Relationships of the Bulbo-clitoral Organ

13

13.1 General

The topographical anatomy of the bulbo-clitoral organ was already partially covered in the first chapters, with its morphology and structure having been observed in situ, i.e. within the external feminine genitalia. However, several points remain to be clarified and very specific connections have yet to be studied. We will discuss the connections with the vestibule, labia and greater vestibular glands; the connections with the urethra, the vagina and the perineal membrane; and finally, the relations with the pelvic diaphragm (levator ani muscles).

13.1.1 Connections with the Vestibule

13.1.1.1 Position of the Bulbs

These connections mainly involve the bulbs for which we have already examined the naming difficulties. Are the spongy bulbs pressed against the walls of the vestibule or do they go deeper? Against the terminal urethra? Against the end of the vaginal duct?

L. Kobelt, who first gave an exact and complete description of the bulbo-clitoral organ, was also the first to replace the older terminology (plexus retiform, plexus reticular) with the name "vestibular bulbs". But a semantic ambiguity should immediately be noted as this author explains why he calls them as such since the formations "are not located around, but at the entry to the vagina". Is this enough to abandon the terminology "vaginal bulbs"? The reality is in fact more complex and only frontal sectioning of the external genitalia makes it possible to reveal the details of bulb topography: The result of these sections is incontrovertible. The bulbs are directly connected not only to the urethral and vaginal orifices but also to the parts preceding it, i.e. the vestibule and the base of the labia minora and what follows the entire distal part of the vagina (Fig. 13.1) and the end of urethra. In other words, the terms "vestibular bulbs", "vaginal bulbs" and "urethral bulbs" all have an element of truth and remain perfectly valid. However, it is the term "vestibular bulbs" that was retained by the Nomina Anatomica. We would have preferred "spongy bulbs in women" (or female spongy bulbs) which is more general and less subject to discussion. Please note, however, that the terminology now present in the nomenclature is in accord with Kobelt, thus paying homage to this author. As for choosing which of the adjectives "urethral" or "vaginal" is best suited for describing the bulbar topography, let us agree that there is no cause for debate. The sections clearly show that the two adjectives are true since the bulbs border the external orifices of both ducts. However, for the urethra, 3/4 of the circumference of its external orifice is lined by spongy bulbar tissue, whereas for the vaginal orifice, only the lateral parts are lined by this tissue. It should also be noted that the bulbs are of varying length and often asymmetrical, such that the lateral walls of the vagina may not be entirely lined by the bulbs or one of the walls may be lined to a greater extent than the other! Finally, let us recall the terminology proposed by H.E. O'Connell et al.: "clitoral bulbs", which cannot be supported from a semantic point of view given that the clitoris and bulbs are two different parts of a whole. In the interest of accuracy, one should therefore refer to "bulbs of the bulbo-clitoral organ" or "genital bulbs" which are easier to express.

13.1.1.2 The Greater Vestibular Glands

On either side of the vestibule, the spongy bulbs connect with the two greater vestibular glands or Bartholin's glands.[1] These glands are well known to gynaecologists and their patients due to their frequent infection (bartholinitis may be the manifestation of a sexually transmitted infection, notably the infection caused by gonococcus: gonorrhoea). These muciparous glands are topographically in contact with the posterior extremity of the bulbs. The glands have an average diameter of 15 mm, a more or less spherical, slightly

[1]The two Bartholin's glands are equivalent to the bulbo-urethral glands (Cowper's glands) in men.

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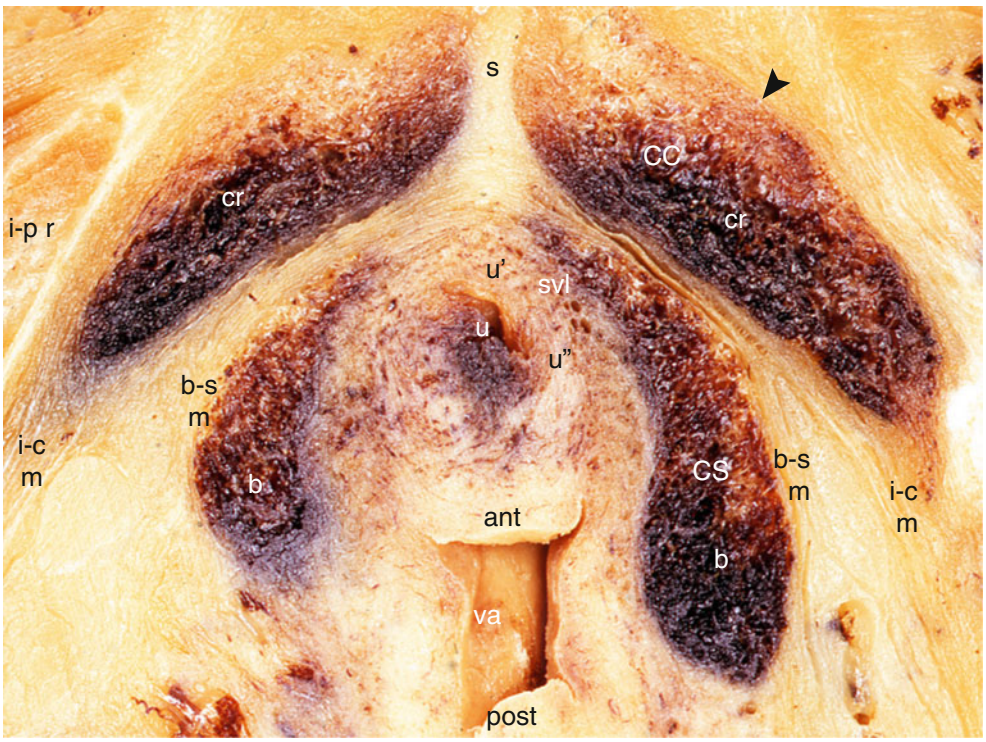

Fig. 13.1 Relationships between both the urethra and vagina with female erectile bodies. Tranverse section of female pelvis through the anterior perineum. *ant* anterior vaginal wall, *b* bulb, *b-s m* bulbo-spongiosus muscle, *CC* corpus cavernosum, *cr* crus clitoridis, *CS* corpus spongiosum, *i-c m* ischio-cavernosus muscle, *i-p r* ischio-pubic ramus, *post* posterior vaginal wall, *s* septum of the crura, *svl* superficial vascular layer (of urethra), *u* urethra, *u′* anterior wall (of urethra), *u′′* lateral wall (of urethra), *va* vagina, *Black arrowhead* it points the clitoral albuginea. Note the close relationship between the bulbs and the urethro-vaginal pyramid

flattened shape, sometimes ovoid, with an irregularly mammillated surface. Their firm consistency allows them to be easily identified upon palpation during dissection. However, strong adherence of the gland to the adjacent cell tissue renders its release difficult. This notion is also demonstrated during surgical release in view of exeresis of this gland, which is made all the more difficult due to the significant inflammatory adherences. The gland has very tight connections with the swollen posterior part of the bulb (Fig. 13.2), connections that the surgeon must be very aware of so as to avoid often serious haemorrhaging due to injury to the homolateral spongy bulb. The gland may be located to the rear and simply tangent to the convexity of the bulb's swollen extremity. More often, it is inserted into this extremity, carving out a sort of bulbar cavity in which it is housed. The vestibular gland may therefore be described as follows: an anterior extremity directed towards the external orifice of the vagina; a posterior extremity connected to the superficial transverse muscle; one medial vulvar surface that is more or less concave; a convex lateral surface facing, but at a distance from, the initial tapered pillar of the clitoris; a superior edge pressed against the inferior fascia of the urogenital diaphragm; and an inferior edge in contact with the superficial transverse muscle. The bulbospongiosus muscle is applied to the inferior edge and then to the inferior surface of the bulb, as seen previously. The excretory duct[2] measures 1–2 cm. Its diameter can reach 2 mm. Slanted forward and inward, it opens into the vestibular sulcus[3] along the insertion of the hymen or its carunculate remnants (carunculae hymenales), at the junction of the anterior 2/3 and posterior 1/3 of the vestibule. The secretion produced by this gland (tubulo-alveolar gland from a histological perspective) is a transparent or opalescent, runny mucus. It is secreted during coitus and contributes to lubrication of the walls of the external genitalia.[4] The neurovascular connections of the greater vestibular gland are lateral. The neurovascular bundle (Fig. 13.2) engaged above the lateral surface of the gland includes rami of the deep perineal artery (bulbar artery), voluminous veins and the deep ramus of the pudendal nerve perineal branch.

13.1.2 Connections with the Urethra

These connections are exceptionally important and had surprising consequences from an anecdotal point of view (see Chap. 1). Despite the shortness of this duct, we now know the various parts of the feminine urethra well (Fig. 13.3) and notably the part that is connected to the bulbo-clitoral organ: It is the distal part of this duct, immediately beyond the posteroin-

[2]This excretory duct may be double.

[3]The vestibular (or labio-hymeneal) sulcus separates the hymen (or its remnants, carunculae hymenales), from the labium minus. The limit between the vestibular epithelium and the epithelium of the medial surface of the labia minora is called "Hart's line" (Fig. 4.2).

[4]The secretion is also produced by many very small "lesser vestibular glands" situated between the urethral and vaginal orifices and opening into the vestibule.

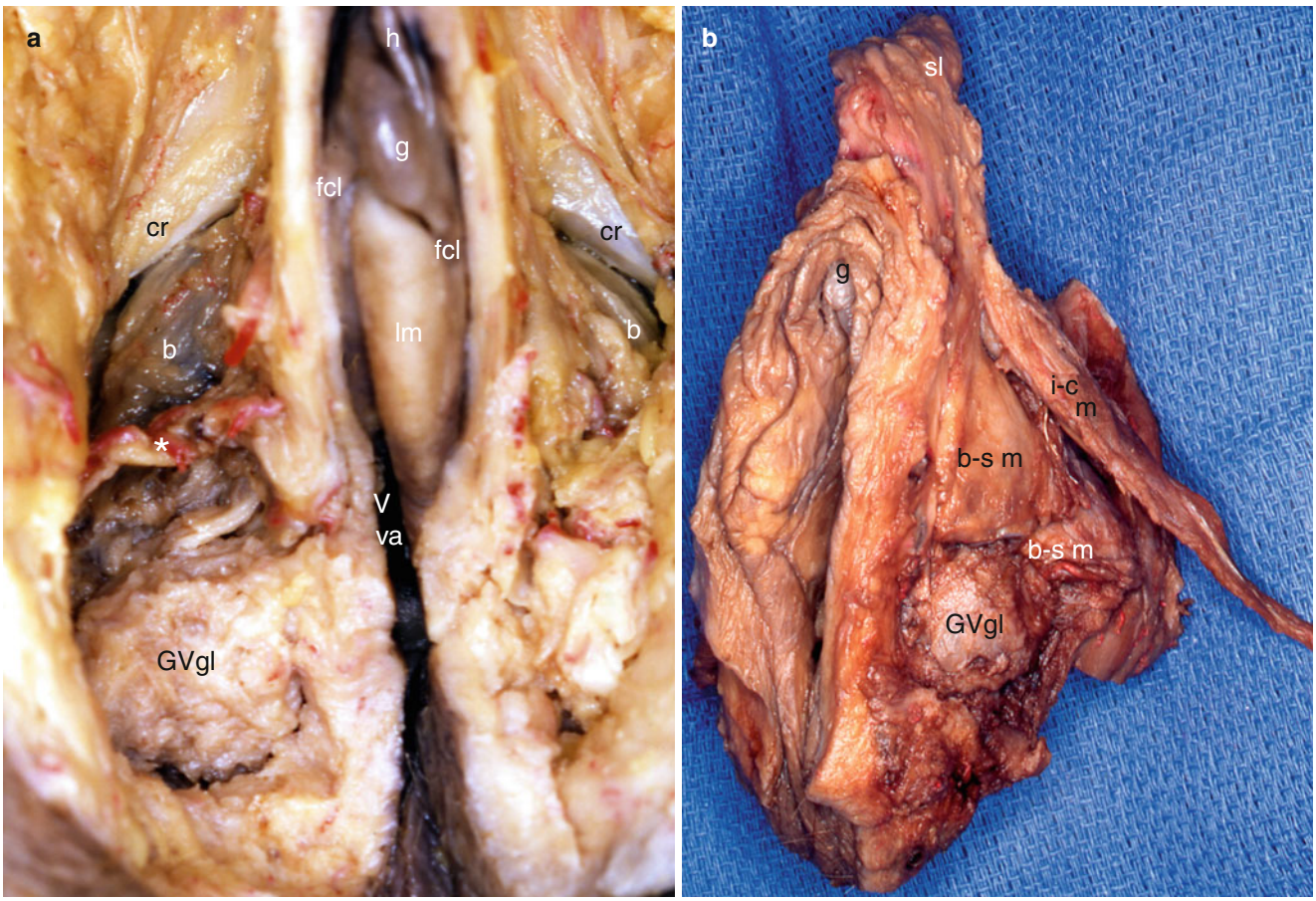

Fig. 13.2 Two dissections of the anterior perineum to show the close relationship between the bulbs and the greater vestibular glands (Bartholin's glands). (**a**) Anterior view showing the right great vestibular gland behind the right bulb; notice the neurovascular bundle* (bulbar artery and rami from the pudendal nerve's perineal branch) engaging obliquely in front of the gland. (**b**) Lateral left view showing a left great vestibular gland, behind the left bulb covered by the bulbospongiosus muscle. *b* bulb (with bulbospongiosus muscle), *b-s m* bulbospongiosus muscle (*black legend* medial part of the muscle, *white legend* lateral part), *cr* crus of clitoris, *fcl* frenum (frenulum clitoridis), *g* glans clitoridis, *h* hood, *lm* labium minus (lesser lip), *GVgl* greater (or major) vestibular gland (Bartholin's gland), *Vva* vestibule of vagina

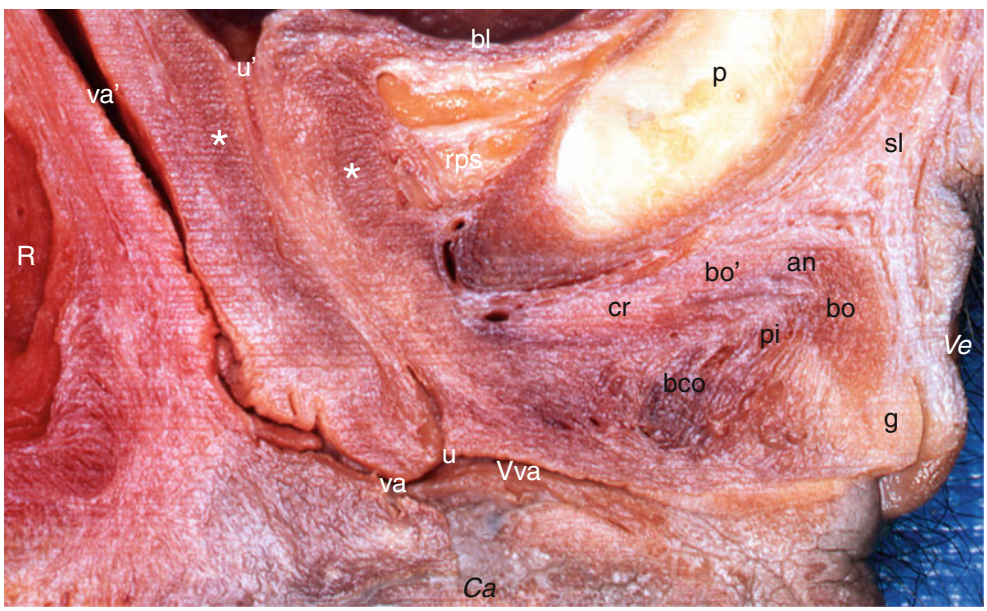

Fig. 13.3 Part of a median sagittal section through the female pelvis showing the location of the bulbo-clitoral organ and its immediate surroundings. *Ve* ventral, *Ca* caudal, *an* angle (elbow), *bco* bulbar commissure, *bl* bladder, *bo* clitoral body (descending part), *bo′* clitoral body (ascending part), *cr* crus clitoridis, *g* glans, *pi* pars intermedia of Kobelt, *p* pubic symphysis, *R* rectum, *rps* retro-pubic space, *sl* suspensory ligament, *u* external urethral orifice, *u′* internal urethral orifice, *va* vaginal orifice (introïtus), *va′* vagina, *Vva* vestibule of vagina, *white asterisks* external sphincter urethrae

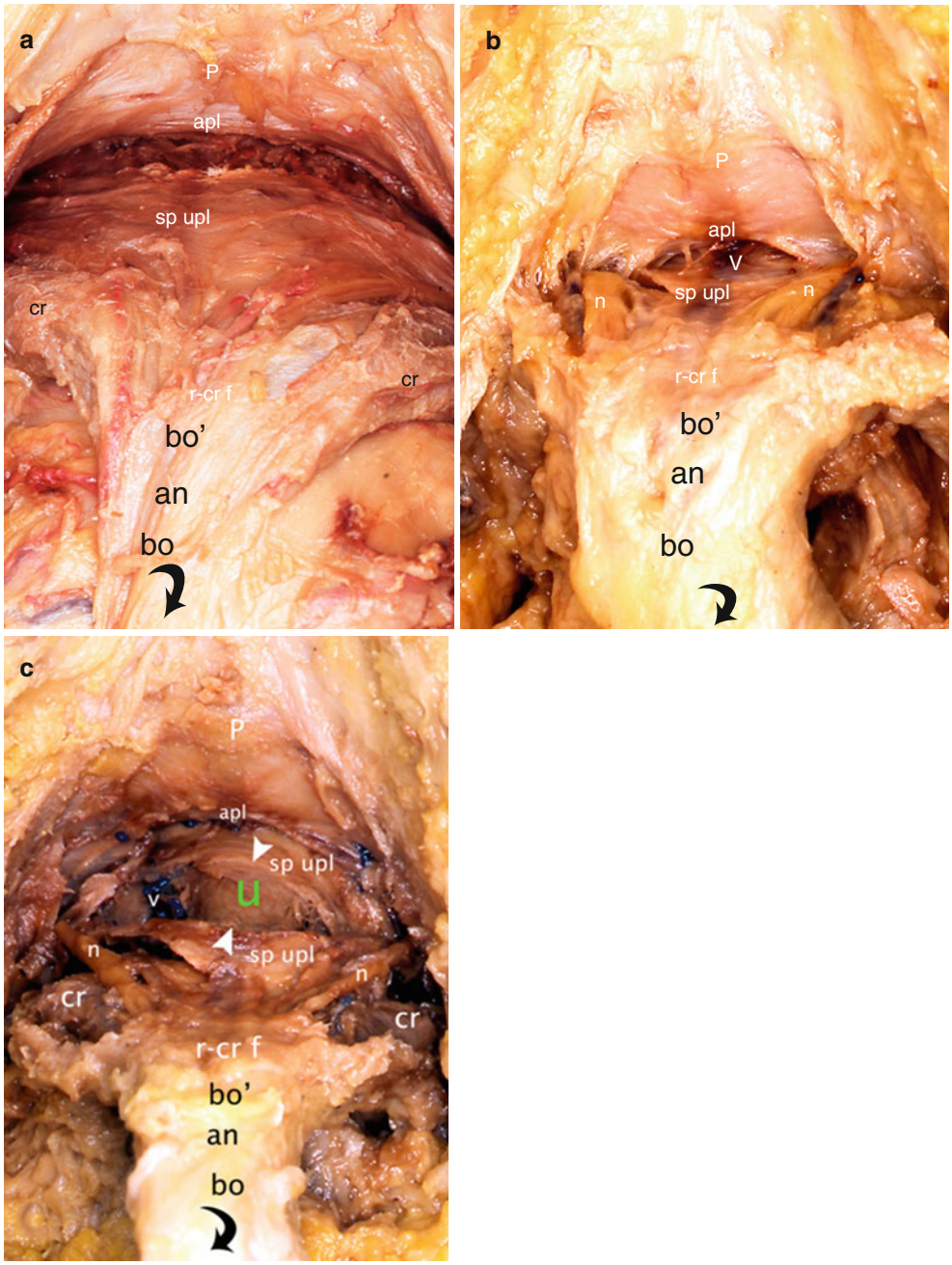

Fig. 13.4 Dissections of the pre- and infra-pubic areas to show the relationship between the dorsal parts of the bulbo-clitoral organ and the urethra (bird's eye views). The clitoral body has been retracted back and down (*black curved arrow*). (**a**, **b**) Gradual release of the subpubic urethral plate. (**c**) Transversal incision of the subpubic urethral plate highlighting the urethra. *an* angle, *apl* arcuate pubic ligament, *bo'* ascending part of the clitoral body, *bo* descending part of the clitoral body, *cr* crus clitoridis, *n* dorsal nerve of clitoris, *P* pubic symphysis, *r-cr f* retro-crural fascia, *sp upl* subpubic urethral plate, *u* (*green*) urethra, *V* deep vein of the clitoris (seen by transparency through the sp upl), *v* right latero-urethral venous plexus, *white arrowheads* they show the two banks of the subpubic urethral plate cut transversally

ferior edge of the pubic symphysis and more accurately immediately beyond the passage through the urogenital diaphragm. This is therefore the extra-pelvic portion of the urethra. This part, called the "distal urethra", very thoroughly evaluated by J.O.L. Delancey, corresponds to the terminal segment extending from 79 % of the total length of the duct to the external orifice (situated at "100 % of the length"). If we take the average length of the female urethra to be 3 cm (extremes: 25–44 mm), the distal urethra only represents 0.8 cm! Serial sectioning of this short segment, perpendicular to the urethral axis, allowed us to gain very precise information to complete the general notions that appeared during dissection.

We were able to observe deep and superficial connections during dissection.

Observation of deep connections first requires dissection of the bulbo-clitoral organ. The organ has to be pushed back and down with a fair amount of force (thus sacrificing the two thin cavernous nerves) in order to access the thin subpubic urethral plate (or supra-urethral lamina). This lamina continues from the retro-crural fascia (see Chap. 5). The underlying urethral duct can be felt through the lamina with a fingertip. As soon as the transversal incision is made in the lamina, the urethra appears (Fig. 13.4). The duct will then pass through the urogenital diaphragm behind the transverse

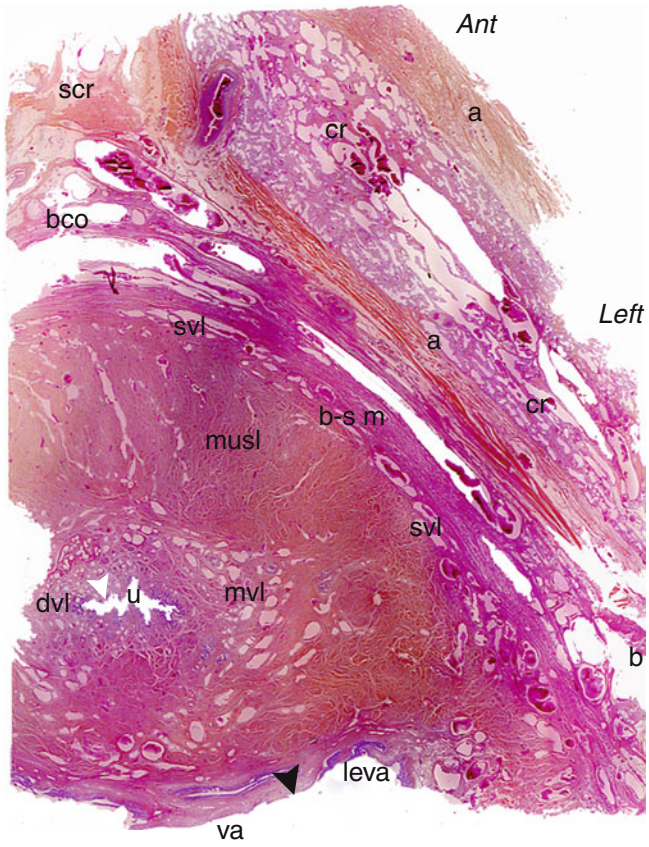

Fig. 13.5 Relationship between the urethra and female erectile bodies. Transverse section (Section 3) (perpendicular to the urethral axis) through the crura clitoridis. *a* albuginea, *b* bulb, *bco* bulbar commissure, *bs m* bulbospongiosus muscle, *cr* crus clitoridis, *dvl* deep vascular layer (layer of small submucosal vessels), *leva* lateral edge of vagina, *musl* muscular layer (thick layer of smooth muscle fibres), *mvl* middle vascular layer (bigger vessels than those of dvl), *scr* septum of crura, *svl* superficial vascular layer (large vessels communicating with the spongy lacunar cavities), *u* lumen of the urethra, *va* vagina, *black arrowhead* it shows the location of the vaginal mucosa on the anterior wall of vagina (this mucosa can be seen just above the left lateral edge of vagina), *white arrowhead* mucous membrane of the urethra

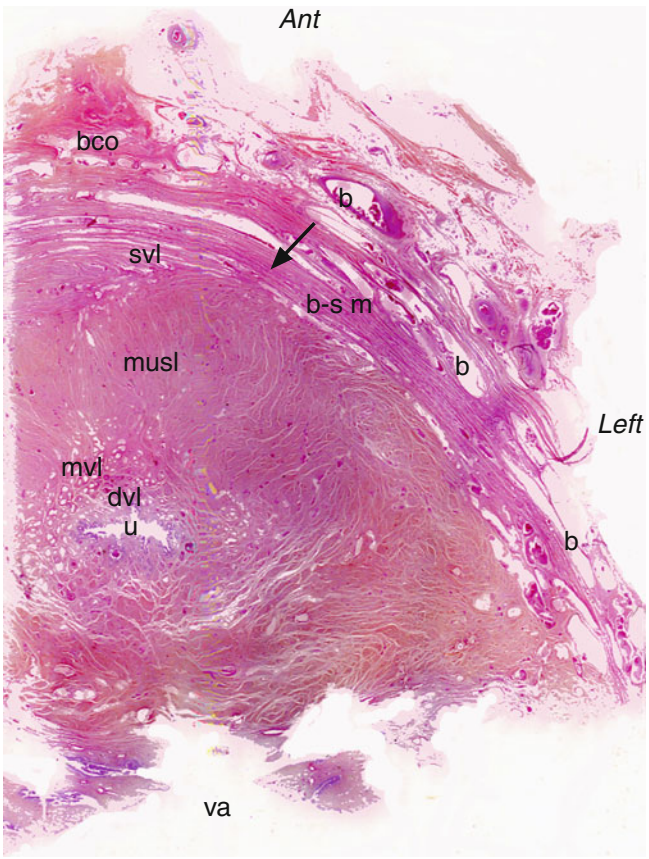

Fig. 13.6 Relationship between the urethra and female erectile bodies. Transverse section (Section 2) (perpendicular to the urethral axis) through the bulbar commissure. *b* bulb, *bco* bulbar commissure, *bs m* bulbospongiosus muscle, *dvl* deep vascular layer (layer of small submucosal vessels), *mvl* middle vascular layer, *musl* muscular layer (thick layer of smooth muscle fibres), *svl* superficial vascular layer (large vessels communicating with the spongy lacunar cavities), *u* urethral lumen, *va* vagina, *black arrow* it shows the striated muscle fibres of the bulbospongiosus muscle, getting between the spongy bulb's vascular cavities and merging with the muscle fibres from the opposite side, so as to form a distal sphincter : the "compressor urethrae muscle" of ancient authors

perineal ligament. It is now becoming perineal. It appears as a cylindrical tube, slightly widened, with a thick wall.

Observation of superficial connections is simpler. The previously dissected bulbo-clitoral organ is left in place. We can see the final mm of the distal portion of the urethra and the external urethral orifice above the external vaginal orifice. The connections are also easy to identify: The urethra in this terminal segment is surrounded by the spongy tissue on 3/4 of its circumference (lateral surfaces bordered by medial surfaces of the bulbs and superior edge, covered by the commissure of the bulbs).

If we lift the entire bulbo-clitoral organ, we are just beyond the limit between the pelvic urethra and the perineal urethra, as the urethra has just started to cross the urogenital diaphragm (Fig. 13.10).

Three levels of histological sections perpendicular to the axis of the perineal urethral duct seem worth considering (Figs. 13.5, 13.6 and 13.7): Section 3 (the deeper) goes through the crura clitoridis; the middle, Section 2, only goes through the spongy structures; and the most superficial, Section 1, is tangent to the external urethral orifice.

- On Section 3, we can see a crus clitoridis from front to back (cavernous tissue surrounded by its albuginea) and the commissure of the bulbs (commissura bulborum) lined in front and back by elements of the bulbospongiosus muscle with striated muscle fibres slipping in between the vascular crevices of the spongy tissue. This spongy tissue covers the anterior surface of the urethra.

  From the centre to its periphery, the urethral Section 3 shows a urethral lumen bordered by its epithelium

Fig. 13.7 Relationship between the urethra and female erectile bodies. Transverse section (Section 1) (perpendicular to the urethral axis) through the end of the urethra, near its external orifice. *b* bulb (right), *b′* bulb (left), *dvl* deep vascular layer (layer of small submucosal vessels), *mvl* middle vascular layer, *svl* superficial vascular layer (large vessels communicating with the spongy lacunar cavities), *u* urethral lumen (tangential to the external urethral orifice), *va* vagina (tangential to the vaginal orifice)

(squamous, multistriated, non-keratinised epithelium), a peri-epithelial layer rich in small vascular lumina (evoking a sort of erectile tissue), then a new vascular layer with vessels of diameters greater than those of the previous layer, a very thick muscularis (with an internal layer of smooth muscle fibres arranged longitudinally and an external layer arranged in a circular pattern) and a last, thinner vascular layer with elongated vessels of greater dimensions than those of the deep vascular layers, but smaller than those of the neighbouring spongy tissue vessels. Behind the urethra, we can finally observe until its lateral edge the thin anterior vaginal wall with its mucous membrane.

- The urethral Section 2 no longer displays cavernous tissue. It only goes through the spongy tissue (bulb and commissure of the bulbs). The striated muscle fibres from the bulbospongiosus muscle are much more abundant and, behind the commissura bulborum, they make up a sort of sphincter that compresses the anterior median part of the urethra. The urethra has a similar appearance to that observed on Section 3. However, the vessels of the two deep vascular layers are less abundant and smaller. On the contrary, the vessels of the superficial layer are larger and already communicate with the spongy vascular lacunae.
- The very superficial urethral Section 1 (at the external orifice), like the previous section, only includes spongy tissue which is particularly abundant (the section passes through meanders of the lumina, bordered in places by the remnants of the epithelium). The thick urethral muscularis cannot be seen on this section. However, the layer of medium-sized vessels is particularly developed and occupies the anterior sinus formed by the junction area of the two bulbs. In the most anterior part of this vascular layer, larger vessels communicate extensively with the spongy vascular lacunae. The role of this well-developed vascular cushion, capable of storing a large quantity of blood, if needed, has yet to be understood.

Another important connection is the **distance separating the summit of the glans and the external urethral orifice**. This distance, which is variable (Fig. 13.8), is the median of the urethral vestibular triangle (of which the summit is the clitoral glans, the two sides are the labia minora and the base is the horizontal line going through the external urethral orifice). Most authors evaluate this distance at an average of 2.1 cm (the extremes found during our study were 1.8 and 3.6 cm). If we believe the publication of a certain A. Narjani in 1924 (a publication that did not include any real statistical study), this distance is predictive of a woman's aptitude to experience orgasm. In fact, Narjani was the pseudonym used by the princess Marie Bonaparte,[5] very concerned with her own frigidity. To publish the measurements, she took on 200 women to prove her reasoning, providing figures on the CUMD distance (distance between the clitoral glans and the centre of the urinary meatus[6] or "clitoris-urinary meatus diameter"). The author classified women into three categories depending on this distance: If the distance is less than 2.25 cm (**paraclitoral** women; 70 % of cases), it is very probable that the woman will easily orgasm during sexual intercourse. If the distance is greater than or equal to 2.5 cm (**teleclitoral** women; 20 % of cases), orgasm during sexual intercourse will be exceptional or even impossible. The remaining 10 % (**mesoclitoral** women) have varying chances of orgasm. Marie Bonaparte explained that in fact, it is the distance between the clitoral glans and the external vaginal orifice (immediately behind the external urethral orifice) that plays a major role. According to her, if this distance is too great, the clitoris cannot be effectively stimulated by the male penis

[5]Granddaughter of one of Napoleon I's nephews, prince Pierre-Napoleon Bonaparte. She married prince Georges of Greece in 1907. She met Freud in 1925, underwent psychoanalysis with him and would become his student, friend and later his representative in Paris. She was grateful to him and enabled Freud and his family to leave Austria, under Nazi rule at the time. She also saved many Jewish intellectuals.

[6]The term "urinary meatus" used by Marie Bonaparte is not suitable. The author is actually referring to the "external urethral orifice" (term from the anatomical nomenclature!).

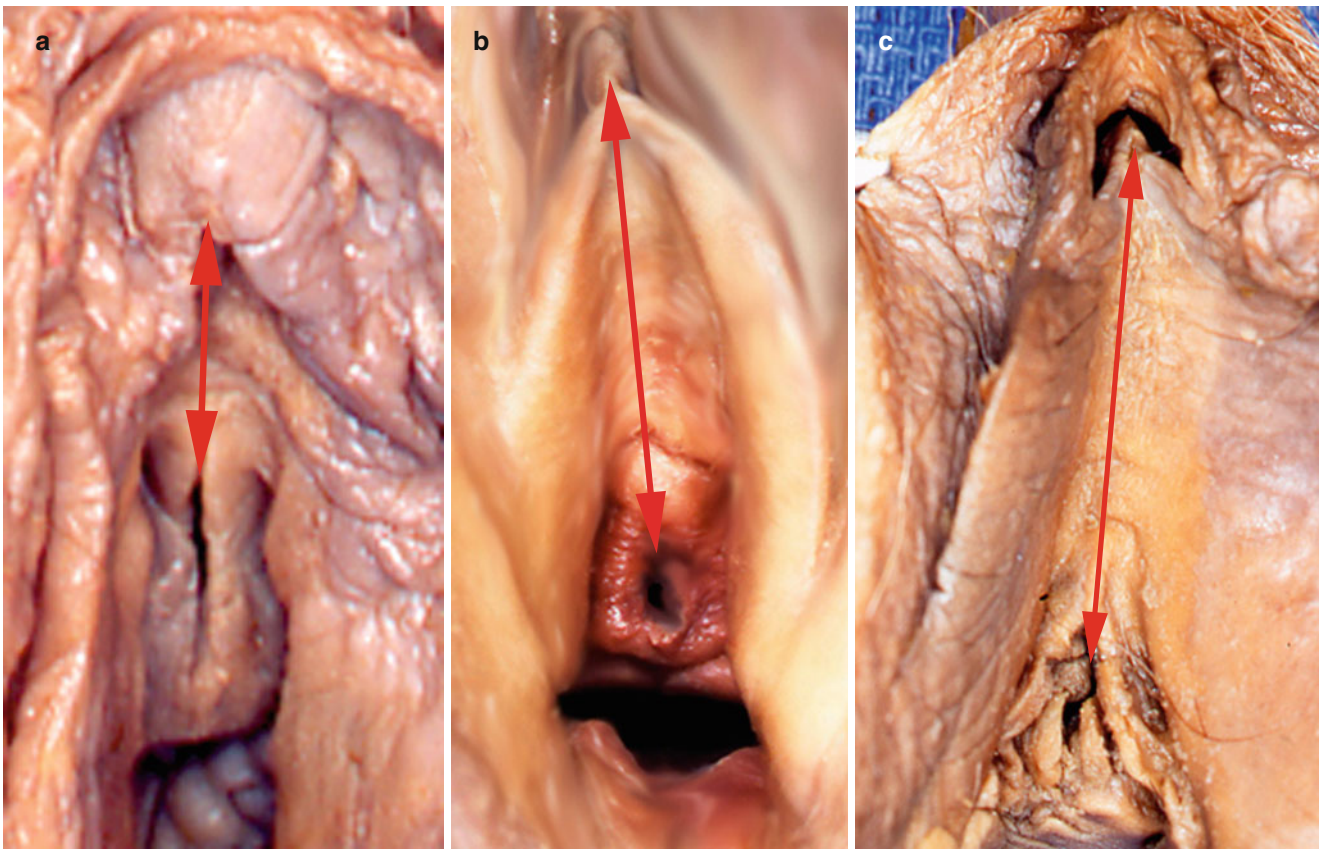

Fig. 13.8 Three examples of the extreme variability of distance between the glans clitoridis and the external urethral orifice (distance CUMD *clitoris-urinary meatus* according to Narjani). (**a**) Very short distance; (**b**) great distance; (**c**) very important distance. Notice on case **c**, the very particular and abnormal external urethral orifice with a hair hood

during coitus. Marie Bonaparte then went on to develop the Halban-Narjani procedure with the famous Austrian surgeon Joseph Halban, which consists in transecting the suspensory ligament of the clitoris to reposition the clitoris closer to the external vaginal orifice. Very convinced and courageous, Marie Bonaparte underwent the surgery herself. Not having received a successful result, yet still just as convinced, she went on to have the operation two more times… again without success (and surely with permanent damage resulting from the sectioning of nerves)! The results were the same for the four other patients who underwent the surgery. A few years later, Marie Bonaparte, convinced by the teachings of Freud, who was now her mentor, would radically change her viewpoint, affirming in 1933 that the CUMD had nothing to do with aptitude to orgasm and that frigidity only resulted from a psychoanalytic process. Despite this change in opinion, the initial theory of Marie Bonaparte remains current and has been adapted and studied by many authors since. An exhaustive, remarkable study co-signed K. Wallen and E.A. Lloyd addresses the question. The two authors conclude that statistical studies with very precise genital measurements could provide interesting conclusions. These authors note that undeniably, there are differences in individuals' aptitude to orgasm and that there are also major variations in the arrangement of external female genital organs (Fig. 13.8). There are surely correlations between these physiological and anatomical modalities. The two authors also ask what causes differences in positioning of the clitoral glans. Adapting the argument already offered by Marie Bonaparte, they mention the role of hormonal impregnation of the female foetus, itself a reflection of the hormonal impregnation of the pregnant woman carrying it. If prenatal exposure to androgens is low, the rostral migration of the genital tubercle does not take place and the clitoris remains near to the external orifice of the vagina. Inversely, in the case of prenatal exposure to androgens, the genital tubercle initiates migration, the resulting clitoris is slightly more developed and the CUMD distance is greater!

The embryological approach is also used to study what Pozzi, a famous French surgeon, called "**la bride masculine**" ("**the male bridle**")[7] and what Félix Léon Jayle would simply refer to as the "bandelette urétro-clitoridienne" (urethro-clitoral

[7]In fact, Neubauer had already included the so-called male bridle in his anatomical drawings as early as 1784 but had not made any comments on his observation of it.

band) in his work "l'Anatomie Morphologique de la Femme" (Morphological Anatomy of the Woman) since it linked the glans clitoridis and the external urethral orifice. In 1884, Pozzi described it as a triangular mucous membrane thickening with an anterior summit at the apex of the glans and a base that forks at the external urethral orifice into two rami that follow the lateral walls of the orifice, then meet under this orifice and finally diverge to "apparently continue with the hymen membrane". This bridle was, according to the author, clearly visible in the female foetus or young girl. He explained that "in the adult, virgin woman, this arrangement can be seen without difficulty, though it is less visible than in young girls. In deflorated women, and especially in multipara, the bridle sometimes becomes virtually invisible". Pozzi thought that this bridle was a vestige of the penile portion of the urethra in men (hence the name "**male bridle**"), but this was not quite accurate. If this thickening is indeed an embryological remnant, it corresponds not to the penile urethra, but to the spongy tissue that would have surrounded this penile portion of the urethra if the foetus had evolved to be male. In other words, this bridle corresponds to a median relief of what we designated as the "IC RSP". The conclusion from A.W.M van Turnhout et al.'s remarkable work can be cited as proof: these authors histologically studied the parts of the male bridles resected during metoidioplasties[8] performed in their hospital, and they found typical spongy tissue every time! In our study, we have highlighted this male bridle several times, once with formation of the small median groove, as observed by F.L. Jayle (Fig. 13.9).

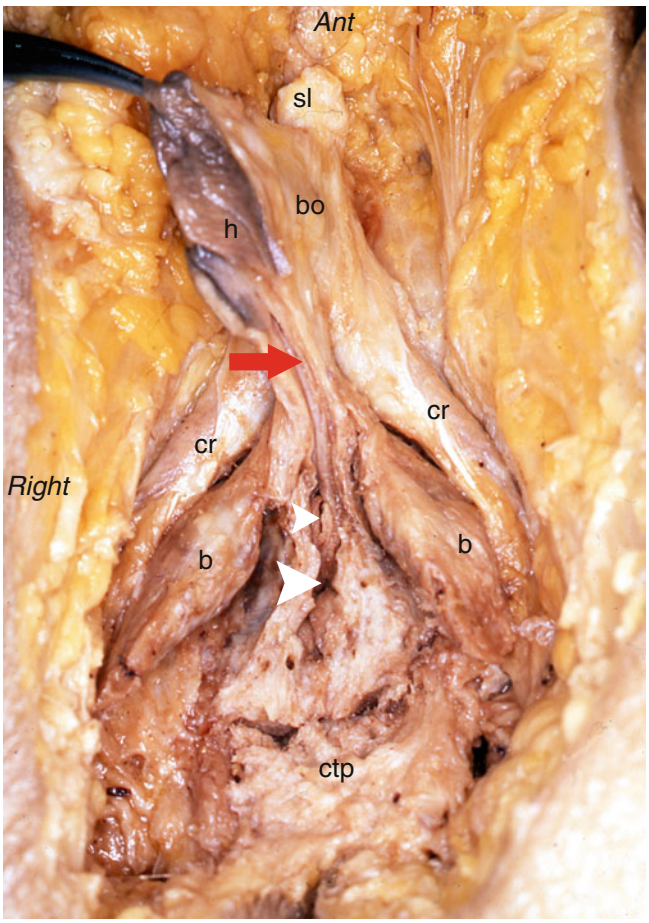

Fig. 13.9 The male bridle ("bride masculine" of French authors) on a perineal view of the female external genital apparatus, after dissection of the erectile bodies (the forceps tracts the prepuce back and right). *b* bulb, *bo* clitoral body, *cr* crus clitoridis, *ctp* central tendon of perineum, *h* hood, *sl* suspensory ligament, *great white arrowhead* vaginal orifice (introïtus), *little white arrowhead* external urethral orifice, *red arrow* male bridle (urethro-clitoral tractus)

13.1.3 Connections with the Perineal Membrane

The pillars (crura) of the bulbo-clitoral organ are applied against the inferior surface of the "**perineal membrane**", i.e. the fascia that lines the inferior surface of the deep transverse muscles of the perineum (former inferior fascia of the urogenital diaphragm). As we saw during the description of this organ, the erectile bodies are attached to this structure, which represents the floor of the deep space of the perineum (and the roof of the superficial space!).

The crura clitoridis attach, by way of their musculofascial envelope, to the lateral edges of the perineal membrane caudal surface, along the ischio-pubic rami (into which they are inserted as well). The perineal membrane is thickened here and the fibrous attachments are very solid. They are formed between the fibrous envelope of the cavernous pillars and the thickened membrane, which has become the "attaching lamina of the corpora cavernosa".

When we release the pillar, we can observe that this manoeuvre is difficult and that the bistoury "squeaks" upon contact with a dense fibrosis! The two spongy bulbs are also attached to the caudal surface of this perineal membrane. Their insertions are near to the most distal part of the urethra and the vagina, on the medial parts of this membrane, along the lateral edges of the urethral and vaginal orifices. Here again, the adherences are solid, even if less so than for crura clitoridis. Let us repeat finally that the perineal membrane is nothing more than the inferior fascia of what was called the "urogenital diaphragm" and a certain trend aims to erase it from anatomical texts. Traditionally, this diaphragm is made up of the deep transverse muscle and two fascias: one inferior, the inferior fascia of the urogenital diaphragm (perineal membrane), and the other superior, superior fascia of the urogenital diaphragm. Currently it is common for authors to contest that the existence of the superior fascia, which granted, is less clearly defined, and the same is true for the deep transverse muscle (T.A. Stein et al., P. Mirilas et al., W. Dorschner et al.). We affirm, after anatomical-histological

[8]Metoidioplasty or metaoidioplasty is a phalloplasty (plastic surgery aiming to construct a phallus in view of sex reassignment).

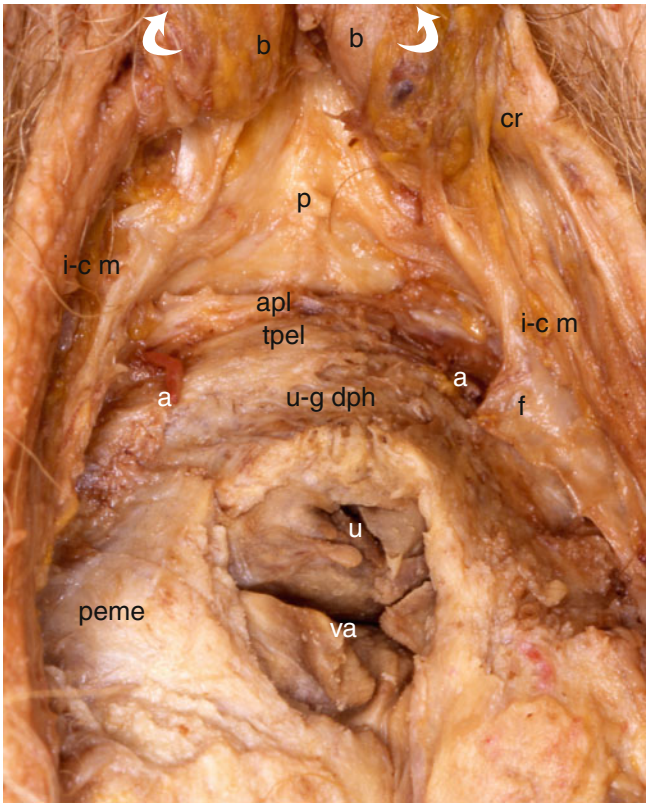

Fig. 13.10 Relationship between the ischiocavernosus muscles and the urogenital diaphragm (dissection of female anterior perineum). The bulbs and the crura of clitoris have been released from their attachments and pulled against the pubis (*white curved arrows*). *a* dorsal artery of clitoris, *apl* arcuate pubic ligament, *b* bulb, *cr* crus clitoridis, *f* fascia encasing ischiocavernosus muscle, *i-c m* ischiocavernosus muscle, *peme* perineal membrane, *tpel* transverse perineal ligament, *u* external urethral orifice, *u-g dph* urogenital diaphragm, *va* vaginal orifice

verifications, that an unchanging musculo-aponeurotic structure exists. The urethra and the vagina pass through it (Fig. 13.10). It is perfectly dissectible, and it plays an undeniable role in urinary continence. This structure, 2–3 mm thick, is lateral to the aforementioned ducts and is formed by two thick fascias (under microscope: thick bundles of collagenous fibres) between which we can see a muscular structure, made up of an abundance of striated muscle fibres in a transverse orientation (Fig. 13.10). These striated muscle fibres must not be confused with the urethro-vaginal sphincter, which belongs to the striated sphincter of the urethra![9] Serial sections of the urogenital diaphragm show that in front, the striated muscle fibres become rare and then disappear such that the two fascias join together as one thick ligament: the transverse perineal ligament (Fig. 13.10). This is the ligament that passes as a bridge to the front of the distal urethra. This is also the ligament that, along with the arcuate pubic ligament, delimits the infra-pubic space where the dorsal and deep veins of the clitoris and the cavernous nerves pass through. In its entirety, the musculo-aponeurotic structure observed consistently at the anterior perineum, if dissected minutely and attentively, presents the shape of a horseshoe, tying the urethro-vaginal assembly "from the front". The crura clitoridis and the spongy bulbs are attached to the caudal surface of this musculo-aponeurotic structure.

13.1.4 Relations with the Pelvic Diaphragm

Relations with the **pelvic diaphragm** are worth mentioning, even if this fibro-muscular layer is deep and more cranial than the perineal membrane to which the erectile bodies are attached, as we have just seen. The **puborectal bundle of the levator ani muscle** (main, very powerful and very active muscular component of the pelvic diaphragm) is tangent to the lateral walls of the urethral and vaginal distal extremities.

Let us remember that the pelvic diaphragm is a musculo-aponeurotic assembly that closes at the bottom of the pelvic cavity and on which the pelvic viscera rest, as on a hammock. It comprises four muscles: the two levator ani muscles, which make up the majority of the muscular plane, and the two coccygeus muscles located behind the levator ani. All of these muscles are covered with fascias, the **superior fascia** and the **inferior fascia of the pelvic diaphragm**. Two large orifices, the urogenital hiatus (formerly the urogenital opening) and the anorectal hiatus, enable the pelvic viscera to cross this diaphragm and pass from the pelvic cavity to the perineum. For both sexes, the anorectal hiatus allows passage of the terminal part of the intestine or rectum.[10] In women, the urogenital hiatus allows passage of the urethra and the vagina. The two levator ani muscles are even and symmetrical and comprise two muscular layers: one cranial layer formed by three bundles—pubococcygeal, iliococcygeal and ischiococcygeal—and one caudal layer formed mainly by a so-called puborectal bundle which is of major importance in pelvic biomechanics as it ties the rectum from behind. This puborectal bundle (Figs. 13.11 and 13.12) follows the lateral wall of the vagina and has very tight connections with the vagina.[11] It is presented as a muscular, ribboned bundle, slightly twisted and very solid, that links the **central tendon of the perineum** to the angular surface of the pubis to which it is fastened. Retrovaginal fibres cross with those on the opposite side to form a true hammock that supports the vagina. The other retrorectal fibres determine the **anorectal angle**, of major importance in terms of function,

[9] It is the caudal part of the striated sphincter of the urethra, located above, pressed in a horseshoe shape against the ventral surface and the lateral surfaces of the urethra, which should be called the "urethro-vaginal sphincter".

[10] The levator ani muscle marks the level where the pelvic rectum continues as the anal canal (former perineal rectum).

[11] The puborectal bundle can be easily perceived on the lateral walls of the vagina during vaginal examination. During examination with the aim of correcting a prolapse, the gynaecologist may evaluate the quality and tonus of the muscle by asking the examined patient to "squeeze" the examiner's fingers.

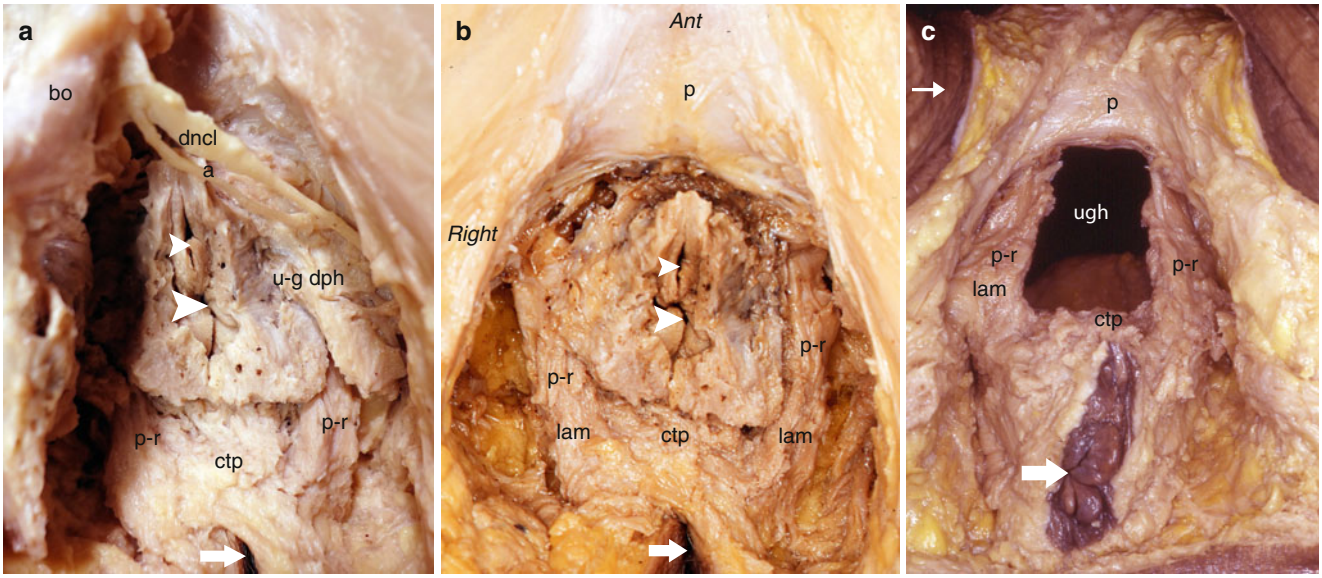

Fig. 13.11 Relationship between both the bulbo-clitoral organ and the urethro-vaginal pyramid with the levator ani muscles (pelvic diaphragm). (**a**) Perineal view of female pelvic floor. The bulbo-clitoral organ, released from its attachments, has been moved backwards and on the right, drawing the left dorsal artery and the left dorsal nerve of clitoris. The urogenital diaphragm (perineal membrane) is always present below the pubo-rectalis (bundle of the levator ani muscle). (**b**) Same perineal view of female pelvic floor after the removal of both the bulbo-clitoral organ and urogenital diaphragm. (**c**) Perineal view of female pelvic floor highlighting the urogenital hiatus (hiatus of levator ani muscles), after removal of bulbo-clitoral organ, urogenital diaphragm and "urethro-vaginal pyramid". *a* dorsal artery of clitoris, *bo* body of clitoris, *ctp* central tendon of perineum, *dncl* dorsal nerve of clitoris, *lam* levator ani muscle, *p* pubic symphysis, *pr* pubo-rectalis (bundle of levator ani), *u-g dph* urogenital diaphragm, *ugh* urogenital hiatus (hiatus of levator ani muscles), *great white arrow* anus, *small white arrow* genitofemoralis sulcus, *great white arrowhead* vaginal orifice, *small white arrowhead* external urethral orifice

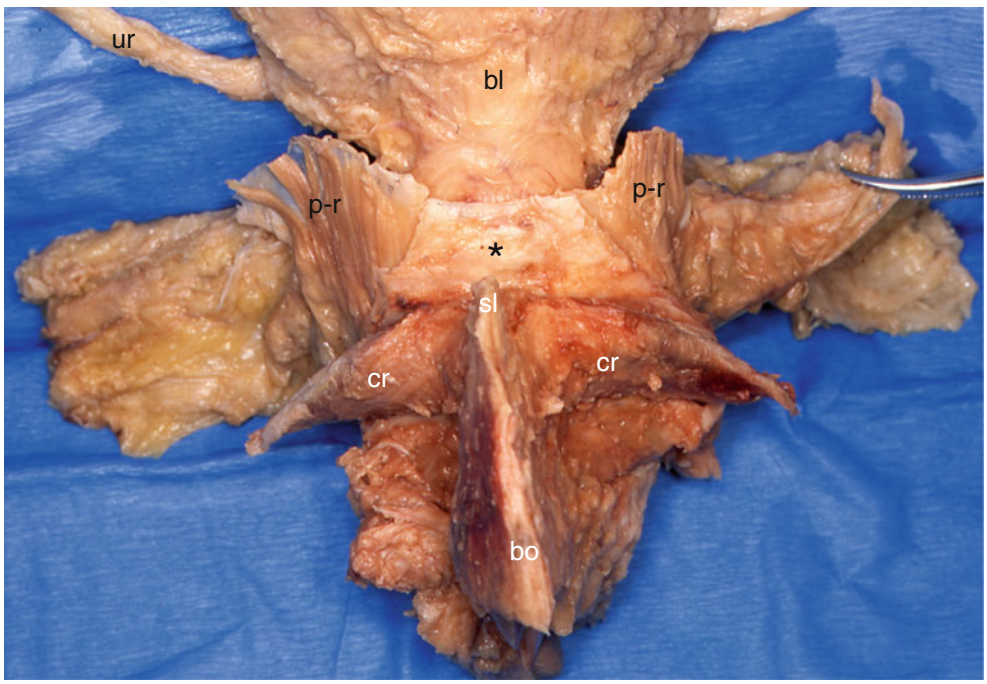

Fig. 13.12 Relations between the crura clitoridis and the pubo-rectalis muscles exposed on a "pelvi-perineal" dissection (*specimen removed from the pubic symphysis*). *bl* bladder, *bo* clitoral body (descending part), *cr* crus clitoridis, *pr* pubo-rectalis muscle (bundle of the levator ani muscle), *sl* suspensory ligament, *ur* right ureter, *black asterisk* fibrous coating of the pubic symphysis's posterior surface; the clamp lifts the left paracervix (Mackenrodt's ligament)

and they participate in anorectal continence and defecation along with the external anal sphincter (the deep part of which the fibres are joined to). Topographically, it is the perineal membrane and the deep transverse muscle that separate the female erectile bodies from the ischioanal fossa (spaces located under the levator ani muscles) and from their ventral extensions. The pelvic-subperitoneal space above the pelvic diaphragm represents a more distant connection.