

ANATOMY OF THE CLITORIS

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ABSTRACT

Purpose: We present a comprehensive account of clitoral anatomy, including its component structures, neurovascular supply, relationship to adjacent structures (the urethra, vagina and vestibular glands, and connective tissue supports), histology and immunohistochemistry. We related recent anatomical findings to the historical literature to determine when data on accurate anatomy became available.

Materials and Methods: An extensive review of the current and historical literature was done. The studies reviewed included dissection and microdissection, magnetic resonance imaging (MRI), 3-dimensional sectional anatomy reconstruction, histology and immunohistochemical studies.

Results: The clitoris is a multiplanar structure with a broad attachment to the pubic arch and via extensive supporting tissue to the mons pubis and labia. Centrally it is attached to the urethra and vagina. Its components include the erectile bodies (paired bulbs and paired corpora, which are continuous with the crura) and the glans clitoridis. The glans is a midline, densely neural, nonerectile structure that is the only external manifestation of the clitoris. All other components are composed of erectile tissue with the composition of the bulbar erectile tissue differing from that of the corpora. The clitoral and perineal neurovascular bundles are large, paired terminations of the pudendal neurovascular bundles. The clitoral neurovascular bundles ascend along the ischiopubic rami to meet each other and pass along the superior surface of the clitoral body supplying the clitoris. The neural trunks pass largely intact into the glans. These nerves are at least 2 mm in diameter even in infancy. The cavernous or autonomic neural anatomy is microscopic and difficult to define consistently. MRI complements dissection studies and clarifies the anatomy. Clitoral pharmacology and histology appears to parallel those of penile tissue, although the clinical impact is vastly different.

Conclusions: Typical textbook descriptions of the clitoris lack detail and include inaccuracies. It is impossible to convey clitoral anatomy in a single diagram showing only 1 plane, as is typically provided in textbooks, which reveal it as a flat structure. MRI provides a multiplanar representation of clitoral anatomy in the live state, which is a major advantage, and complements dissection materials. The work of Kobelt in the early 19th century provides a most comprehensive and accurate description of clitoral anatomy, and modern study provides objective images and few novel findings. The bulbs appear to be part of the clitoris. They are spongy in character and in continuity with the other parts of the clitoris. The distal urethra and vagina are intimately related structures, although they are not erectile in character. They form a tissue cluster with the clitoris. This cluster appears to be the locus of female sexual function and orgasm.

KEY WORDS: genitalia, female; clitoris; anatomy and histology; magnetic resonance imaging; history of medicine

The anatomy of the clitoris has not been stable with time, as would be expected. To a major extent its study has been dominated by social factors. A number of anatomists from the 16th century and thereafter claimed the discovery of the clitoris, including Colombo, Falloppia, Swammerdam and De Graaf. Prominent anatomists, notably Galen and Vesalius, regarded the vagina as the structure equivalent to the penis, Vesalius having argued against the existence of the clitoris in normal women. What constituted the clitoris, what it was called, what characterized normal anatomy and whether having a clitoris at all was normal were controversial issues.

Some recent anatomy textbooks omit a description of the

clitoris.¹ By comparison, pages are devoted to penile anatomy. Because surgery is guided by accurate anatomy, the quality and validity of available anatomical description are relevant to urologists, gynecologists and other pelvic surgeons. Accurate anatomical information about female pelvic structures should be found in classics, such as Gray's Anatomy,² the Hinman urological atlas,³ sexuality texts such as the classic Master and Johnson Human Sexual Response⁴ or any standard gynecologic text. These texts should provide the surgeon with information about how to preserve the innervation and vasculature to the clitoris and related structures but detailed information is lacking in each of these sources. The clitoris is a structure about which few diagrams and minimal description are provided, potentially impacting its preservation during surgery. Specific study of anatomical textbooks across the 20th century revealed that details from genital diagrams presented early in the century were subsequently omitted from later texts.⁵ These examples, particularly with the backdrop of the clitoris being discovered and rediscovered, indicate that the evolution of female anatomy

Submitted for publication August 18, 2004.

Supported by the Bruce Pearson Fellowship of the Australasian Urology Trust and a Victor Hurley Medical grant for dissecting equipment.

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† Financial interest and/or other relationship with Continence Control Systems International.

across the 20th century occurred as a result of active deletion rather than simple omission in the interests of brevity. In their diagrams the feminists of the 1970s expanded clitoral anatomy to include the bulbs and even the urethra as part of the clitoris.⁶ Were there excellent and accurate accounts in the historical literature?

The relationship between the clitoris and related structures has also been under scrutiny. In fact, a modern anatomy text states: "The clitoris is thus in many details a small version of the penis, but it differs basically in being entirely separate from the urethra."² Few would argue that the urethra is central to our territory as urologists. Recent research has demonstrated the integral relationship between the clitoris, and the distal urethra and vagina.⁷⁻⁹

A search using the PubMed and Ovid databases was done from 2004 back to 1966. Each relevant article was searched to find the original research in English, French and German, and when there was an English abstract. We related the findings of modern anatomical research to the historical literature with the goal of perpetually clarifying female sexual anatomy.

In this review of clitoral anatomy we clarify 1) the consistent features of the clitoris that would logically define its component parts, 2) the relationship between the clitoris, urethra and vagina, 3) the anatomy of its neurovascular supply, 4) its histological structure and relevance to new drug options, 7) historical descriptions consistent with the findings of modern anatomical study and 8) the historical literature that helps us understand the controversy surrounding something as stable and uncontroversial as human anatomy.

MODERN STUDIES OF CLITORAL ANATOMY

Results of gross anatomical studies using dissection and magnetic resonance imaging (MRI) in adults. In a recent series of dissections of fresh and fixed cadaver tissue O'Connell et al observed that the clitoris is a multiplanar structure positioned deep to the labia minora, labial fat and vasculature, bulbospongiosus and ischiocavernosus muscles, inferior to the pubic arch and symphysis with a broad attachment to it, and via extensive supporting tissue to the mons pubis and labia.^{7,10} The clitoris consists of a nonerectile tip, the glans and erectile bodies (the paired bulbs, crura and corpora) (figs. 1 and 2). The latter bodies commence proximal as the crura and join distal as a single body that projects into the glans, which in turn projects into the fat of the mons pubis. As here defined, the clitoris is a highly vascular entity with a consistent relationship to the distal urethra and vagina. The latter 2 structures form a midline core in an otherwise pyramidal shaped structure. The apex of the pyramid is the most superior point of the clitoral body, where it attaches to the under surface of the pubic symphysis by the deep suspensory ligament. This relationship is best seen on MRI axial section (fig. 3).^{8,11} The bulbs of the clitoris form the lateral margins of the base of the pyramid. The base of the pyramid extends from the ischiopubic rami on either side ventral to the anus.

As the clitoral body projects from the bone into the mons pubic fat, it descends and folds back on itself in a boomerang-like shape. This is seen well on MRI sagittal section (fig. 4). MRI differs from dissection views, in that it reveals the true position of the clitoris relative to the supine position, whereas dissections are balanced on their base, which is rotated greater than 90 degrees from the supine position for balance during dissection.

The suspensory ligament maintains this bent position, preventing it from becoming straight, as distinct from the penis. A detailed description of the deep and superficial suspensory ligaments is provided by Rees et al.¹⁰ The glans is a small, button-like extension of the body of the clitoris. It is partly

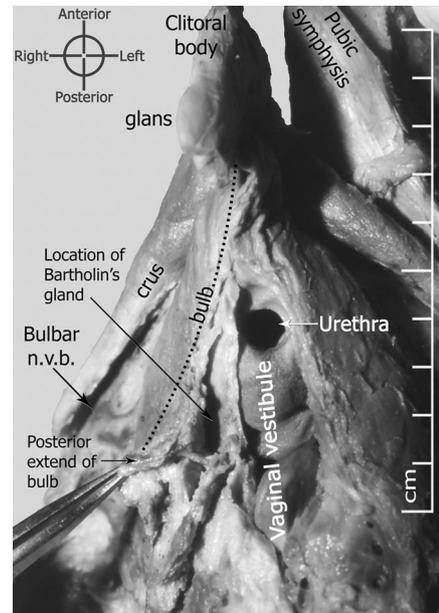


FIG. 1. Frontal view of dissected clitoris and vulva, as seen from perineum in fresh cadaver of 57-year-old postmenopausal woman. n.v.b., neurovascular bundle.

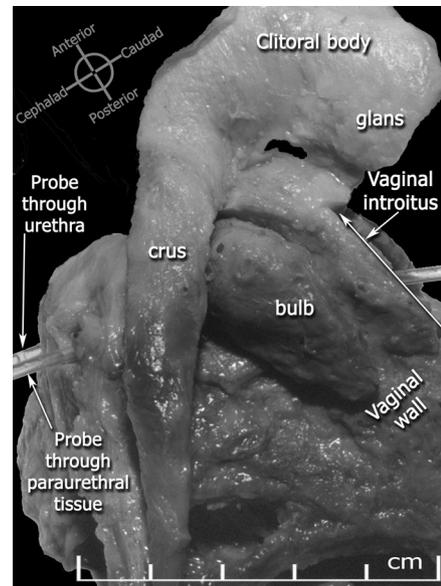


FIG. 2. Lateral view of dissected clitoris in fresh cadaver of 57-year-old postmenopausal woman.

external, as distinct from the remainder of the clitoris, which is deep to the epithelium, labial fat and deep fascia of the perineum. Because of the superficial nature of the clitoral glans, it has previously been the subject of considerable study, eg variations in its size and shape have been well documented.¹²

Clitoral innervation and perineal neurovascular bundles are paired terminations of the pudendal neurovascular bundles. They arise at the pelvic side wall. The clitoral neurovascular bundle ascends along the periosteum of the ischiopubic ramus to meet the neurovascular bundle from the other side close to the midline. Where the crura unite to become the body (the body of the clitoris), the clitoral neurovascular bundles pass to the superior surface of the clitoral body. After some minimal branching the dorsal clitoral nerves pass largely as intact, large neural trunks into the clitoral glans. The perineal neurovascular bundle supplies the urethra and

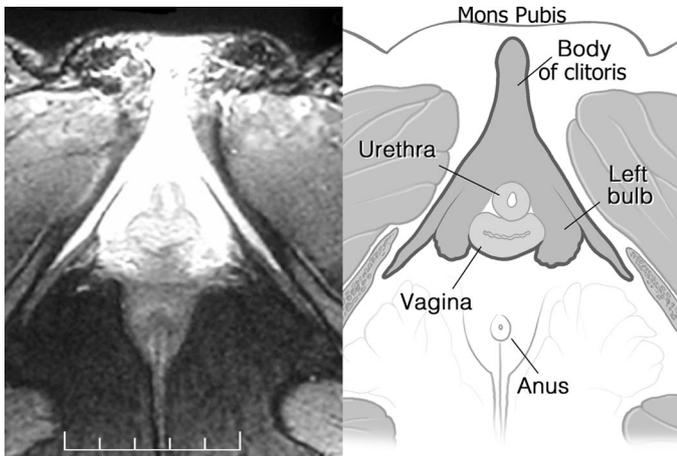


FIG. 3. MRI of clitoris and its components in axial plane in premenopausal nullipara. Bulbs, crura and corpora are well demonstrated. These structures lie ventral and lateral to urethra and vagina as cluster or complex. Reprinted with permission.¹¹

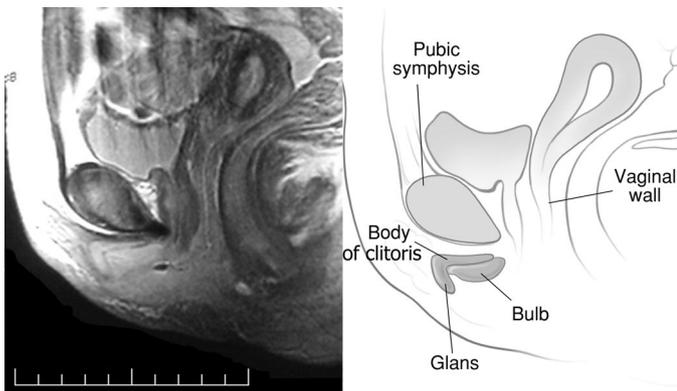


FIG. 4. MRI of clitoris and its components in mid sagittal plane in premenopausal nullipara. This midline sagittal section highlights almost boomerang-like appearance of clitoral body, crura and glans. Reprinted with permission.¹¹

bulbs, and on each side passes under the pubic arch to gain access to this area. These neurovascular bundles are large and visible to the naked eye (fig. 5). The nerves are 2 mm in diameter even in infancy. The cavernous or autonomic neural anatomy is microscopic and difficult to define consistently. In dissection based studies it appears to be a network of nerves rather than discrete nerves, although the anatomy appears to vary with 1 of the 14 specimens having a discrete cavernous neurovascular bundle.⁷ In anatomical textbooks the dorsal nerve of the clitoris is not described but is noted to be “the corresponding nerve. . . very small and supplies the clitoris.”^{9,22} Thus, the impressive size of the nerves, their course or ultimate destination is not provided. The arteries and veins are treated similarly. Dissection and MRI clearly revealed the arteries and veins of the dorsal clitoral and perineal neurovascular bundles, and the bifurcation of the termination of the pudendal neurovascular bundle. The fat saturation sequence provided the greatest clarity of clitoral anatomy by demonstrating excellent contrast between the white of erectile tissue bodies and all remaining structures, including the urethra and vagina, but particularly against the fat, which appears black.¹¹ Recently Yucel et al reported that the cavernous nerve supplies the female urethral sphincter complex and clitoris.¹³ The branches of the cavernous nerve were noted to join the clitoral “dorsal” nerve at the hilum of the clitoral bodies. These branches stain positive for neuronal nitric oxide synthase. The cavernous nerves originate from the vaginal plexus component of the pelvic plexus. They

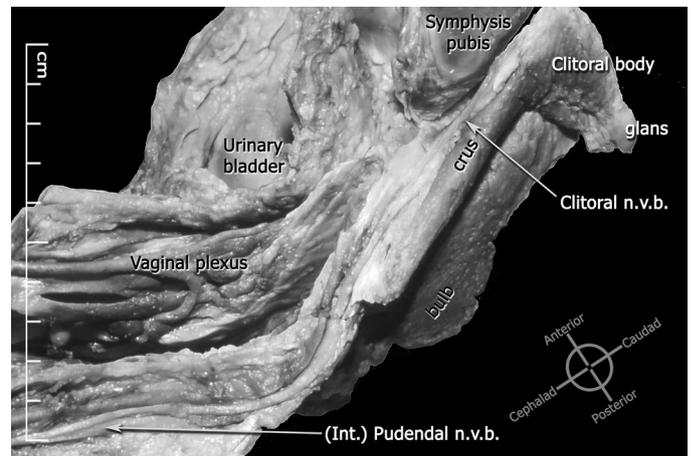


FIG. 5. Lateral view of dissected specimen of clitoris with its neurovascular bundle (*n.v.b.*) in fresh cadaver of 57-year-old postmenopausal woman. *Int.*, internal.

travel at the 2 and 10 o'clock positions along the anterior vaginal wall, and then at the 5 and 7 o'clock positions along the urethra. This study in fetuses clearly demonstrates the cavernous nerves, highlighting the importance of further study in adults to define the anatomy accurately to preserve their integrity during reconstructive and ablative surgery.

Histology, immunohistochemistry and clitoral pharmacology. The histology of each component of the clitoris was recently presented.¹⁴ The body is surrounded by a thick tunica albuginea. On the outer surface of the body lie branches of the dorsal nerves and vessels. In each erectile core of the corpora lie the deep clitoral arteries.¹⁴ Briefly, the clitoral body has a histology similar to that of the penis. It is composed of conjoined corpora separated by an incomplete septum (fig. 6). The septum continues in the midline halfway into the glans.¹⁵ The corpora are surrounded by branches of the dorsal nerve of the clitoris, although the bulk of the nerve continues intact into the glans. Baskin et al emphasized the lack of nerves at the 12 o'clock position and the fact that the lowest nerve density in the glans is on its ventral aspect juxtaposed to the glans septum,¹⁵ which are facts of significance in genital reconstruction. The glans is a densely neural structure that is not erectile in nature but is in direct continuity with the erectile bodies to which it attaches. The cavernous tissue and its surrounding tunica albuginea extend from the clitoral body into the proximal aspect of the glans. The glans contains dense vascular dermis and a large number of sensory receptors, especially Pacini's corpuscles, which provide deep sensation and sense vibration. Pacini's corpuscles are also closely related to the neurovascular bundles and their branches, which surround the body.

Previous studies have included fetal tissue, tissue derived from the clitoris at the time of its excision for pathological study or gender reassignment, or they have focused on the sensory aspects of the glans rather than on erectile tissue.¹⁵⁻²¹ The histology of the crura resembles that of the body in its type of erectile tissue but it lacks the surrounding neurovascular structures and internal vasculature. The bulbs are composed of spongy tissue.^{9,14} The cavernous tissue of the bulbs has larger spaces and few nerves relative to the corpora, while there is no tunica albuginea, giving it a purple appearance macroscopically relative to the pink of the corpora and crura. The greater vestibular glands lying deep to the bulbs can be seen in histological sections between the bulbs and the outer aspect of the distal vaginal wall. Further comprehensive study of the histology of the vulval structures is required.

Nitric oxide synthase has been demonstrated in many studies to be the mediator of clitoral smooth muscle relax-

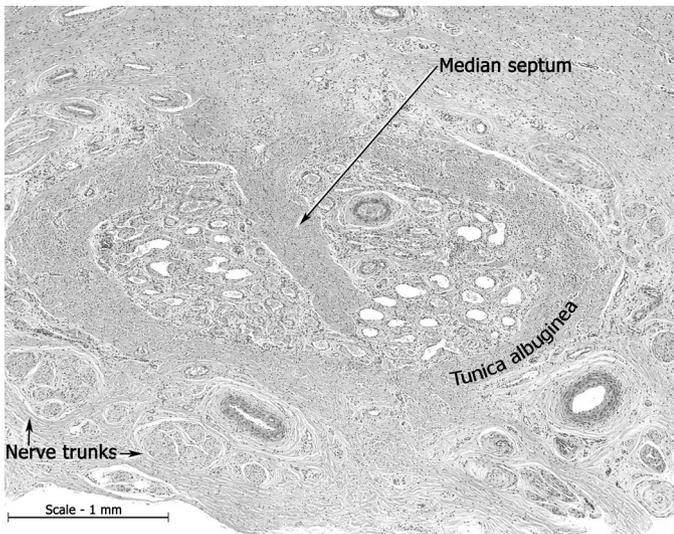


FIG. 6. Low power photomicrograph through clitoral body of 2-year-old child reveals several large neural trunks, which are branches of dorsal clitoral nerve. H & E, reduced from $\times 5$.

ation.^{22–24} The immunoreactivity of clitoral tissue does not appear to differ from that of penile tissue with the latter having been studied extensively. The pharmacology and physiology of the clitoris and vaginal wall were recently reviewed by Munarriz et al.²⁴ Apomorphine induced changes in cavernous and vaginal blood flow have been observed in a rabbit model.²⁵ Topical application of alprostadil resulted in a significant increase in peak systolic and end diastolic velocity, as observed using duplex ultrasound evaluation of the clitoris and labia.²⁶ Estrogen has been shown convincingly in recent years to be the primary hormone subserving the female sexual response, not testosterone, although the latter also has an influence. In animal studies sildenafil promotes clitoral smooth muscle relaxation, resulting in increases in clitoral and vaginal blood flow as well as in vaginal lubrication. Despite considerable evidence that the mediators of clitoral and vaginal smooth muscle are similar to those of penile tissue, about which much has been written, the clinical value of those responses appears to be substantially different. There is ongoing controversy about the role of type 5 phosphodiesterase inhibitors in female sexual dysfunction. The reasons for this difference are beyond the scope of this article.

HISTORY OF ANATOMY OF THE CLITORIS

According to Vesalius the female form is the same as that of the male, the difference being that each genital structure is inverted.²⁷ In his model the penis corresponded with the vagina and there was no role for a clitoris. At that time the anatomists Falloppia and Colombo described the anatomy of the clitoris. In his opposition to the idea of a clitoris Vesalius stated, “It is unreasonable to blame others for incompetence on the basis of some sport of nature you have observed in some women and you can hardly ascribe this new and useless part, as if it were an organ, to healthy women. I think that such a structure appears in hermaphrodites who otherwise have well formed genitals, as Paul of Aegina describes, but I have never once seen in any woman a penis (which Avicenna called albaratha and the Greeks called an enlarged nympha and classed as an illness) or even the rudiments of a tiny phallus.”²⁷

Presumably it was difficult for the average anatomist to rebel from the stand of such powerful anatomists as Vesalius and Galen. Confusion about clitoral anatomy was furthered by the lack of consensus regarding its terminology.

Terminology and its controversies. Various terms have been used historically to refer to the clitoris and the word was not used in the English literature until the 17th century.²⁸ Hippocrates used the term *columella* or little pillar. Avicenna named the clitoris the *albatra* or *virga* (rod). Albucasis, another Arabic medical authority, named it *tentigo* (tension). *Amoris dulcedo* (sweetness of love), *sedes libidinis* (seat of lust) and *gadfly of Venus* were terms used by Colombo.²⁹ It would appear that in each instance the structures included were the body and glans of the clitoris. Magnus was one of the most prolific writers of the Middle Ages, famous for his objective observations.³⁰ He stressed “homologies between male and female structures and function” by adding “a psychology of sexual arousal” not found in Aristotle. Magnus devoted “equal space to his description of the male and female—whereas in Constantine’s treatise, references to the female are quite incidental.”³¹ Magnus used the word *virga* as the term for the male and female genitals.

De Graaf emphasized the need to distinguish *nympha* from clitoris and to avoid confusion he chose to “always give it the name, clitoris.”³² Since his 17th century description of the clitoris, there appears to have been constant use of this label. *Nympha* later became a term specific to the labia minora but early on it was inclusive of the clitoris, ie an anatomical concept similar to *vulva*. Confusion resulted from the varied use of the term *nympha*. Park discussed the implications of the linguistic imprecision that resulted from the confusion.³³

The Greek word *κλειτοριζ* (clitoris) is possibly derived from the Greek word *κλειτοριζειν*, which means to rub.²⁹ However, the same Greek word *κλειτοριζ* is connected to the word *hill* and it is translated by some as the little hill.³⁴ It may be that the ancients used the term clitoris as a play on words. The linguist Cohen devoted a chapter to a discussion of the significance and origins of the word clitoris.³⁵ Suffice it to say that the derivation of the word appears to be unclear to this day.

Discovery and rediscovery of the clitoris. Park provided a detailed discussion entitled “Rediscovery of the Clitoris.”³³ In the Renaissance (1545) Estienne was the first writer to identify the clitoris in a work based on dissection.³³ In the report of Estienne the clitoris was given a urinary function. Colombo claims to have rediscovered the clitoris but the claim of Falloppia in his report of 1561 appears more justified.³⁶ He stated, “Modern anatomists have entirely neglected it. . . and do not say a word about it. . . and if others have spoken of it, know that they have taken it from me or my students.”³⁶ Apparently the discovery of Falloppia caused an upset in the European medical community. Colombo, the successor to Vesalius in the chair at Padua, claimed to be the first anatomist to accurately describe the clitoris.

In the 16th century justification for clitoridectomy seems to have been tied up in the confusion related to hermaphroditism and the imprecision created by the word *nymphae* rather than clitoris. The major French surgical text of Dalechamps, which was intended to “make broadly accessible the surgical knowledge of medieval and, especially the ancient authorities,” contained some noteworthy discussion about surgery on the clitoris and the social implications of clitoral anatomy.³⁷ Following the chapter on hermaphrodites Dalechamps wrote about nymphotomia. Nymphotomia was an operation to excise unusually large nymphae. However, what constituted unusually large nymphae was the problem. He believed that this was “an unusual feature that occurred in almost all Egyptian women” as well as “some of ours, so that when they find themselves in the company of other women or their clothes rub them while they walk or their husbands wish to approach them, it erects like a male penis and indeed they use it to play with other women, as their husbands would do. . . . Thus the parts are cut off as is described in Aetius [an early 6th century Greek writer] and others.”³⁷

The work of De Graaf indicates that clitoral anatomy was

rediscovered again in the 17th century. In 1672 he wrote, "We are extremely surprised that some anatomists make no more mention of this part than if it did not exist at all in the universe of nature. In every cadaver we have so far dissected we have found it quite perceptible to sight and touch."³² The work by De Graaf in the 17th century seems to be the first comprehensive account of clitoral anatomy.

Thus, for periods as long as 100 years anatomical knowledge of the clitoris appears to have been lost or hidden, presumably for cultural reasons. The work of Kobelt mentions yet other claimants for the discovery of the clitoris.³⁸

*Kobelt*³⁹ and *De Graaf*.³² The 2 most influential and detailed descriptions of clitoral anatomy have been those of De Graaf³² and Kobelt,³⁹ both of which have been translated into English. De Graaf described the bulbs, calling them plexus retiformis: "The constriction of the penis (by the female) previously mentioned is assisted in a wonderful way by those bodies which, when the fleshy expansions arising from the sphincter have been removed."³² Lowry attributed the discovery of the bulbs to De Graaf.⁴⁰ The account of De Graaf is the only one ascribing a physiological role to the clitoral bulbs.

Kobelt provided a clear perspective of clitoral anatomy as it was in the 1840s.³⁹ "In this essay, I have made it my principal concern to show that the female possesses a structure that in all its separate parts is entirely analogous to the male; I scarcely dare to expect the same sort of success as in my studies of the male, as all previous attempts of this nature have always come to naught because our knowledge in regard to these female structures is still full of gaps."³⁹ His account of female sexual anatomy is extremely comprehensive. He performed dissection, comparative anatomy and injection studies, the latter to simulate sexual arousal. He subdivided the female sexual organs into active (clitoral shaft and vagina) and passive (bulbus vestibuli, associated muscles, pars intermedia and the glans clitoridis) organs. He described the internal macroscopic structure of the glans clitoridis in an era without histology. The arterial supply to the clitoris via the 2 dorsal arteries was observed. Minimal branching of the dorsal nerves of the clitoris and the thickness of the nerves as they enter the glans were noted. "Here they are, even before their entrance so very thick that one scarcely imagines how such an abundance of nerve mass can still find room between the countless blood vessels of this very tiny structure."³⁹ The account of Kobelt is superb, as are the accompanying drawings. The details of the suspensory ligaments are not as well described as those in the Poirier and Charpy⁴¹ account in the subsequent literature.

A controversial structure that Kobelt emphasized, particularly after his comparative anatomical studies, is a structure he called the pars intermedia, which he described in

detail. It is a vascular entity "which on both sides lies under the corpus clitoridis and is in direct contact with the upper end of the bulbus vestibuli. . ."³⁹ Our dissections identified a double row of veins surrounding the distal urethra adjacent to the bulbs. Figure 7 shows the diagrams of Kobelt representing the pars intermedia, which did not correspond to any structure seen at dissection or on MRI.

The bulbs have been applied various names, indicating some confusion about the composition of the clitoris. In all modern textbooks they are referred to as the bulbs of the vestibule. Kobelt listed some names that have been given, including bulbus vestibuli, plexus retiformis, reticularis of R. de Graaf, crura clitoridis interna of Swammerdam, plexus cavernosus of Tabarranus, corpus cavernosum of Santorini, bulbe du vagin of the French, semibulb of Taylor and corpus spongiosum urethra.³⁹

Kobelt provided a comprehensive account of the musculature surrounding the clitoris.³⁹ His account of the role of the clitoris and vagina in the female sexual response is compelling reading.

Few other comprehensive accounts of clitoral anatomy were identified in the historical literature. An excellent description was provided more recently.⁴¹ These descriptions should have guided the authors of anatomical textbooks to provide accurate information but that has not been the case. The typical anatomical textbook description lacks detail, describes male anatomy fully and only gives the differences between male and female anatomy rather than a full description of female anatomy.

CONTEXT OF ANATOMICAL CONTROVERSY

Clitoridectomy was an operation justified for millennia in some parts of the world. Its practice has been reviewed in recent years.⁴² However, it is not long ago that it was used in Western countries, not as a religious ritual, but rather as an operation to treat a range of medical disorders, including insanity, epilepsy, catalepsy and hysteria.⁴³ In a prizewinning essay Sheehan reviewed the practice of clitoridectomy, and the rise and fall of the prominent British obstetrician who wrote the textbook advocating clitoridectomy for a myriad of female maladies.⁴⁴ As Sheehan observed, "The 19th Century medical profession wanted it both ways: the clitoris was so unimportant to a normal woman as to not be missed if removed, yet lurking in its tissue was the greatest threat to female welfare ever known."⁴⁴

At his trial Brown said, "I have come to the conclusion that the operation of clitoridectomy was a justifiable operation—not my operation, recollect, gentlemen but an operation . . . that has been practiced from the time of Hippocrates and has

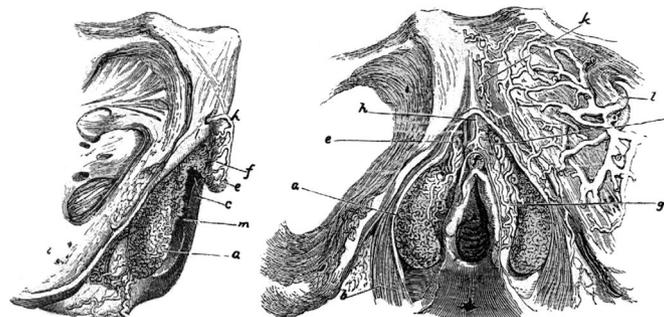


FIG. 7. Diagrams of Kobelt.³⁹ Lateral view of erectile structures of external organs in female (left). Blood vessels were injected, and skin and mucous membrane were removed. *a*, bulbus vestibule. *c*, plexus of veins named pars intermedia. *e*, glans clitoridis. *f*, clitoral body. *h*, dorsal vein of clitoris. *l*, right crus clitoridis. *m*, vestibule. *n*, right gland of Bartholin. Front view of erectile structures of external organs in female (right). *b*, sphincter vaginae muscles. *e*, venous plexus of pars intermedia. *f*, glans clitoridis. *g*, connecting veins. *k*, veins passing beneath pubes. *l*, obturator vein.

been mentioned by all writers since that period again and again.⁴⁴

A recent review of female genital mutilation stated that as many as 120 million girls and women worldwide have been mutilated. The difficulties involved in abolishing this practice are complex and the introduction of laws to stop such practices typically drive the activity underground.⁴² The practice of female genital mutilation reveals in the extreme the interaction between female genital anatomy and the prevailing sociocultural framework.

According to Kaplan, until the practical study of Masters and Johnson in 1966, "most clinicians believed that stimulation of the clitoris produced 'clitoral' orgasm only in infantile women, ie those who were fixated at an early state of development and had failed to achieve genital primacy. In short, retention of clitoral sensation was considered prima facie evidence of neurosis."⁴⁵ Clinical research by sex therapists and sex educators revealed that women experience orgasm through indirect or direct clitoral stimulation. The report of Hite comprehensively reviewed female sexual experience.⁴⁶ This is not to say that the vagina is not key to the female sexual response. A word that considers the clitoris, distal urethra and distal vagina would possibly be more useful for the site of female sexual response. Douglass and Douglass⁴⁷ and Sevely⁴⁸ discussed the issue of appropriate terminology for the organ responsible for the female sexual response. MRI and dissection clearly demonstrate the extent to which the clitoris, distal urethra and vagina are related.

The popular press frequently refers to a focus of female sexual function, namely the G spot. Grafenberg first described an erogenous zone located in the anterior vaginal wall.⁴⁹ Ultrasonic studies have correlated the focus of female sensitivity with the external urethral sphincter. It is possible that this focus is the erectile tissue itself as it wraps around the distal urethra and vagina. Findings in cadavers and on MRI did not reveal any additional structure separate from the bulbs, glans or corpora of the clitoris, urethra and vagina that could be regarded as the G spot.

CONCLUSIONS

Kobelt used the term clitoris in a limited way and not in the inclusive way that the word penis is used.³⁹ No specific name or word was given for the entire cluster of erectile parts. Instead he chose to use the rather cumbersome terms "female passive and active sex organs," and did not discuss his use of terminology or its shortcomings.

There is appeal in using a simple term, the clitoris, to describe the cluster of erectile tissues responsible for female orgasm. With time agreement will be reached as to whether the entire cluster of related tissues (distal vagina, distal urethra and clitoris including the bulbs, crura, body and glans) should be included in the term clitoris. For now it seems appropriate to unite the vascular structures that form a unified cluster, as on MRI, and refer to those structures as the clitoris. The distal vagina and urethra are clearly related, forming a midline core to the clitoris. Whether this cluster (distal vagina, distal urethra and clitoris) should be regarded as another entity and given a separate name is worthy of discussion. Such an inclusive concept would probably lead to the cessation of artificial discussions on the unnecessary separation of the orgasmic focus, that is clitoral vs vaginal.

The neurovascular supply to the clitoris is derived from the pudendal and cavernous nerves. The exact anatomy of the cavernous nerves has been defined in fetal studies but consistent demonstration in adults is lacking. The histology, immunohistochemistry and pharmacology are increasingly well defined. To date gains in the laboratory have not translated directly into clinical practice, the response to sildenafil being the most obvious example.

Writers of major anatomy textbooks have had access to

comprehensive descriptions and diagrams of the clitoris since the studies of Kobelt.³⁹ The lack of anatomical detail in pelvic surgical texts has reinforced the blinkered approach to pelvic anatomy typical of anatomical textbooks. The description of Kobelt with a few modifications but aided by MRI and photographs of dissection provide a comprehensive account of female sexual anatomy.

The tale of the clitoris is a parable of culture, of how the body is forged into a shape valuable to civilization despite and not because of itself.⁵⁰

REFERENCES

1. Sinnatamby, C. S.: *Last's Anatomy. Regional and Applied*, 10th ed. Edinburgh: Churchill Livingstone, pp. 298–314, 1999
2. Williams, P. L., Bannister, L. H., Berry, M. M., Collins, P., Dyson, M., Dussek, J. E. et al: *Gray's Anatomy*, 38th ed. New York: Churchill Livingstone, 1995
3. Hinman, F.: *Atlas of Urosurgical Anatomy*. Philadelphia: W. B. Saunders Co., pp. 389–406, 1993
4. Masters, W. H. and Johnson, V. E.: *Human Sexual Response*. Boston: Little, Brown and Co., p. 46, 1966
5. Moore, L. J. and Clarke, A. E.: Clitoral conventions transgressions: graphic representations in anatomy texts, c1900–1991. *Feminist Studies*, **21**: 255, 1995
6. Downer, C., Chalker, R. and Sullivan, I.: *A New View of a Woman's Body*. New York: Simon and Schuster, 1980
7. O'Connell, H. E., Hutson, J. M., Anderson, C. R. and Plenter, R. J.: Anatomical relationship between urethra and clitoris. *J Urol*, **159**: 1892, 1998
8. Suh, D. D., Yang, C. C., Cao, Y., Garland, P. A. and Maravilla, K. R.: Magnetic resonance imaging anatomy of the female genitalia in premenopausal and postmenopausal women. *J Urol*, **170**: 138, 2003
9. Baggish, M. S., Steele, A. C. and Karram, M. M.: The relationships of the vestibular bulb and corpora cavernosa to the female urethra: a microanatomic study. Part 2. *J Gynecol Surg*, **15**: 171, 1999
10. Rees, M. A., O'Connell, H. E., Plenter, R. J. and Hutson, J. M.: The suspensory ligament of the clitoris: connective tissue supports of the erectile tissues of the female urogenital region. *Clin Anat*, **13**: 397, 2000
11. O'Connell, H. E. and DeLancey, J. O. L.: Clitoral anatomy in nulliparous healthy premenopausal volunteers using unenhanced magnetic resonance imaging. *J Urol*, **173**: 2060, 2005
12. Verkauf, B. S., Von Thron, J. and O'Brien, W. F.: Clitoral size in normal women. *Obstet Gynecol*, **80**: 41, 1992
13. Yucl, S., de Souza, A., Jr. and Baskin, L. S.: Neuroanatomy of the human female lower urogenital tract. *J Urol*, **172**: 191, 2004
14. O'Connell, H. E., Anderson, C. R., Plenter, R. J. and Hutson, J. M.: The clitoris: a unified structure. *Histology of the clitoral glans, body, crura and bulbs*. *Urodynamic*, **14**: 127, 2004
15. Baskin, L. S., Erol, A., Li, Y. W., Liu, W. H., Kurzrock, E. and Cunha, G. R.: Anatomical studies of the human clitoris. *J Urol*, **162**: 1015, 1999
16. van Turnhout, A. A., Hage, J. J. and van Diest, P. J.: The female corpus spongiosum revisited. *Acta Obstet Gynecol Scand*, **74**: 767, 1995
17. Toesca, A., Stolfi, V. M. and Cocchia, D.: Immunohistochemical study of the corpora cavernosa of the human clitoris. *J Anat*, **188**: 513, 1996
18. Burnett, A. L., Calvin, D. C., Silver, R. I., Peppas, D. S. and Docimo, S. G.: Immunohistochemical description of nitric oxide synthase isoforms in human clitoris. *J Urol*, **158**: 75, 1997
19. Yamada, K.: On the sensory nerve terminations in clitoris in human adult. *Tohoku J Exp Med*, **54**: 163, 1951
20. Yamada, K.: Studies on the innervation of clitoris in 10th month human embryo. *Tohoku J Exp Med*, **54**: 151, 1951
21. Krantz, K. E.: Innervation of the human vulva and vagina; a microscopic study. *Obstet Gynecol*, **12**: 382, 1958
22. Yoon, H. N., Chung, W. S., Park, Y. Y., Shim, B. S., Han, W. S. and Kwon, S. W.: Effects of estrogen on nitric oxide synthase and histological composition in the rabbit clitoris and vagina. *Int J Impot Res*, **13**: 205, 2001
23. Park, K., Moreland, R. B., Goldstein, I., Atala, A. and Traish, A.: Sildenafil inhibits phosphodiesterase type 5 in human clitoral corpus cavernosum smooth muscle. *Biochem Biophys Res*

- Commun, **249**: 612, 1998
24. Munarriz, R., Kim, S. W., Kim, N. N., Traish, A. and Goldstein, I.: A review of the physiology and pharmacology of peripheral (vaginal and clitoral) female genital arousal in the animal model. *J Urol, suppl.*, **170**: S40, 2003
 25. Tarcan, T., Siroky, M. B., Park, K., Goldstein, I. and Azadzi, K. M.: Systemic administration of apomorphine improves the hemodynamic mechanism of clitoral and vaginal engorgement in the rabbit. *Int J Impot Res*, **12**: 235, 2000
 26. Becher, E. F., Bechara, A. and Casabe, A.: Clitoral hemodynamic changes after a topical application of alprostadil. *J Sex Marital Ther*, **27**: 405, 2001
 27. Vesalius, A.: *Observationum anatomicarum Gabrielis Fallopii examen*. Venice: Francesco de'Franceschi da Siena, p. 143, 1564
 28. Crooke, H.: *Mikrokosmographia: A Description of the Body of Man*. London: Thomas and Richard Cotes, p. 250, 1631
 29. Jocelyn, H. D. and Setchell, B. P.: Regnier de Graaf on the human reproductive organs. An annotated translation of *Tractatus de Virorum Organis Generationi Inservientibus* (1668) and *De Mulierub Organis Generationi Inservientibus Tractatus Novus* (1962). *J Reprod Fertil Suppl*, **17**: 1, 1972
 30. Magnus, A.: *On Animals*, pp. 1349–1350, 1277
 31. Shaw, J. R.: Scientific empiricism in the Middle Ages: Albertus Magnus on sexual anatomy and physiology. *Clio Med*, **10**: 53, 1975
 32. Longo, L. D.: *De mulierum organis generationi inservientibus tractatus novus*. *Am J Obstet Gynecol*, **174**: 794, 1996
 33. Park, K.: The rediscovery of the clitoris. In: *The Body in Parts. Fantasies of Corporeality in Early Modern Europe*. Edited by D. Hillman and C. Mazzio. New York: Routledge, pp. 171–193, 1997
 34. Williamson, S. and Nowak, R.: The truth about women. A new anatomical study shows there is more to the clitoris than anyone ever thought. *New Scientist*, **159**: 34, 1998
 35. Cohen, M.: The mysterious origins of the word "clitoris." In: *The Classic Clitoris: Historic Contributions to Scientific Sexuality*. Edited by T. P. Lowry. Chicago: Nelson-Hall, pp. 5–9, 1978
 36. *Classic pages in obstetrics and gynecology: Gabrielis Fallopii—Observationes anatomicae ad petrum mannann medicum cremonensem*. Venetiis, M. A. Ulmum, 1561. *Am J Obstet Gynecol*, **117**: 144, 1973
 37. Dalechamps, J.: *Chirurgie Francoise*. Lyon: Guillaume Rouille, 1573
 38. Kobelt, G. L.: The female sex organs in humans and some mammals. In: *The Classic Clitoris: Historic Contributions to Scientific Sexuality*. Edited by T. P. Lowry. Chicago: Nelson-Hall, pp. 19–56, 1978
 39. Kobelt, G. L.: *Die männlichen und weiblichen Wollustorgane des Menschen und einiger Säugethiere*. Freiburg, 1844
 40. Lowry, T. P.: *The Classic Clitoris: Historic Contributions to Scientific Sexuality*. Chicago: Nelson-Hall, p. 120, 1978
 41. Poirier, P. and Charpy, A.: *Traité d'Anatomy Humaine*, 2nd ed. Paris: Masson, 1901
 42. Elchalal, U., Ben-Ami, B. and Brzezinski, A.: Female circumcision: the peril remains. *BJU Int, suppl.*, **83**: 103, 1999
 43. Brown, I. B.: *On the Curability of Certain Forms of Insanity, Epilepsy, Catalepsy and Hysteria in Females*. London: Robert Hardwicke, p. 85, 1866
 44. Sheehan, E.: Victorian clitoridectomy: Isaac Baker Brown and his harmless operative procedure. *Med Anthropol Newsl*, **12**: 9, 1981
 45. Kaplan, H. S.: *The New Sex Therapy: Active Treatment of Sexual Dysfunctions*. London: Bailliere Tindall, p. 544, 1974
 46. Hite, S.: *The New Hite Report*. London: Hamlyn, 2000
 47. Douglass, M. and Douglass, L.: *Are We Having Fun Yet?* New York: Hyperion, 1997
 48. Sevely, J. L.: *Eve's Secrets: A New Theory of Female Sexuality*. New York: Random House, 1987
 49. Grafenberg, E.: The role of urethra in female orgasm. *Int J Sexol*, **III**: 145, 1950
 50. Laqueur, T.: *Making Sex: Body and Gender From the Greeks to Freud*. Cambridge, Massachusetts: Harvard University Press, p. 313, 1990