4. DEVELOPMENT OF THE MESONEPHRIC (Wolffian) DUCTS - male

TERMINOLOGY:

SEGMENTS OF THE VESICOURETHRAL CANAL (m):

Cranial segment: future urachal remnant, (median umbilical ligament)
Middle segment: future urinary bladder
Caudal segment: future prostatic urethra, colliculus seminalis, and the membranous urethra

COMPONENTS OF A MESONEPHRIC (WOLFFIAN) DUCT: (m).

Body and tail of the epididymis, vas deferens, ureteric bud, duct of the seminal vesicle, seminal vesicle, ejaculatory duct.

The ejaculatory ducts descend posterior to the urethral crest of the prostatic urethra, travel through the colliculus seminalis and open on anterior surface of the colliculus seminalis, at the upper border of the membranous urethra (pelvic part of the male vestibule). The mesonephric ducts are lined by *pseudostratified columnar epithelium***,** which differentiates from mesoderm.

DEVELOPMENT OF THE MESONEPHRIC (WOLFFIAN) DUCTS:

Development of the mesonephric ducts starts about 1month after conception.
*The mesonephric ducts in the male develop in response to testosterone, secreted by the L*eydig cells of the embryonic testes. Unlike the lower segments of the *paramesonephric (Müllerian) ducts,* which *fuse to form the uterus and cervix*, the mesonephric ducts develop entirely as a *bilateral system of ducts*.

The *mesonephric ducts* develop in *intermediate mesoderm*, *dorsal to the paramesonephric ducts*. *The mesonephric ducts* run medially and forwards, crossing under the unfused segment of the *paramesonephric ducts* (potential fallopian tubes). They descend in parallel, on either side of the midline, anterior to the fused *paramesonephric ducts* (potential uterus and cervix).

Caudal to the (cervical segment) of the fused paramesonephric ducts, *the mesonephric ducts* continue their parallel descent on either side of the midline, *posterior to the (tubular) vesico-urethral canal. The mesonephric ducts* travel through the *sinus tubercle* (future colliculus seminalis), anterior to a cylinder of mesoderm (future vagina masculinus), and drain into the urogenital sinus/vestibule, by tiny openings on the surface of the *sinus tubercle*.

In male development, the paramesonephric ducts, disappear, due to Müllerian inhibiting factor (MIF) secreted by the Sertoli cells of the embryonic testes. The cranial ends of the paramesonephric ducts persist as appendixes of the testis. The *appendix testis* (hydatid of Morgagni), is a pedunculated cyst, attached to tunica albuginea of the antero-lateral aspect of the upper pole of the testis, that is prone to torsion.

DEVELOPMENT OF THE MESONEPHRIC DUCTS, POSTERIOR TO THE BLADDER SEGMENT AND POSTERIOR TO THE PROSTATIC URETHRAL SEGMENT OF THE VESICOURETHRAL CANAL AND TRIGONAL PART OF THE SINUS TUBERCLE:

Formation of ureteric buds:
At the level of the future interureteric ridge, in the trigone section of the bladder, (above the openings of the ducts of the seminal vesicles), the *mesonephric ducts develop ureteric buds (future ureters and collecting systems of the kidneys).*

Ducts of the seminal vesicles, and seminal vesicles:
Just below the ureteric buds, the mesonephric ducts give rise to the short *ducts of the seminal vesicles, which develop the seminal vesicles.*

Mesonephric ducts become the ejaculatory ducts:
Distal to the openings of the ducts of the seminal vesicles, the mesonephric ducts become the *ejaculatory ducts.*

Proximal to the openings of the ducts of the seminal vesicles, the mesonephric ducts become the vas deferens, and tail and body of the epididymis.

Mesodermal panels develop anterior to the mesonephric ducts and posterior to the vesico-urethral canal:
Between the mesonephric ducts and the vesicourethral canal, a *narrow vertical rectangular panel of mesoderm, condenses on either side of the midline.*
The *upper end of the mesodermal panel* is at the level of the future interureteric ridge, in the caudal one third of the bladder segment of the vesicourethral canal.
The *lower end of the mesodermal panel* is in the upper part or future trigonal section of the sinus tubercle (colliculus seminalis).

THE MESODERMAL PANELS ARE THE ANLAGE, OF THE TRIGONE OF THE BLADDER, THE URETHRAL CREST IN THE PROSTATIC URETHRA, AND THE TRIGONE OF THE COLLICULUS SEMINALIS.

The ureteric buds attach to the upper end of the mesodermal panels:
The ureteric buds detach from the antero-medial aspect of the mesonephric ducts and attach to the adjacent lateral ends of the upper border of the midline mesodermal panels.

The mechanism by which the ureteric buds, transfer from the mesonephric ducts to the upper ends of the mesodermal panels, is not clear. However, since the mesonephric ducts descend in parallel on either side of the midline, just behind the vesicourethral canal, and the mesodermal panels straddle the midline, between the mesonephric ducts and vesicourethral canal, suggests that the ureteric buds are close to, or in contact with, the lateral borders of the upper ends of the mesodermal panels.

The mesodermal panels and ureteric buds form the trigone:
The *mesodermal panels and attached ureteric buds, insert into, and become incorporated, in* the posterior wall, of the vesicourethral canal and posterior wall of the sinus tubercle (colliculus seminalis).

a) The ureteric buds and mesodermal panels in the bladder segment of the vesicourethral canal, form the trigone of the bladder.
b) The mesodermal panels in the prostatic urethral segment of the vesicourethral canal, form the urethral crest.
c) The lower ends of the mesodermal panels, form the trigone of the colliculus seminalis.

The seminal vesicles:

The *ducts of the seminal vesicles* arise from the lateral walls of the mesonephric ducts. The short thin ducts, develop into a coiled thick-walled tube, with blind ending sacs, that are the *seminal vesicles.* The seminal vesicles are lined by pseudostratified columnar epithelium with goblet cells, lying on a lamina propria, surrounded by an inner circular, and outer longitudinal, layer of smooth muscle.

On each side, the short ducts of the seminal vesicles join the lateral sides of the mesonephric ducts, at an acute angle. The junctions of the ducts of the seminal vesicle, demarcates the vasa deferentia from the ejaculatory ducts

Vas deferens and ejaculatory ducts:

Distal to the *openings of the ducts of the seminal vesicles*, the mesonephric ducts become the *ejaculatory ducts.* Cephalad to the openings of the seminal vesicle ducts, the mesonephric ducts become the *vasa deferentia.* Each vas deferens, joins the ipsilateral *tail of the epididymis. T*he tail of the epididymis joins the *body of the epididymis*. The head of the epididymis develops from the rete testis and is not considered to be part of the mesonephric duct.

Notes:

1) The lower ends of the seminal vesicles are level of the interureteric ridge.
2) The short ducts of the seminal vesicles, join the vasa deferentia to form the ejaculatory ducts.
3) Above the prostate, the ejaculatory ducts, and seminal vesicles, diverge, from the midline.
4) In the prostate, the ejaculatory ducts, run on either side of the midline, posterior to the urethral crest
5) In the colliculus seminalis, the ejaculatory ducts diverge slightly from the midline, to open on the colliculus seminalis anterolateral to the introitus of the vagina masculinus.

Ejaculatory ducts in the prostatic urethra:

Once formed, the ejaculatory ducts immediately pierce the base of the prostate, and descend in parallel in the prostatic urethra, on either side of the midline, posterior to the urethral crest.

Ejaculatory ducts in the colliculus seminalis:

At the lower end of the prostatic urethra, the ejaculatory ducts enter the superior aspect of the colliculus seminalis. The ejaculatory ducts run anterior to the vagina masculinus. In the colliculus seminalis, the ejaculatory ducts diverge slightly from the midline, and open by tiny orifices *superolateral to the ostium of the vagina masculinus* (utricle).

Development of the prostate:
15-20 ducts arise on either side of the prostatic urethral segment of the vesicourethral canal. The ducts develop branching tubuloalveolar glands. The glands are consolidated within a layered fibrous capsule. The prostatic ducts drain by 15-20 openings in the prostatic sinus on either side of the urethral crest. The urethral crest is derived from the prostatic urethral segment of the trigone. In infancy the ejaculatory ducts descend posterior to the urethral crest. Proliferation of the glands of the prostate at puberty, and the development of benign prostatic hyperplasia in older men, can distort the normal passage of the ejaculatory ducts in the prostate.

Development of the colliculus seminalis: (m)
The *colliculus seminalis* develops from the *sinus bulb* (Müllerian eminence).
The *sinus bulb (Müllerian eminence)* develops as a projection in the posterior wall, of the primitive urogenital sinus (UGS), and divides the primitive UGS into the *vesicourethral canal* above, and the *definitive UGS or vestibule*, below.

In males the sinus tubercle *develops* <u>*at the upper border of the membranous urethra*</u>.

In the sinus tubercle, the *ejaculatory ducts* run anterior to a *cylinder of condensed mesoderm* (future vagina masculinus) to open on the luminal aspect of the upper part of the sinus tubercle.
The anterior aspect of the sinus tubercle is covered by endoderm of the definitive UGS.
The cylinder of mesoderm undergoes cavitation to form the, *vagina masculinus.* The lower end of the vagina masculinus is closed by a bilaminar membrane. The bilaminar layer forms the hymen of the vagina masculinus. The inner layer of the bilaminar membrane is derived from mesoderm of the sinus bulb, and the luminal layer is derived from endoderm of the vestibule, that covers the sinus tubercle. A perforation develops in the hymen, to form the *introitus, of the vagina masculinus*.
The ejaculatory ducts open superolateral to the introitus of the vagina masculinus.
The sinus bulb is now the *colliculus seminalis.*

Development of the mesonephric ducts, above the prostate:
At the base of the prostate t*he mesonephric ducts diverge from the midline* and are joined by ducts of the seminal vesicles to become the *vasa deferentia.* When the *testes descend* to the scrotum, the vasa*,* run laterally in the pelvis, cross the external iliac vessels, enter the deep inguinal ring, run through the inguinal canal, and descend into the scrotum.

Anatomy of the vas deferens:
In the scrotum, the tail of the epididymis makes a U-turn, develops a thick coat of smooth muscle, and becomes vas deferens. Alongside the body and tail of the epididymis. the *wall of the vas deferens is coiled* and twisted but becomes smooth above the head of the epididymis. The vas deferens enters the superficial inguinal ring, runs through the inguinal canal, exits the inguinal canal at the deep inguinal ring, curves around the lateral side of the inferior epigastric artery, ascends anterior to the external iliac artery, crosses the external iliac vessels. It runs backwards, then medially, to the fundus of the bladder. It crosses *anterior to the ureter*, curves over the top the seminal vesicle and descends on its medial aspect. Medial to the seminal vesicle, the vas deferens is dilated to form the *ampulla of the vas deferens*.

The lower end of the ampulla of the vas deferens, and lower third of the seminal vesicle, are about the level as the *interureteric ridge, in the bladder.*

Below the ampulla the *vas becomes very narrow*. It is *joined on its lateral wall* by the *short thin duct of the seminal vesicle* (at an *acute angle) to become the ejaculatory duct*.
The ejaculatory ducts *immediately pierce the base of the prostate* and descend in the prostatic urethra, on either side of the midline, *posterior to the urethral crest*. At the lower end of the prostatic urethra, the ejaculatory ducts enter the colliculus seminalis, diverge slightly from the midline, and present *tiny openings anterolateral to the vagina masculinus.*

Fundus of the bladder: (m).
The *triangular fundus of the bladder* is the *postero-inferior wall of the bladder,* that faces the rectum. The fundus of the bladder is triangular.
The base of the fundus is at the rectovesical fold, which covers the tops of the seminal vesicles. The terminal segments of the vasa deferentia, run on the medial aspects of the seminal vesicles. The *seminal vesicles and vasa*, directed downwards and medially, form the *lateral borders* of the fundus of the bladder.
The t*rigone of the bladder is at the level of the lower third of the fundus* of the bladder.

The ureters:
The ureters are derived from the ureteric buds, that form ureteric diverticula

Ureterovesical junction:
The ureterovesical junction (UVJ), joins the ureter to the bladder. The UVJ can be divided into the longer *transmural segment*, which runs through the smooth muscle wall of the bladder, and the shorter *intravesical segment*, which runs under the mucosa of the bladder. The intravesical ureters open in the bladder at the *ureteral orifices.*
The intravesical segments of the ureterovesical junctions can be observed at cystoscopy. The ureteral *orifices* open at the ends of the *interureteric ridge*.

The transmural ureter:
At the lateral angles of the fundus (posterior wall), of the bladder, the (vertical) ureters descend, behind the (horizontal) vasa deferentia. The ureters penetrate the smooth muscle wall of the bladder wall of the bladder, anterior to the upper ends of the seminal vesicles.
The transmural ureters descend obliquely downwards and forward and medially, through the bladder wall, to join the intravesical segment of the ureters.

Intravesical ureters:
The short intravesical segments of the ureters are visible at cystoscopy. The openings of the ureteral orifices are seen at either end of the of the interureteric ridge.

Posterior walls of the intravesical ureters:
The posterior walls of the intravesical ureters are part of the trigone of the bladder.
Origin: The *posterior walls of the intravesical ureters* are extensions of the interureteric ridge of the trigone of the bladder. Like the trigone of the bladder, the posterior walls of the intravesical ureters, are integral parts of the posterior wall of the bladder.

The posterior walls of the intravesical ureters, are backed by a ureteric sheath, which is in *direct continuity with the (subepithelial) interureteric ridge* of the trigone of the bladder. Urothelium lining the *posterior wall of the intravesical ureter*, is continuous with epithelium on the *surface of the interureteric ridge (*transitional or non-keratinizing squamous epithelium), differentiated from underlying *mesoderm.*

Anterior walls of the intravesical ureters:
The *anterior walls of the intravesical ureters are truly submuco*sal, being covered by urothelium of the bladder. At the ureteral orifice, urothelium lining the lumen of the anterior walls of the intravesical ureters, reflects on urothelium covering the anterior walls of the intravesical segments of the ureters, derived from *endoderm of the vesicourethral canal*.

Urothelium of the ureters:
Urothelium lining the *ureters and collecting systems* of the kidneys (including the anterior walls of the intravesical ureters), is differentiated from *mesoderm* derived from the lining if the *ureteric buds and ureteric diverticula*, which were generated by the *mesonephric ducts*. Urothelium lining the *posterior walls of the intravesical ureters* is differentiated from *mesoderm of the interureteric ridge of the trigone* of the bladder.

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