

## 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.<sup>1</sup> 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,<sup>2</sup> the Hinman urological atlas,<sup>3</sup> sexuality texts such as the classic Master and Johnson Human Sexual Response<sup>4</sup> 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.<sup>5</sup> These examples, particularly with the backdrop of the clitoris being discovered and rediscovered, indicate that the evolution of female anatomy

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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.<sup>6</sup> 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."<sup>2</sup> 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.<sup>7-9</sup>

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.<sup>7,10</sup> 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).<sup>8,11</sup> 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.<sup>10</sup> The glans is a small, button-like extension of the body of the clitoris. It is partly

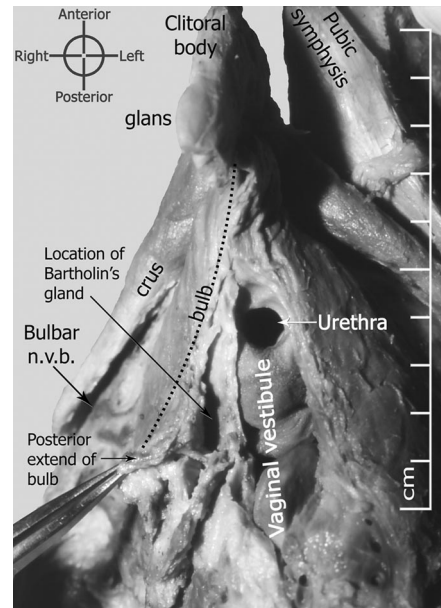


FIG. 1. Frontal view of dissected clitoris and vulva, as seen from perineum in fresh cadaver of 57-year-old postmenopausal woman. n.v.b., neurovascular bundle.

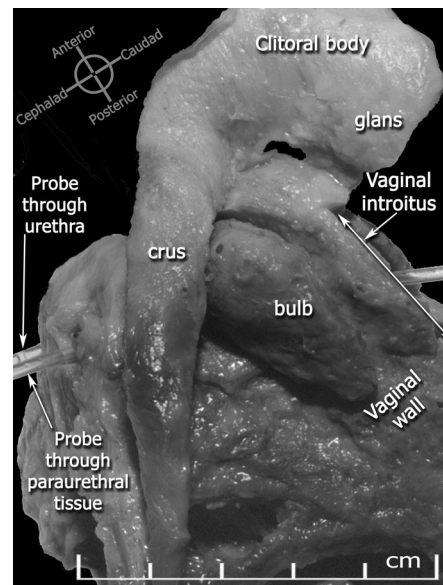


FIG. 2. Lateral view of dissected clitoris in fresh cadaver of 57-year-old postmenopausal woman.

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.<sup>12</sup>

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

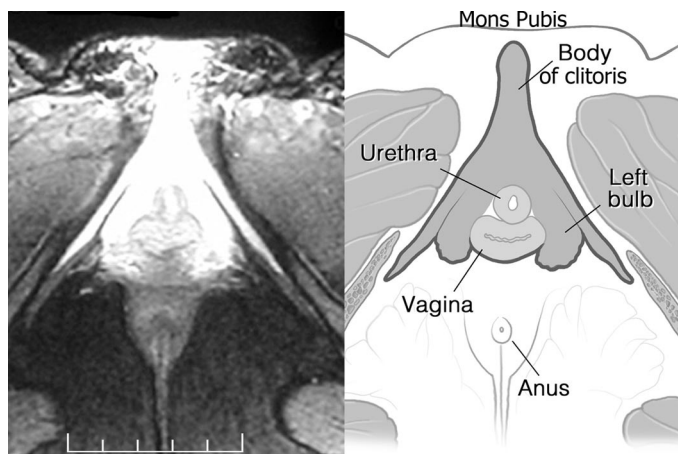


FIG. 3. MRI of clitoris and its components in axial plane in premenopausal nullipara. Bulbs, crura and corpora are well demonstrated. These structures lie ventral and lateral to urethra and vagina as cluster or complex. Reprinted with permission.<sup>11</sup>

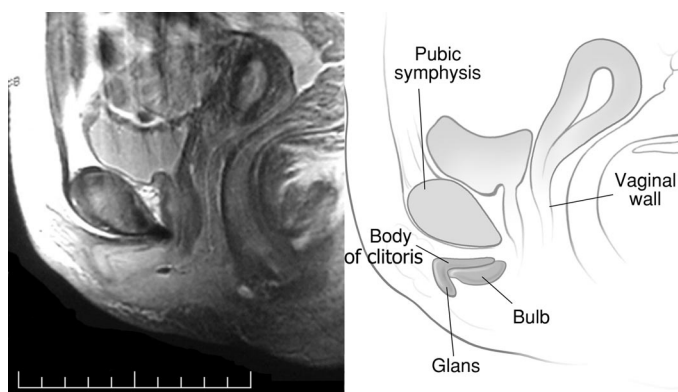


FIG. 4. MRI of clitoris and its components in mid sagittal plane in premenopausal nullipara. This midline sagittal section highlights almost boomerang-like appearance of clitoral body, crura and glans. Reprinted with permission.<sup>11</sup>

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.<sup>7</sup> 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.”<sup>22</sup> 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.<sup>11</sup> Recently Yucel et al reported that the cavernous nerve supplies the female urethral sphincter complex and clitoris.<sup>13</sup> 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

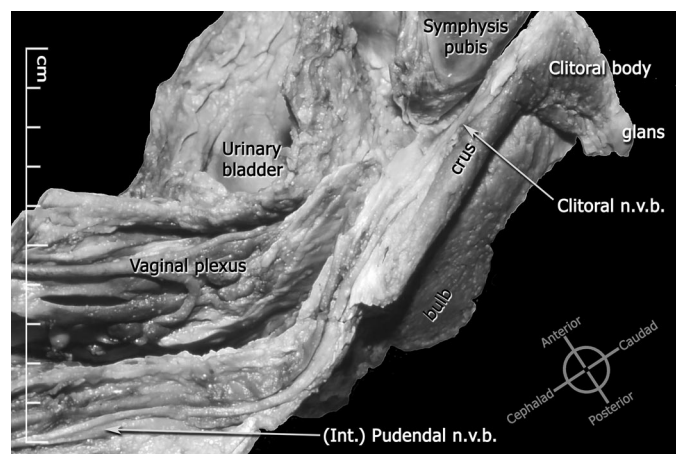


FIG. 5. Lateral view of dissected specimen of clitoris with its neurovascular bundle (n.v.b.) in fresh cadaver of 57-year-old postmenopausal woman. Int., internal.

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.<sup>14</sup> 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.<sup>14</sup> 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.<sup>15</sup> 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,<sup>15</sup> 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.<sup>15–21</sup> 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.<sup>9,14</sup> 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-



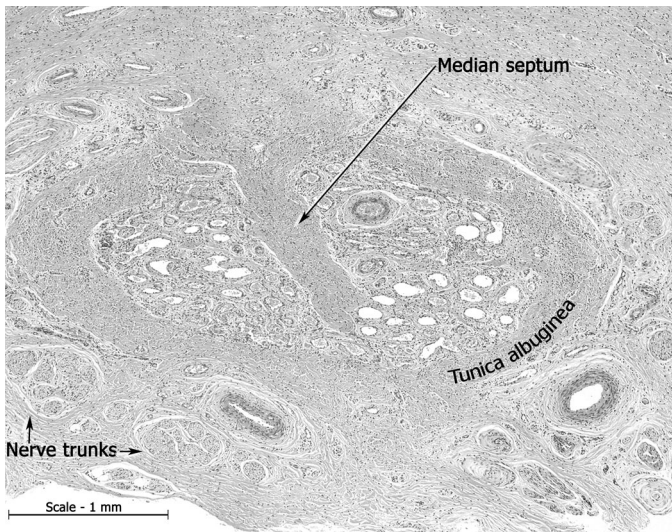


FIG. 6. Low power photomicrograph through clitoral body of 2-year-old child reveals several large neural trunks, which are branches of dorsal clitoral nerve. H & E, reduced from  $\times 5$ .

ation.<sup>22–24</sup> 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.<sup>24</sup> Apomorphine induced changes in cavernous and vaginal blood flow have been observed in a rabbit model.<sup>25</sup> 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.<sup>26</sup> 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.<sup>27</sup> 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.”<sup>27</sup>

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.<sup>28</sup> 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.<sup>29</sup> 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.<sup>30</sup> 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.”<sup>31</sup> 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.”<sup>32</sup> 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.<sup>33</sup>

The Greek word κλειτοριζ (clitoris) is possibly derived from the Greek word κλειτοριζειν, which means to rub.<sup>29</sup> However, the same Greek word κλειτοριζ is connected to the word hill and it is translated by some as the little hill.<sup>34</sup> 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.<sup>35</sup> 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.”<sup>33</sup> In the Renaissance (1545) Estienne was the first writer to identify the clitoris in a work based on dissection.<sup>33</sup> 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.<sup>36</sup> 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.”<sup>36</sup> 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.<sup>37</sup> Following the chapter on hermaphrodites Dalechamps wrote about nymphotomia. Nymphotomia was an operation to excise unusually large nymphae. However, what constituted unusually large nympha 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.”<sup>37</sup>

The work of De Graaf indicates that clitoral anatomy was





been mentioned by all writers since that period again and again."<sup>44</sup>

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.<sup>42</sup> 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."<sup>45</sup> 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.<sup>46</sup> 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 Douglass<sup>47</sup> and Sevely<sup>48</sup> 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.<sup>49</sup> 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.<sup>39</sup> 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.<sup>39</sup> 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.<sup>50</sup>

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