10. DEVELOPMENT OF THE UROGENITAL SINUS/VESTIBULE (female):

The *urorectal septum* divides the *cloaca* into the dorsal *anorectal canal* and the ventral circular *primitive urogenital sinus.* When the *urogenital membrane* disintegrates, mucosa *(endoderm)* of the primitive urogenital sinus joins the epithelium *(ectoderm)* on the inner aspect of the circumferential vestibular fold at *Hart's line*.

The sinus bulb/Müllerian tubercle forms a bulge in the posterior wall of the primitive urogenital sinus (UGS). The eminence is composed mesoderm and is covered on its ventral aspect by endoderm (mucosa) of the urogenital sinus. The Müllerian tubercle will form the definitive *colliculus feminalis.* The lower border of the colliculus feminalis, divides the primitive UGS into the *vesicourethral canal* above, and the *definitive UGS* (vestibule) below.

In the pelvis, the paramesonephric (Müllerian) ducts descend in parallel, on either side of the midline, posterior to the vesicourethral canal.

The vesicourethral canal differentiates as follows:

Upper part: allantoic diverticulum (urachus).
Middle part: urinary bladder.
Lower part: bladder neck, glandular urethra and membranous urethra.

The fused Müllerian ducts differentiate into the uterus and cervix. The lower end of the fused Müllerian ducts joins the upper end of a column of mesoderm in the Müllerian that will form the vagina. The column of mesoderm that will form the vagina, joins the distal end of the fused ***Müllerian ducts to the mucosa covering the*** Müllerian tubercle.

Development of the vagina:
The vagina develops by cavitation of the column of mesoderm in the Müllerian tubercle. Cavitation of the upper end of the vagina forms the fornix of the vagina that surrounds the cervix. The distal end of the vagina is closed by a vaginal plate. The posterior surface of the vaginal plate is lined by mesoderm of the Müllerian tubercle. The anterior surface of the vaginal plate is covered by endoderm of the urogenital sinus. Perforation of the vaginal. The vaginal plate forms the *hymen* of the vagina. Perforation of the vaginal plate forms the *introitus* of the vagina.

The mesonephric (Gartner's) ducts run in the *anterolateral walls of the fused* paramesonephric (Müllerian) ducts and upper part of the vagina.

The *Müllerian tubercle* tilts backwards and comes to lie posterior to the membranous urethral segment of the vesicourethral canal. The Müllerian tubercle is now the definitive *colliculus feminalis.*

The *vagina lengthens* in a cephalad direction, as does the *glandular urethral segment* of the vesicourethral canal. Gartner's ducts leave the (upper 1/3rd) of the vagina (at the level of the upper end of the glandular urethra and descend in the *posterior wall* of the glandular and membranous urethral segments of the *vesicourethral canal*.

The Gartner's ducts descend in parallel behind the urethral crest in the glandular and membranous urethra. The Gartner's ducts lie *within the membranous segment of lissosphincter* (smooth muscle component of the distal sphincteric complex DSC).

The lissosphincter of the membranous urethra and glandular urethra inserts in a connective tissue raphe (CTR), on the posterior wall of the (sphincteric) urethra. The posterior wall of the glandular and membranous urethra is embedded in the anterior wall of the vagina.

The rhabdosphincter (striated muscle component of the distal sphincteric complex DSC) encircles the membranous urethra, distal ends of Gartner's ducts and lower end of the vagina.

Gartner's ducts open on the colliculus feminalis immediately posterior to the opening of the membranous urethra (distal urethral orifice). The openings of Gartner's ducts are anterolateral to the introitus of the vagina.

The colliculus feminalis (CF) lies posterior to the membranous urethra. The CF contains the lower end of the vagina, and distal ends of the Gartner's ducts.

In review: The *lower border of the Müllerian tubercle* divides the primitive urogenital sinus into the vesicourethral canal above and the definitive urogenital sinus (UGS) below. The vagina and distal ends of the Gartner's duct open on the Müllerian tubercle. With the posterior displacement of the Müllerian tubercle behind the membranous urethra, the *Müllerian tubercle* is now the *colliculus feminalis*. The vagina, Gartner's ducts (in the colliculus feminalis) and membranous urethra, open in the roof of the definitive vestibule.

The floor of the UGS is the urogenital membrane. The urogenital membrane is also the roof of the urogenital groove. The urogenital groove is surrounded by the urogenital folds. When the *urogenital membrane disintegrates*, the mucosa of the UGS, meets epithelium of the upper border of the urogenital folds.

The definite UGS is now the definitive *vestibule*. The urogenital folds are now the *vestibular/ labial folds* or *labia minora*. Mucosa (endoderm) of the vestibule meets epithelium (ectoderm) of the upper borders of the labia minora, at Hart's line. The lateral walls of the vestibule are compressed from side to side. The labia minora are apposed in the midline around the opening of the vestibule.

With development of the phallic swelling (clitoris) the *anterior end of the vestibule is prolonged on the ventral aspect of the clitoris*. The posterior ends of the labia minora join at the posterior commissure of the labia minora. The anterior ends of the labia, under the clitoris, also called the frenulum of the clitoris, unite in the anterior commissure of the frenulum/labia minora.

Sections of the vestibule:
a) Posterior section
b) Middle section
c) Anterior section
d) Opening of the vestibule

The posterior and middle sections of the vestibule comprise the *perineal section* of the vestibule; the anterior section is the *phallic section* of the vestibule. The cleft-like opening of the vestibule is surrounded by the labia minora which are joined posteriorly and anteriorly by the posterior and anterior commissure of the labia minora.

a) The *posterior section* of the vestibule is below the colliculus feminalis and therefore below the openings of the vagina and Gartner's ducts.
The distal end of the *vagina* in the colliculus feminalis, pierce the (inferior) perineal membrane to open as *introitus of the vagina* in the roof of the posterior section of the vestibule. The distal ends of the *Gartner's ducts* run in the posterior wall of the glandular urethra. The Gartner's ducts and distal end of the membranous urethra, pierce the (inferior) perineal membrane to open in the roof of the posterior section of the vestibule. The tiny openings of Gartner's duct on the posterior lip of the distal urethral meatus are anterolateral to the introitus of the vagina. The *posterior lip of the distal urethral meatus* belongs to the *colliculus feminalis*.

b) The *middle section* of the vestibule is below the *opening of the membranous urethra,* with a *forward extension* to the level of the *suspensory ligament of the clitoris*.
The *membranous urethra* (and Gartner's ducts in the posterior wall of the membranous urethra) pierces the (inferior) perineal membrane and opens in the roof of the middle section of the vestibule as the *distal urethral orifice*. The distal urethral orifice is anterior to the openings of Gartner's ducts on the colliculus feminalis. The roof of the middle section of the vestibule (anterior to the distal urethral orifice) *extends slightly forwards* to the level of the *suspensory ligament of the clitoris.*

In adult females the anterior and middle sections of the vestibule measure about 4-5cm. in length and about 3-4mm in depth, corresponding to the length and height of the vestibular bulbs.

Formation of the bulbs of the vestibule and pars intermedia:
The vestibular bulbs are formed by condensations of spongy mesoderm that develop along the lateral walls of the posterior and middle sections of the vestibule. The bulbs are joined in the posterior midline behind the curved posterior wall of the vestibule.
At the level of the arcuate ligament of the pubic symphysis, the anterior ends of the vestibular bulbs converge and fuse in the midline. The fused ends of the vestibular bulbs, form a thin curved band of spongy tissue, the *pars intermedia*, adherent to the roof of the anterior section of the vestibule. The dorsal surface of pars intermedia is adherent to the ventral groove in the tunica albuginea of the bicavernosal body of the glans clitoris.

Formation of the bulbovestibular glands (greater vestibular/Bartholin's glands):
The openings of the bulbovestibular gland ducts form in the mucosa of the lower end of the lateral walls of the posterior section of the vestibule. The ducts run in the ventral borders of the vestibular bulbs. The ducts proliferate to form the compound alveolar acini of the greater vestibular/Bartholin's glands. The small oval Bartholin's glands are located on either side of the posterior curved wall of the vestibule, within posterior ends of the vestibular bulbs. Mucus secreted by the acini of the Bartholin's glands lubricates the vestibule during arousal.

Bartholin's duct cyst and Bartholin's abscess:
Bartholin duct cyst presents as a mass in the vestibule, adjacent to the posterior end of a labium minor. Bartholin's gland abscess presents as a tender mass under the posterior end of a labium majus.

The Bartholin's glands are equivalent to Cowper's glands in the male, which are embedded on either side of the midline in the expanded posterior end or bulb, of the corpus spongiosum of the bulbar urethra.

The *outlet of the posterior* and *middle sections* of the vestibule:
Is formed by *inner surface* of the *posterior commissure/fourchette* of the labia minora, and *inner surfaces* of the *labia minora posterior to the suspensory ligament* of the clitoris. Epithelium (ectoderm) at the upper border of the *inner layers* of the labia minora and posterior commissure of the labia minora, meets mucosa (endoderm) of the lower border of the vestibule, at *Hart's line.*

Epithelium (ectoderm) of the outer layer of the posterior commissure/fourchette of the labia minora, reflects on epithelium (ectoderm) of the perineal (ano-genital) raphe. Epithelium (ectoderm), of the outer surfaces of the labia minora reflects on the interlabial groove (labial folds), between the labia minora and labia majora.

c) The *anterior section* of the vestibule is distal to the suspensory ligament of the clitoris. The anterior section of the vestibule is *ventral to the pars intermedia* of the clitoris.
In the adult female, the length of the anterior section of the vestibule is about 1.5-2.0cm. corresponding to the approximate length of the clitoris.
The dorsal surface of pars intermedia is adherent to the ventral surface of the bicavernosal body of the clitoris. The ventral surface of pars intermedia is intimately attached to the mucosal *roof of the anterior section* of the vestibule.
The *opening of the of the anterior section* of the vestibule, is formed by the inner surfaces of the fine folds of the frenulum/labia minora, and inner surface of the anterior commissure of the frenulum/labia minora. The anterior commissure of the labia minora is ventral to the anterior end of pars intermedia which forms the ventral end of the conical cap of the glans clitoris.

The *anterior section of the vestibule* is limited to a *mucosal roof*, adherent to the ventral surface of pars intermedia.
The anterior section of the vestibule lacks side walls and therefore has no depth. The border of the mucosal roof (endoderm) of the anterior section of the vestibule, meets epithelium (ectoderm) at the upper border of the *inner surfaces* of the (fine folds of the) labia/frenulum, and anterior commissure of the labia minora/frenulum at *Hart's line*. The anterior commissure is ventral to the *end of the pars intermedia*, which is just ventral to the conical *tip of the cap* of the glans clitoris.

Outlet of the anterior section of the vestibule:
Is formed by the *inner surfaces of the labia minora/frenulum* of the clitoris and *anterior commissure of the labia minora/frenulum*. Epithelium *(ectoderm)* at the upper borders of the inner surfaces of the labia minora/ frenulum and anterior commissure, meets lateral borders of the flat mucosal roof *(endoderm),* of the anterior section of the vestibule, at *Hart's line.*

Epithelium (ectoderm) of the upper border of the outer surfaces of the labia minora/frenulum, meets epithelium (ectoderm of the genital fold) of the ventral borders of the roof of the glans clitoris.

Epithelium (ectoderm), of the upper border of the outer surface of the *anterior commissure* of the labia minora/frenulum, meets epithelium (ectoderm of the genital fold), of the ventral point of the crescentic cap of the glans clitoris, just below the tip of the glans clitoris.

Hart's line:

Origin:

The urogenital fold surrounds the urogenital groove. When the urogenital membrane disintegrates, mucosa (endoderm) at the lower end of the definitive urogenital sinus (vestibule), meets epithelium (ectoderm) of the *upper end of the inner layer of the circumferential urogenital fold* (labia minora), at *Hart's line.*

Epithelium of the inner layer of the *posterior commissure/fourchette of the urogenital fold/labia minora,* meets the mucosa of the lower border of the curved posterior end of the vestibule. In the *perineum*, the inner layers of the urogenital fold/labia minora, meets mucosa of the lower borders of the (posterior and middle sections of the) vestibule. In the *phallus/clitoris*, epithelium of the inner layers of the urogenital fold/labia minora), meets mucosa of the lateral borders of the flat roof mucosa of the anterior section of the vestibule. Epithelium of the inner layer of the *anterior commissure* of the urogenital fold/frenulum/labia minora, meets mucosa of the sharply curved anterior end of the flat roof of the vestibule.

The *curved ventral end of the flat mucosal roof* (of the anterior section) of the *vestibule*, is adherent to the ventral surface of the *distal end of pars intermedia,* which is a fraction *below, the tip* of the (spongy cap) of the *glans clitoris.* The distal end of pars intermedia extends slightly distal to the bicavernosal body of the clitoris.

The dorsal surface and lateral borders of the distal extension of pars intermedia, forms the ventral point of the spongy crescentic cap of the glans clitoris. The tip of the spongy cap of the glans clitoris is molded over the conical end of the bicavernosal body.

==========

From https://anatomydevelopment.com/#undefined

Jeffrey J Pollen MD, MB BCh (Wits), FRCS (Eng), MRCP (UK), FACS.

E: jpollen2@optonline.net

==========