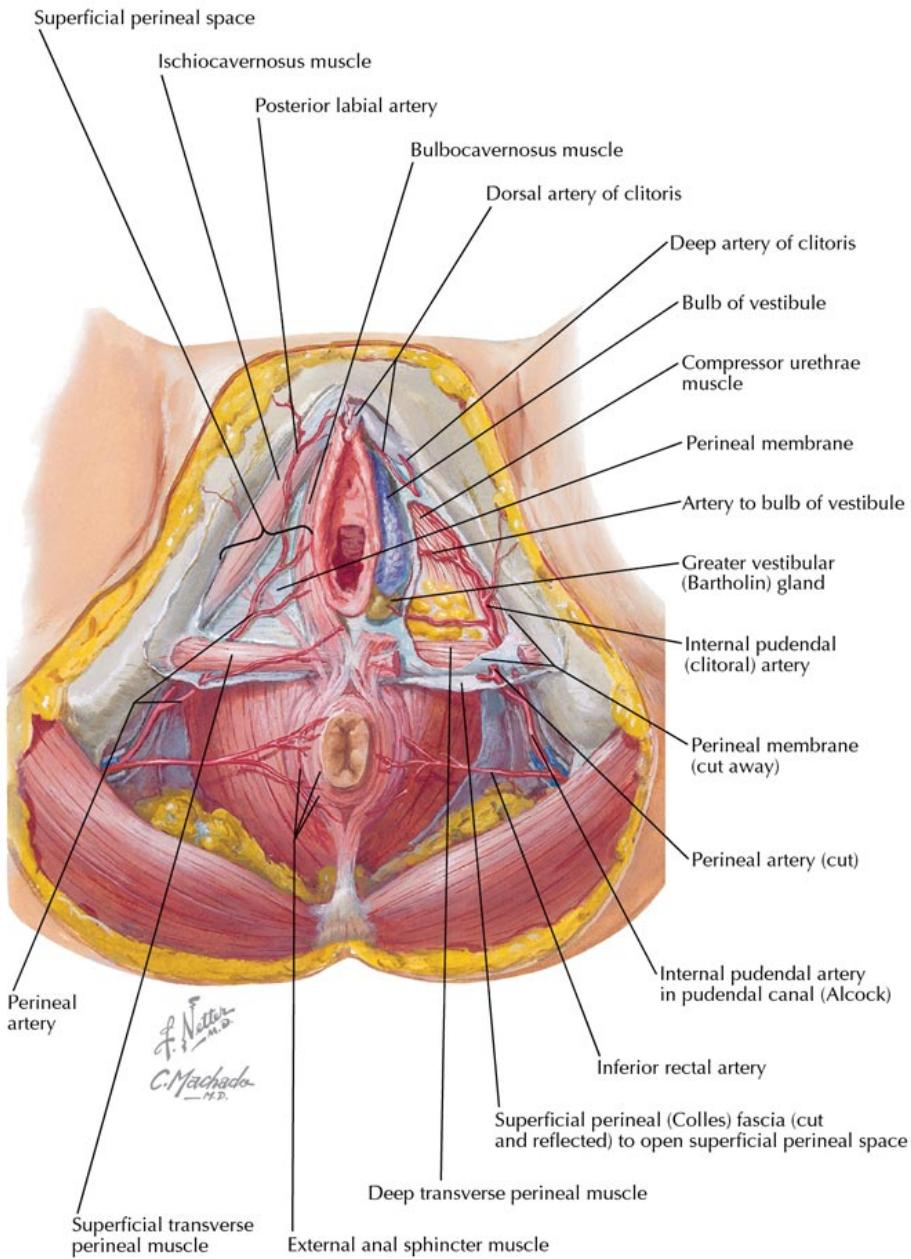
Drainage is through the external and internal pudendal veins.

3.4 Lymphatic Drainage

The superficial and deep inguinal nodes drain the external female genitalia.

3.5 Innervation

The ilioinguinal nerve, arising superiorly, ends in the anterior labial branch. The pudendal nerve, arising posteriorly and traveling through Alcock's canal, gives off the perineal nerve which has both superficial and deep branches and terminates in the posterior labial nerves. Also arising from the pudendal nerve is the dorsal nerve of the clitoris. The perineal branch of the posterior cutaneous nerve of the thigh supplies the skin laterally.



Note: Deep perineal (investing or Gallaudet) fascia removed from muscles of superficial perineal space.

Figure 3: Blood Supply to Perineum

4. Male Urethra

4.1 Gross Structure

There are 5 sections of the male urethra: **glanular, pendulous (penile), bulbous, membranous and prostatic**. The urethra is a tubular structure with a submucosal layer which runs the entire length and an outer striated muscular layer located only in the prostatic and membranous portions.⁴ Numerous periurethral glands (of Littré) drain into the pendulous and bulbar urethra. The verumontanum protrudes from the posterior wall of the prostatic urethra and contains openings for

the prostatic utricle at the apex with ejaculatory ducts on either side of the utricle.⁵

4.2 Histology

The glanular urethra is lined with stratified squamous epithelium. Moving proximally, the penile urethral epithelium is stratified or pseudostratified columnar to the level of the bulbar urethra. From the bulbar to the prostatic urethra there is a gradual change to transitional epithelium which is continuous with the trigone and bladder.

4.3 Arterial Anatomy

The internal pudendal artery becomes the common penile artery which has three terminal branches. Two of these branches, the dorsal artery and the urethral artery, provide dual blood supply to the male urethra. Prostatic branches off of the inferior vesical and middle rectal arteries supply the prostatic urethra.

4.4 Venous Anatomy

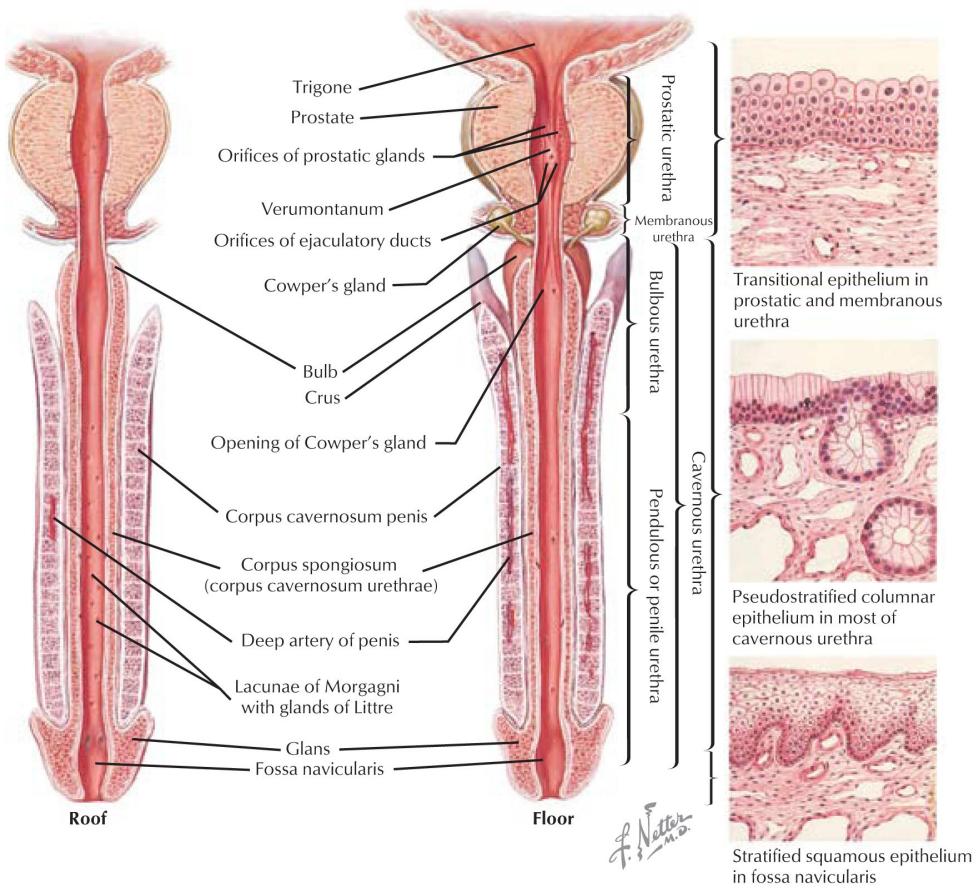
Periurethral veins drain to circumflex veins which ultimately drain into the deep dorsal vein and into the prostatic venous plexus.

4.5 Lymphatic Drainage

The distal male urethra drains to the superficial inguinal lymph nodes. The bulbar, membranous and prostatic urethra drain to the iliac, obturator and presacral lymph nodes. Crossover may occur at the prepubic lymphatic plexus.⁶

4.6 Innervation

The pudendal nerves supply motor and sensory innervation while the autonomic innervation arises from the pelvic plexus.



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Image No. 14683

Figure 4: Penis Urethra

5. Female Urethra

5.1 Gross Structure

The female urethra is a 4 cm complex tubular structure which connects the bladder to the external meatus. Numerous small glands (Skene glands) open into the urethra and distally group together at the meatus into two small ducts.⁵ There are 3 layers in a normal urethra: an **inner layer** of mucosal epithelium, a **middle layer** of richly vascularized elastic tissue forming the submucosa which is hormonally sensitive and an **outer layer** formed by a collagen-rich muscular envelope.⁷ Both smooth and striated muscle fibers are found in the outer layer. The smooth muscle extends from the trigone and has an inner longitudinal and a thin, outer circular layer lying deep to the outermost striated urogenital sphincter muscle. In the proximal two-thirds of the urethra, the striated fibers are circular compared to the distal one-third of the urethra where the fibers exit the urethra and surround the vaginal wall. This striated muscle is composed mainly of slow-twitch fibers and voluntary activation increases the constriction of the urethra when needed. The fascial support of the urethra is one aspect in the continence mechanism. Periurethral tissue along with the anterior vaginal wall is connected via fascial attachments to the arcus tendineus at the pelvic sidewall. In addition, there are

muscular attachments to the medial border of the levator ani. With increased intra-abdominal pressure, the urethra is compressed inhibiting the flow of urine. This urethral compression, along with the urethral sphincter mechanism and a quiescent bladder, aids in maintaining continence.⁸

5.2 Histology

The distal two-thirds of the urethra is lined with non-keratinized stratified squamous epithelium which gradually changes to transitional epithelium in the proximal one-third and extending into the bladder.

5.3 Arterial Anatomy

The internal pudendal, vaginal and inferior vesical arteries supply the female urethra.

5.4 Venous Anatomy

Internal pudendal and vaginal veins follow the same routes as the arterial supply.

5.5 Lymphatic Drainage

The distal urethra and labia drain to the superficial and deep inguinal nodes, whereas the proximal urethra drains to the iliac, obturator, presacral and para-aortic nodes.⁶

5.6 Innervation

Somatic and autonomic nerves travel laterally near the urethra in the vaginal walls. Smooth muscle control is under parasympathetic cholinergic control. The pudendal and pelvic somatic nerves both innervate the striated urethral sphincter.⁵

References

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1 Dr. Ceccarelli's piece is a succinct, yet comprehensive review on the embryology of male and female genitalia. He includes helpful visual references to demonstrate the stages of sexual development, as well as a timeline in text and table format

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