Review

Embryology and anatomy of the vulva: the female orgasm and women’s sexual health

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ABSTRACT

Sexual health is vital to overall well-being. Orgasm is a normal psycho-physiological function of human beings and every woman has the right to feel sexual pleasure. The anatomy of the vulva and of the female erectile organs (trigger of orgasm) is described in human anatomy textbooks. Female sexual physiology was first described in Dickinson’s textbook in 1949 and subsequently by Masters and Johnson in 1966. During women’s sexual response, changes occur in the congestive structures that are essential to the understanding of women’s sexual response and specifically of their orgasm. Female and male external genital organs arise from the same embryologic structures, i.e. phallus, urogenital folds, urogenital sinus and labioscrotal swellings. The vulva is formed by the labia majora and vestibule, with its erectile apparatus: clitoris (glans, body, crura), labia minora, vestibular bulbs and corpus spongiosum. Grafenberg, in 1950, discovered no “G-spot” and did not report an orgasm of the intraurethral glands. The hypothetical area named “G-spot” should not be defined with Grafenberg’s name. The female orgasm should be a normal phase of the sexual response cycle, which is possible to achieve by all healthy women with effective sexual stimulation. Knowledge of the embryology, anatomy and physiology of the female erectile organs are important in the field of women’s sexual health.

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1. Introduction

Orgasm is a normal psycho-physiological function of human beings [1]. Women have the right to feel sexual pleasure: “sexual health is a global issue that is vital to overall well-being” [2]. The anatomy of the vulva and of the female erectile organs (trigger of

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During women’s sexual response, changes occur in the congestive structures that are essential to the understanding of their sexual response and specifically of their orgasm.

2. The embryological development of the vulva

In anatomy textbooks there is a separation between the embryological development of the internal and external genital organs in the male and in the female. It is important to know this because it is related to the function of these organs, i.e. the internal genitals have a reproductive function, while the external ones have the function of giving pleasure [3–5].

There is an important difference between the two genders: in the male, ejaculation and the release of sperm happen at the same time as orgasm. In the female, however, orgasm is not connected to reproductive function, and ovulation is not accompanied by orgasm. The ovum is fertilized when it is in the uterine tubes, while in the male, ejaculation and the release of sperm happen at the same time as orgasm. In the female, however, orgasm is not connected to reproductive function, and ovulation is not accompanied by orgasm. The ovum is fertilized when it is in the uterine tubes, although in the early phases the clitoris exceeds the length of the male homologous counterpart [3].

The vestibule of the vagina, the labia minora, the vestibular bulbs and the corpus spongiosum are formed by the pelvic and phallic part of the urogenital sinus and from the urogenital folds, which do not fuse together. The labioscrotal swellings do not form and they form the labia majora [3,8].

In the male, the pelvic part of the urogenital sinus moves down, is incorporated by the phallic part and opens externally as the vaginal and urethral orifices. In the male, the pelvic part of the urogenital sinus corresponds to the internal portion of urethra located under the seminal collicle (veru montanum), a prominence in the dorsal surface of the prostatic urethra where the ejaculatory ducts open. Between the two ejaculatory ducts is the prostatic utricle (i.e. the “male vagina”: it is the homologous to the female vagina) [3,4]. Sometimes the ejaculatory ducts open into the prostatic utricle instead of the prostatic urethra. The small segment of the prostatic urethra which reaches the seminal collicle from the bladder corresponds to the whole female urethra [3,4].

The main difference between male and female genitalia is the lack of the development in the female of the external urethra, as consequence of the non-fusion of the urogenital folds. However, the structures responsible for forming the external urethra in the male are also present in the female and correspond to the vestibule of the vagina and to the internal surface of the labia minora [3,4].

The labia, in fetal life and after birth, appears with the labia majora closed: to visualize the vaginal opening it is necessary to open the labia, and therefore the labia minora are in contact with each other. The picture of the normal vulva should be shown with the labia majora and the labia minora closed.

3. The vulva

The vulva is formed by the labia majora and vestibule, with its erectile apparatus: labia minora, clitoris (glans, body, crura), and vestibular bulbs with the corpus spongiosum. These structures are localized under the urogenital diaphragm, behind the pubic symphysis in the anterior perineal region [3–5].

3.1. The vestibule

The vaginal vestibule is triangular in shape. It corresponds to the dorsal wall of the male cavernosa urethra. Here the external orifice of the urethra with the paraurethral (Skene’s) ducts opening on both sides are localized [3–5]. Their length is 0.5–3 cm and they are found, in women, with the intraurethral (Skene’s) gland which has been named the female prostate [4,5,9]. This structure can be affected by the same diseases as the male counterpart, including carcinoma and prostatitis; the secretion of these glands, expelled during the female orgasm (female ejaculation) into the vaginal vestibule through the urethral meatus or through the orifices of the paraurethral ducts, contains prostate-specific antigen [9].

From a physiological point of view the term “female emission” is more accurate than female ejaculation (in a few women there is a powerful expulsion of this fluid); in the male it corresponds to the phase of emission of seminal liquid which is ejected out in the prostatic urethra [10]. The lack of the ejaculation phase in the female could explain why women do not have a refractory period and are able to have multiple orgasms.

In the mid-line of the vestibule is located a longitudinal formation 4–5 mm wide, with defined margins and more pale than the nearby tissue, thin and well wedged in the dermis of the vestibule, which goes up from the urethral orifice to the sulcus of the inferior surface of the corpora cavernosa of the clitoris up to the glans, described first by Pozzi in 1884 and named “masculine bride” (habenulae uretrales). It corresponds to the dorsal part of the male corpus spongiosum of urethra: it is the female corpus spongiosum [3–5,8].

The vagina is an internal genital organ and the vaginal opening (introitus) is usually a median fissure, under the urethral meatus. The anterior vaginal wall is separated from the posterior urethral wall by the urothelial septum and there are no secretory glands in the vagina [3–5].

The Bartholin’s glands end up on the sides of the vaginal opening, and are homologous to the male bulbourethral glands or Cowper’s gland [3–5]. According to some studies, pre-ejaculatory fluid secreted by Cowper’s gland in the distal urethra, during sexual stimulation, does not cause a pregnancy after coitus interruptus [11]. Bartholin’s glands secrete a sticky liquid similar to the mucus preceding orgasm and, as in the male, this pre-orgasmic secretion is light and more frequent after prolonged sexual stimulation [1]. Endocrine cells producing serotonin, calcitonin, bombesin, katacalcin and alpha-hCG have been found in Bartholin’s glands [12]. Furthermore in the vestibule many mucous glands open, called minor vestibular glands [3,4].

3.2. The labia minora

The labia minora, or nymphs, are two small cutaneous folds, 3–4 cm long. They are normally approximated together. They correspond to the ventral wall of both the cavernosa urethra and the corpus spongiosum of the urethra in the male [3–5]. They vary in size. They may be almost unrecognisable or may protrude from the labia majora (“hypertrophic” labia minora should not be considered a malformation). In addition they can be asymmetrical or double on one or both sides [3–5,13,14]. In some races the labia minora can be very large because of the practice of stretching them: in some African populations they can be as large as 20 cm and are known as “Hottentot apron” [4,5]; today this is classified in the type IV female genital mutilations [15].

The upper points converge to form the prepuce and frenulum of the clitoris; posteriorly they form the frenulum of the labia minora but they can be also separated [3–5]. The labia minora contain erectile tissue constituted by a thick connective tissue rich in small blood vessels. With sexual arousal the labia minora, because of
engorgement with blood, become turgid, doubling or tripling in thickness. They have a great sensitivity, due to the considerable number of nerve endings and sensory receptors. Among these, as in the male, the most important for erogenous sensitivity are the genital corpuscles (typical receptors of the external genitals); the Krause–Finger corpuscles (corpuscles of voluptuousness) are predominant. Pacini and Meissner corpuscles (cutaneous mechanoreceptors distributed on various areas of the skin, but concentrated in areas especially sensitive to light touch) are also present [1,3–5,17].

3.3. The clitoris

The clitoris is usually considered the homologue of the male penis. It is formed by two corpora cavernosa and the glans, covered by the prepuce [1,3–5,7,17]. The corpora cavernosa are two cylindrical organs, made of cavernous erectile tissue that becomes turgid and erect with sexual arousal; the crura represent the hidden part of the clitoris located in contact with the ischiopubic ramus, covered by the ischiocavernosus muscle, a superficial perineal muscle [1,3–5,17].

The perineal muscles are innervated by branches of the pudendal nerve coming Onuf’s nucleus; “pudendal nerve integrity may play a role in female sexual dysfunction” [18]. Onuf’s nucleus is located at the sacral level of the spinal cord and is formed by motoneurons innervating the perineal muscles; the number and the size of these neurons are sexually dimorphic: this dimorphism is mediated by androgens (in absence of these hormones the motoneurons die by apoptosis) with ciliary neurotrophic factor (CNTF) and other trophic factors [19]. Because of this, in females the ischiocavernosus muscles are much thinner than the male counterparts. Their contraction during female arousal determines a surge of blood in the crura towards the corpora cavernosa of the clitoris and a compression of the deep dorsal vein, contributing therefore to erection of the clitoris [1,3–5].

The ischiocavernosus muscles, like the bulbocavernosus, are type mixed muscles (even if histologically they are striated). During erection, they are implicated in producing a continuous involuntary reflex hypertonic contraction, important not only for the rigidity of the penis but also for the maintenance of the erection [3,4,20].

The crura are joined beyond and in front of the pubic symphysis, forming the body of the clitoris (which in the flaccid state is 1–3 cm long), which goes back and up to the glans. The suspensory ligament links the clitoral body to the mons pubis and pubic symphysis [3–5,17]. The erectile tissue of the clitoris is made up of caverns covered by the tunica albuginea: the two corpora cavernosa have the same structure as the male penis; in some studies a subbulbigenal layer in the corpora cavernosa is not present and the subbulbigenal venous plexus is not located internally [3–5,21]. The glans is 4–7 mm long and covers the distal part of the corpora cavernosa, from which it is independent [3–5].

The prepuce covers all or part of the glans, its size varies considerably, and it is just like the foreskin of the male penis; it is a specialized, specific erogenous tissue in both males and females. The fetal development of the prepuce and the glans in the male and female is similar: they are fused together during the first year after the birth. If they are not divided it can cause adhesions and phimosis, as in the male. An accumulation of smegma in infants and preadolescent girls under the prepuce is responsible for adhesions between the glans and prepuce and for phimosis of the clitoris [3–5,22].

The glans contains cavernous tissue, as in the male, in direct contact with the skin due to the absence of the albuginea. It is rich in nerve endings and in genital and Krause–Finger corpuscles, and corpuscles of Pacini and Meissner [3–5,17]. These receptors, because of the smaller dimensions of the clitoris, are more concentrated in the female than in the male glans and they probably do not require to surface to be excited by mechanical stimuli. Some studies have suggested that penile mechanoreceptors are more responsive when the penis is erect or near body temperature [23]. In fact the glans has a protopathic sensitivity and it can be maintained, much more easily than in the male, in a state of arousal without an evident increase in its dimensions, with an easier receptiveness of the Krause–Finger corpuscles [1,5,24].

Verkauf et al. with prospective measurement of clitoral dimensions in 200 normal women at routine gynecologic examination in an office setting, suggested that the clitoris is not influenced by age, height, weight, or current use of oral contraceptives, but in pregnant women it was significantly larger [25]; the clitoral sexual response is not affected by aging [11]. As in males, in females it is possible to have priapism of the clitoris, a rare condition associated with prolonged erection of the corpora cavernosa, an erection lasting for more than six hours and unassociated with sexual arousal, causing engorgement, swelling, and pain of the clitoris and immediate adjacent area. The cause of priapism, in male and female, is impaired outflow of blood from the corpora cavernosa because of venous obstruction or because of failure of the alpha-adrenergic relaxation system [26,27]. “Most reported cases of female priapism describe the association with the use of antidepressant and other psychotropic drugs, all with alpha-adrenergic blocking potential, such as trazodone, bupropion, citralopram and nefazodone. Treatment consisted of discontinuing the offending medication or providing symptomatic pain relief. Serious permanent damage where treatment has been delayed has been reported in men but not in women. Furthermore, the association between congenital clitoromegaly and priapism has also not been reported previously. With this concern in mind, we felt justified to resort to management options described for male priapism but hitherto not for female priapism, i.e. the direct injection with epinephrine and heparin, followed by aspiration to provide immediate decompression” [27].

3.4. The vestibular bulbs and the female corpus spongiosum

The vestibular bulbs are two erectile organs and correspond to the urethral bulb in the male. The bulbs are situated in the anterior region of the perineum, the bulbocavernous region, which is homologous to penile region in the male. Their dimensions in the flaccid state are 3–4 cm in length and they become engorged or “erected” during arousal, when in the lower third of the vagina the “orgasmic platform” of Masters and Johnson is reached [1,3–5,8,17].

The two bulbs are joined together, under the vestibule of the vagina, by the commissure of the bulbs and, through the corpus spongiosum or “pars intermedia”, they extend to the base of the glans. The corpus spongiosum is constituted by cavernous tissue which thins towards the glans and is situated underneath the vestibular epithelium [3–5,8].

In the angle of the clitoris, in the space between the corpora cavernosa and the female corpus spongiosum, there is the venous plexus of Kolbert, responsible for communication between the venous circulation of the bulbs and of the corpora cavernosa of the clitoris; it corresponds to the inferior veins of the male corpora cavernosa, which open in the inferior median sulcus between corpora cavernosa and the male urethra, and receives the veins coming from the upper part of the male corpus spongiosum [3–5].

The bulbs are covered by the bulbocavernosus muscles, which are implicated in inferior vaginismus, while the pubovaginal muscle is responsible for superior vaginismus. Some studies have suggested that the components of the levator ani muscle are the puborectal, iliococcygeal, pubovisceral muscles, further subdi-
vided into pubovaginal, puboperineal and puboanal. This terminology was accepted in 1998 by the Federative Committee on Anatomical Terminology [3–5,28]. The rhythmic contractions of lower third of the vagina during orgasm are mainly due to the contractions of the bulbocavernosus muscle [1,3–5].

3.5. The corpus spongiosum of the female urethra

The corpus spongiosum of the urethra is present in all women, as in the male. It is a cavernous tissue rich in veins, situated at submucosal level and among the muscular bundles of the smooth muscular tunica of the urethral wall. It becomes engorged, or “erect”, with sexual arousal and Grafenberg in 1950 wrote “In the course of sexual stimulation the female urethra begins to enlarge” [4,17,29]. Female urethral sensitivity has been little investigated until now, though Dickinson wrote in 1949 “Indeed, the meatus is largely endowed with special sensibility” [5], and Grafenberg in 1950 described some cases of female and male urethral masturbation [29].

Therefore the erectile structures are the same in female and in male. The clitoris is the homologue of the two corpora cavernosa, glans and prepuce of the male penis, and the male erection is equivalent to the erection of all female erectile organs (vaginal lubrication is a consequence of congestion) [3–5,17]. The female external genitals are joined together even though separated by the presence of the vaginal opening, and they represent the penis and the scrotum of the male (Figs. 1 and 2) [3–5,8]. This has been recognized for many years. In 1949 Dickinson wrote: “Vulvo-vaginal changes in excitement. Protrusion of erectile bulbs of vestibule. Clitoris erection. Labial erection.” [5]. Laqueur wrote that Realdus Columbus, in 1559, named “the love or sweetness of Venus” (“amoris dulcedo”) what he found in the nature, a female penis [7,30].

4. Discussion

Addiego et al. in 1981 wrote: “At the April, 1979, testing session, the subject identified an erotically sensitive spot, palpable through the anterior wall of her vagina. We subsequently named this area the Grafenberg spot, in recognition of the person who wrote of its existence and relationship to female ejaculation (Grafenberg, 1950)” [31]. Subsequently the “Grafenberg spot” (i.e. intraurethral glands or female prostate) was seized on by the popular media, which called it the “G-spot”. The G-spot is currently an hypothesis: Grafenberg, in 1950, discovered no G-spot [29,32]. In his article he did not describe a vaginal spot, but “the role of the urethra in female orgasm” (not the role of the vagina): the urethra, on the anterior wall of the vagina, is a “distinct erotogenic zone” in women [29].

Grafenberg described some cases of female urethral masturbation and the corpus spongiosum of the female urethra, stating that, “analogous to the male urethra, the female urethra also seems to be surrounded by erectile tissues like the corpora cavernosa”. He did not report an orgasm of intraurethral glands, but wrote: “Involuntary expulsion of urine is reported in sex literature. In the cases observed by us, the fluid was examined and it had no urinary character. I am inclined to believe that urine reported to be expelled during female orgasm is not urine, but only secretions of the intraurethral glands” [29].

In 1950 Grafenberg wrote about the corpus spongiosum of the female urethra: “In the course of sexual stimulation the female urethra begins to enlarge and can be felt easily. It swells out greatly at the end of orgasm. The most stimulating part is located at the posterior urethra, where it arises from the neck of the bladder” [29]. The so-called “G-spot” of the anterior vaginal wall is located in Pawlick’s triangle (which corresponds to Lieutaud’s triangle in bladder) that has a smooth vaginal mucosa and it is only a space with minor resistance [4].
Hines in 2001 wrote: “Graftenberg discusses no evidence for a G-spot. ... [Some female patients], he says, derived sexual pleasure from inserting objects, such as hat pins, into their urethras. Just how later writers (i.e. 2) transformed these reports into evidence for a G-spot is unclear. ... Women who fail to find their G-spot, because they fail to respond to stimulation as the G-spot myth suggests that they should, may end up feeling inadequate or abnormal.”[32]

Burri et al. in 2010 wrote: “The existence of the G-spot seems to be widely accepted among women, despite the failure of numerous behavioral, anatomical, and biochemical studies to prove its existence. ... there is no physiological or physical basis for the G-spot.”[33] Besides, there are no ultrasonographic images or anatomical pictures of the G-spot, and the female prostate has no anatomical structure that can cause an orgasm [3–5]. The hypothetical area named G-spot should not be defined with Graftenberg’s name.

“G-spot amplification” is a procedure that is not medically indicated. The American College of Obstetricians and Gynecologists states: “So-called vaginal rejuvenation, designer vaginalplasty, revirgination, and G-spot amplification are vaginal surgical procedures being offered by some practitioners. Women should be informed about the lack of data supporting the efficacy of these procedures and their potential complications, including infection, altered sensation, dyspareunia, adhesions, and scarring”[34].

The importance of orgasm has been questioned: “Orgasm and resolution are not essential in Basson’s model of the sexual response cycle”[35], Basson et al. in 2005 wrote, “Orgasm may or may not be necessary for sexual satisfaction”[36]. According to Masters and Johnson, however: “Physiologically sexual response could be described as a cycle with four phases: excitement, plateau, orgasm, and resolution” (i.e. “the period of return to the unaroused state”) ... If there has been considerable excitement but orgasm has not occurred, resolution takes a longer time ... there is sometimes a lingering sensation of pelvic heaviness or aching that is due to continued vascongestion ... this may create a condition of some discomfort, particularly if high levels of arousal were prolonged”[1,37].

In 1949 Dickinson wrote about long-term sequelae of female sexual excitement without orgasm: “Vulvo-vaginal changes in excitement. Chronic or persisting alterations due to strong, long continued and close-set repetition of excitation are the following: (1) Inflammation at mouth of duct of vulvo-vaginal gland. (2) Prominent veins in certain locations about vulva. (3) Varicosities of bulb, and of pars intermedia toward clitoris. (4) Varicosities in base of broad ligament. (5) Varicosities in upper part of broad ligament. (6) Enlargement of clitoris. (7) Labial enlargement. (8) Enlargement of vessels in glans. (9) Hymen gaping, worn, ironed out or disappearing. (10) Chronic bladder base congestion, (11) Hemorrhoids.”[5] The evidence for these statements is unclear but physiologically, female sexual satisfaction is based on orgasm and resolution [1,37,38].

5. Conclusion

Dickinson wrote: “Exalting vaginal orgasm while decrieing clitoris satisfaction is found to beget much frustration. Orgasm is orgasm, however achieved”[5]. Masters and Johnson agreed: “Physiologically all female orgasms follow the same reflex response patterns, no matter what the source of sexual stimulation. An orgasm that comes from rubbing the clitoris cannot be distinguished physiologically from one that comes from intercourse or breast stimulation alone”[1,37]. Clitoral/vaginal/uterine orgasm, “G/A/C/U” orgasm, are terms that should not be used by sexologists, women and mass-media [3,4,38].

The female orgasm (and resolution) should be a normal phase of the sexual response cycle, which is possible to achieve by all healthy women with effective sexual stimulation, and “aging alone does not diminish female sexual interest or the potential of the woman to be sexually responsive if her general health is good”[1,37].

Clitoral bulbs, clitoral or clitoris–urethrovaginal complex, urethrovaginal space, perirethral glans, genitosensory component of the vagus nerve, and G-spot, are terms used by some sexologists but they are not accepted or shared by experts in human anatomy [3,4,38]. Findings from the disciplines of embryology, anatomy, and physiology about the congestive structures of women’s urogenital areas, which are homologous to men’s erectile organs, should form the basis of the discourse about the biological basis women’s orgasm.

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