

# ANATOMICAL RELATIONSHIP BETWEEN URETHRA AND CLITORIS

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## ABSTRACT

**Purpose:** We investigated the anatomical relationship between the urethra and the surrounding erectile tissue, and reviewed the appropriateness of the current nomenclature used to describe this anatomy.

**Materials and Methods:** A detailed dissection was performed on 2 fresh and 8 fixed human female adult cadavers (age range 22 to 88 years). The relationship of the urethra to the surrounding erectile tissue was ascertained in each specimen, and the erectile tissue arrangement was determined and compared to standard anatomical descriptions. Nerves supplying the erectile tissue were carefully preserved and their relationship to the soft tissues and bony pelvis was noted.

**Results:** The female urethra, distal vaginal wall and erectile tissue are packed into the perineum caudal (superficial) to the pubic arch, which is bounded laterally by the ischiopubic rami, and superficially by the labia minora and majora. This complex is not flat against the rami as is commonly depicted but projects from the bony landmarks for 3 to 6 cm. The perineal urethra is embedded in the anterior vaginal wall and is surrounded by erectile tissue in all directions except posteriorly where it relates to the vaginal wall. The bulbs of the vestibule are inappropriately named as they directly relate to the other clitoral components and the urethra. Their association with the vestibule is inconsistent and, thus, we recommend that these structures be renamed the bulbs of the clitoris.

**Conclusions:** A series of detailed dissections suggest that current anatomical descriptions of female human urethral and genital anatomy are inaccurate.

**KEY WORDS:** anatomy, clitoris, urethra

The gross and histological anatomy of the human female perineum is often described in cursory<sup>1</sup> or comparative terms.<sup>2,3</sup> Typically, the human female perineal anatomy is briefly described only in terms of its differences from the male perineal anatomy. Frequently, descriptions of the neurovascular supply to the perineal area are scant or absent. Female urethral anatomy, with the exception of its sphincters and surrounding fascia, is usually described without reference to surrounding structures, particularly the clitoris. The clitoris is said to be different from the penis in that the urethra "does not traverse it."<sup>4</sup>

The initial goal of this research was to determine the female anatomy of the cavernosal nerves and whether it was analogous to that of the male anatomy. To begin our investigation microscopic dissections were performed on fresh tissue from 10 female infant cadavers who had died of sudden infant death syndrome. They were investigated because comparable work had been performed on male infant cadavers.<sup>5</sup> While performing these dissections it became apparent that the end organ erectile tissue was surprisingly different from the descriptions of it in anatomy publications. To ensure that such major differences were not age related and to broaden the scope of our research, further investigation of this anatomy was performed on adult cadavers. In this study we determine and describe accurately the gross anatomy of the urethra and its surrounding erectile tissue complex, the clitoris. We also review the appropriateness of current anatomical terminology used in describing these tissues.

## MATERIALS AND METHODS

The perineum and pelvis of 2 fresh and 8 fixed female human cadavers were dissected in detail. Fresh tissue was processed for histology and immunohistochemistry, the findings from which will be published separately. The anatomy of the female erectile tissue and its relationship to the urethra were determined by dissection and documented photographically. The dissections were compared to anatomy and pelvic surgery texts, and historical anatomy literature.

We were able to determine the age range of the cadavers but not the menopausal status as these data were not available. The ages indicated that 2 were likely premenopausal (22 and 36 years old, fresh and fixed tissue, respectively). Of the remaining cadavers 6 were 70 years old or older and 2 were 51 and 55 years old (fresh and fixed tissue, respectively). The appearances of these latter 2 cadavers suggested that they were postmenopausal. The erectile tissue structures were more bulky and more easily defined in the younger specimens. No record of previous surgery was obtainable although 3 elderly specimens showed evidence of hysterectomy. There was no evidence of prior perineal surgery.

Before dissection fixed cadaveric tissue was subjected to a standard embalming regimen of the Department of Anatomy and Cell Biology, University of Melbourne using a mixture of 40% formaldehyde, glycerine, ethanol, phenol and saline. Although the dissection sequence varied somewhat depending on the goal of a specific dissection, a general sequence was followed. In the fixed cadavers both lower limbs were amputated and, after section of the abdomen a few cm. above the pubic symphysis, all pelvic viscera except the uterus, vagina, bladder and urethra were removed. The perineal dissection involved excision of the adductor muscles at their

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origin, taking care to avoid injury to the adjacent erectile tissue and associated musculature. The suspensory ligament was dissected in detail in 4 specimens. The labia majora were dissected and their highly vascular adipose content was noted. After excision of the fat superficial to the ischiocavernosus and bulbospongiosus muscles these muscles were removed, exposing the underlying crura and deep perineal membrane. The bony pelvis was excised unilaterally after division of the pubic symphysis. Extreme care was taken to avoid injury to the neurovascular bundle observed to run adjacent to the lower edge of the ischiopubic ramus. The bone was separated from the soft tissues progressing from the lateral edge to the median plane. This separation revealed the clitoral crura and after excising the suspensory ligament the body of the clitoris was also exposed. The flimsy capsule surrounding the bulbs of the vestibule was removed to expose the underlying erectile tissue, and the relationship between the bulbs and the urethra was noted in each specimen. The internal pudendal and cavernosal neurovascular bundles were dissected in each specimen and their course was noted. Exposure of these bundles was facilitated by bilateral excision of the ischioanal fossa fat and levator ani.

The fresh tissue obtained post mortem involved a much more limited dissection after a standard postmortem examination had been performed. An en bloc dissection of the uterus, vagina, bladder, urethra, small segment of pubic symphysis, surrounding erectile tissue, and associated musculature and fat was performed, and a more detailed dissection was performed using an operating microscope in the laboratory. All specimens are described according to the anatomical position. This research was performed after obtaining appropriate ethics approval from the Victorian Institute

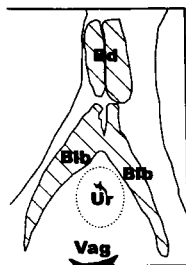


FIG. 1. Coronal section of female erectile tissue of 76-year-old fixed cadaver. Plane is parallel to superficial surface of pubic rami. Note cross section of bulb (*Bib*) and its clear relationship to crura and body of clitoris (*Bd*) as well as to urethra (*Ur*) medially. There is distinct color difference between erectile tissue of bulb (darker), crura and corpora (dark), and surrounding tissue. *Vag*, vagina.



FIG. 2. Dissection of 55-year-old cadaver demonstrating same relationships as shown in figures 1 and 7. Note bulbs (*Bib*) flanking urethra rather than vaginal vestibule (*Vest*) as in figure 1. Cannulas are present in urethra and periurethral plane through which instruments are passed for colposuspensions and pubovaginal slings. *Cr*, crura. *Gl*, glans of clitoris.

of Forensic Pathology and the Board of Medical Research, Royal Melbourne Hospital.

RESULTS

The erectile tissue complex (clitoris) consists of a midline body (corpora) giving rise to bilateral crura and separate bulbs which sit posterior to the body as displayed in figures 1 to 3. The urethra lies surrounded by this complex with the body directly anterior to it, flanked superficially by the bulbs and deeply by the crura. Thus, the urethra is a pelvic and perineal conduit embedded in the anterior vaginal wall but in all other directions it is surrounded by erectile tissue (figs. 1 and 4). Figure 1, a photograph of a section of the erectile tissue in a coronal plane perpendicular to the urethral wall, reveals the intimate relationship between the urethra and the bulbs.

In anatomy texts the bulbs are referred to as the bulbs of the vestibule and appear as if they form an erectile core of the labia minora (fig. 5). However, our dissections reveal that the bulbs relate most closely to the clitoris and urethra, and do not have a consistent relationship to the vaginal vestibule (figs. 1 to 4 and 6). The bulbs lie on the superficial aspect of the vaginal wall and do not form the core of the labia minora.

The arrangement of the erectile tissue complex and its distribution in a young premenopausal woman are clearly demonstrated in figure 3, A and B. In this dissection the left labium minora remains intact to demonstrate the position of the erectile tissue with respect to the skin. The bulbs lie deep to the bulbospongiosus muscle and are covered with a delicate membrane which is markedly different from the thick and tough capsule surrounding the clitoral corpora. In this specimen the bulbs are extensive and almost completely

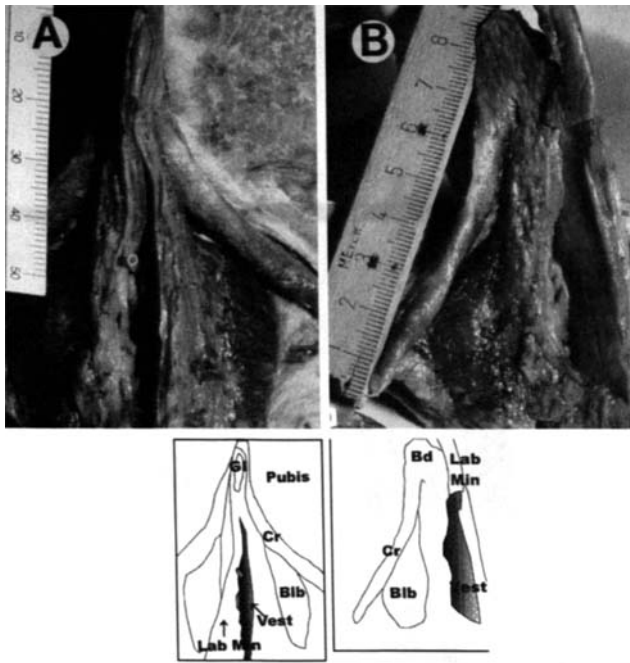


FIG. 3. Dissection of 36-year-old fixed premenopausal cadaver reveals extensive erectile tissue with bulb (*Bib*) fully flanking lateral vaginal wall on superficial (lateral) aspect. Bulbar neurovascular bundle is seen in space between crus and bulb. *A*, clitoris appears to be flat. *B*, oblique view of same specimen indicating 3-D character. *Cr*, crura. *Gl*, glans of clitoris. *Lab min*, labia minora. *Vest*, vestibule.

cover the distal vaginal wall, which is that part of the wall lying superficial to the bony pelvis. In other specimens from postmenopausal cadavers the bulbs related more exclusively to the clitoris or to the urethra (figs. 1, 2 and 6). The texture of the erectile tissue of the body and crura was the same but different from that of the bulbs, which appeared to contain a dense deep blue vasculature. By comparison, the body and crura were heavily encapsulated and their vasculature was deep pink, distinct from the surrounding tissue (fig. 1).

The clitoris is a tri-planar complex with the corpora lying in the median sagittal plane and the crura lying parallel to the ischiopubic rami. The bulbs then partially or completely fill the gap between the labia minora, body and crura lateral to the vaginal wall and urethra. Thus, the clitoris is not flat against the bone as is shown in anatomy and surgery texts (fig. 5). The body of the clitoris is 1 to 2 cm. wide and composed of paired corpora that are 2 to 4 cm. long. The crura extend laterally from the deep aspect of the body, and are 5 to 9 cm. long and slightly narrower than the body. The bulbs are 3 to 7 cm. long, crescentic or triangular in shape, and fill in the space between the crura, body and urethra, superficial to the vaginal wall (figs. 3 and 6).

The glans and frenulum of the clitoris are usually accurately described in textbooks and are easily demonstrated because of their superficial position at the junction of the labia minora anterior to the urethra. Our dissections revealed no structures consistent with previous descriptions (fig. 5) of the greater vestibular (Bartholin's) glands.<sup>3</sup>

The internal pudendal neurovascular bundle was observed to divide at the most lateral point of the ischiopubic ramus into the dorsal neurovascular bundle of the clitoris and the bulbar neurovascular bundle (fig. 7). The male dorsal neurovascular bundle is clearly described in standard textbooks although the reference to corresponding female neuroanatomy is usually absent or inaccurate. Williams stated that "in the female, the corresponding nerve (dorsal nerve of the clitoris) is very small and supplies the clitoris."<sup>3</sup> We have

found the dorsal nerve of the clitoris to be noticeably large, in most dissections greater than 2 mm. in diameter. At the lateral limit of the ischiopubic ramus the neurovascular bundle runs medially and the dorsal nerve runs along the top surface of the corpora to enter the deep aspect of the glans clitoris (figs. 8 and 9).

In previous studies a cavernosal neurovascular bundle has been observed lateral to the urethra and lying directly on the pelvic aspect of the anterior vaginal wall.<sup>6</sup> Careful excision of the endopelvic fascia and bladder facilitates exposure of this bundle (fig. 9).

#### DISCUSSION

Since the studies of Masters and Johnson<sup>7</sup> there has been surprisingly little investigation of basic female sexual anatomy or physiology. In Kaplan's discourse on male and female sexual structure and function, the clitoris is described as "a small knob of tissue located below the symphysis pubis."<sup>8</sup> Later, the author states that "the nerve pathways and spinal reflex centers have not yet been anatomically delineated with precision."

Illustrations of female perineal anatomy from some historical foreign literature demonstrate diagrams of dissections largely consistent with our findings.<sup>9-12</sup> However, modern anatomy texts have reduced descriptions of female perineal anatomy to a brief adjunct after a complete description of the male anatomy. There are several major shortcomings in the anatomy depicted in current literature. The bulbs are either omitted or, if described, their relationship to other cavernous tissue is not observed. The urethra is not shown to relate to the clitoris. The erectile tissue complex is displayed as if it were flat against the pubic symphysis and not 3-dimensional (D). The clitoris is pictured as minute<sup>7,13</sup> or not represented at all, and its neurovascular supply is rarely described.

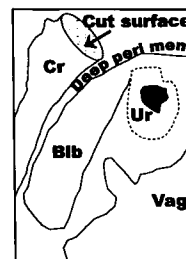
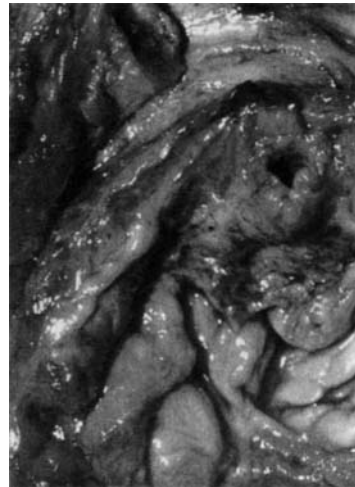


FIG. 4. Dissection of fresh tissue from 22-year-old cadaver. Body of clitoris has been removed revealing that urethra (*Ur*) lies directly posterior and bulbs (*Bib*) are in direct lateral continuity to urethra. *Cr*, crura. *Deep peri mem*, deep perineal membrane. *Vag*, vagina.

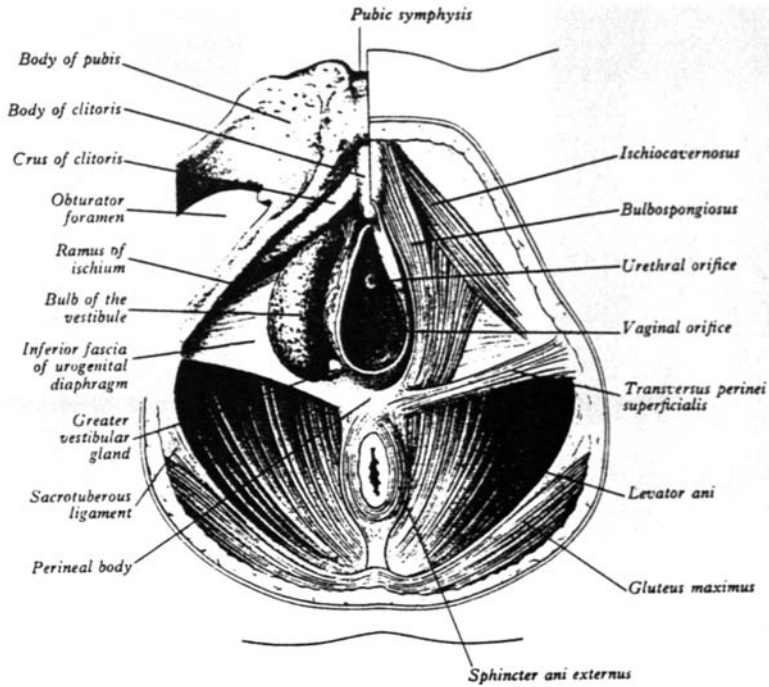


FIG. 5. Diagram shows view of female perineal anatomy typical of standard textbooks. Reprinted with permission<sup>3</sup>

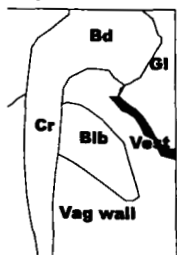


FIG. 6. Lateral view of cadaver shown in figure 2. Shape of bulb (*Blb*) is different from specimen in figure 3. Note how small bulb is and how little of lateral vaginal (*Vag*) wall is flanked compared to figure 3. *Bd*, body of clitoris. *Cr*, crura. *GI*, glans of clitoris. *Vest*, vestibule.

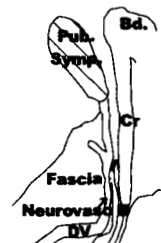


FIG. 7. Clitoris of 36-year-old cadaver demonstrated in relation to dorsal and pudendal neurovascular bundle (*Neurovasc B*). Arrow indicates point of origin of dorsal neurovascular bundle, which runs medially along lower aspect of ischiopubic ramus, which has been removed. For clarity ischiorectal fat and levator ani have been removed, leaving adjacent deep fascia. *Cr*, crura. *DV*, dorsal vein. *Pub. symp.*, pubic symphysis.

Our dissections indicate that the clitoral components are 3-D, and this feature has contributed to the poor documentation of the clitoris because it is relatively difficult anatomy to display. In our research the systematic use of photography

throughout the dissections enhanced our understanding of the 3-D nature of female perineal anatomy. For example, demonstrating the anatomy from the lateral or oblique as-

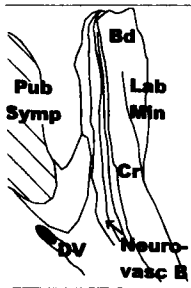
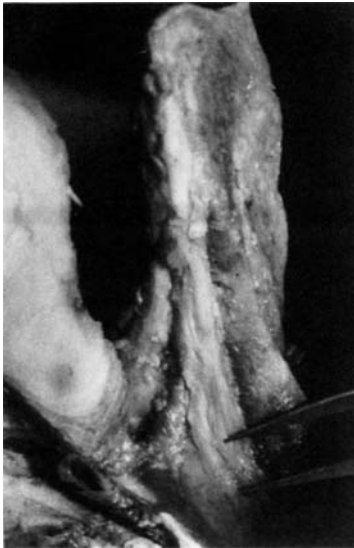


FIG. 8. Dissection of deep aspect of body (*Bd*) and right crus (*Cr*) of clitoris, and dorsal neurovascular bundle (*Neuro-vasc B*). Dorsal vein complex is also seen, including lumen of deep dorsal vein (*DV*). *Lab min*, labia minora. *Pub. symp.*, pubic symphysis.

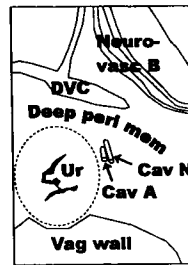
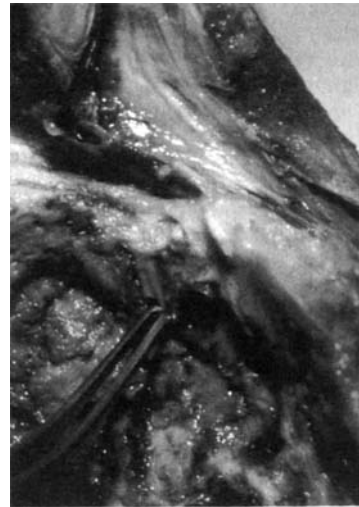


FIG. 9. Dissection of inside of pelvic floor reveals dorsal vein complex (*DVC*), dorsal neurovascular bundle (*Neuro-vasc B*), vaginal (*Vag*) wall from pelvic side and edge of endopelvic fascia after careful excision of bladder and endopelvic fascia. Cavernosal neurovascular bundle is clearly seen lateral to urethral (*Ur*) wall. *Cav A*, cavernosal artery. *Cav N*, cavernosal nerve. *Cr*, crura. *Deep peri mem*, deep perineal membrane.

pect prevents the typical foreshortening usually associated with illustrations of the body of the clitoris. With photography the exact size of a structure can be displayed and, thus, the body is seen to be 2 to 4 cm. long.

The bulbar erectile tissue is intimately related to the other components of the clitoris and urethra, and our research indicates that it has been inappropriately named the bulbs of the vestibule. For clarity and completeness it makes more sense to refer to the bulbs by their constant relationship to the clitoral components and to call them the bulbs of the clitoris.

While local vasocongestion of the corpora cavernosa and spongiosum of the penis are said to produce male erection, the "bulbs of the vestibule which surround the introitus, produce vaginal lubrication and the swelling which creates the orgasmic platform."<sup>8</sup> Although there is a paucity of accurate clinical investigation assessing the specific function of the bulbar erectile tissue, it appears that this tissue is likely to have a significant sexual role. We hypothesize that the bulbs add support to the distal vaginal wall to enhance its rigidity during penetration.

The urethra is intimately related to each component of the clitoris, but whether it has a role in sexual activity is uncertain. In a feminist account of female perineal anatomy the bulbar erectile tissue is referred to as the urethral "sponge."<sup>14</sup> The authors stated they had no access to dissection material on which to base their description of anatomy. In a recent French ultrasonographic study of female sexual sensitivity the site of the external sphincter of the urethra was identified as the most sensitive area along the anterior vaginal wall.<sup>15</sup> In that study the urethral sphincter was referred to as the "G point" and the perineal urogenital tissue referred to as the

"ensemble urethro-clitorido-vulvaire." Our study leads us to suspect that the role of the urethra in sexual function is related to the position of the surrounding erectile tissue rather than the urethral sphincter.

Whether the urethra has a role in sexual function is 1 issue. Perhaps, of greater concern to the urologist and pelvic surgeon is whether during operations in the vicinity of the urethra tissues responsible for female sexual function are damaged. Examples of such surgery include partial and total urethrectomy, urethral and vaginal suspension procedures, and partial and total vaginectomy. An extensive review of the literature indicates how seldom sexual function and its preservation are considered in the outcomes of these operations.

Our dissections demonstrated considerable age related variation in the dimensions of the erectile tissue between specimens. The specimens derived from premenopausal cadavers revealed substantially more extensive erectile tissue than those of the elderly cadavers. It is possible that typical dissections of female genital anatomy are performed on cadavers of more advanced age than those dissections performed on male subjects. Certainly the size of the erectile tissues uncovered by our dissections was greater than expected based on anatomy textbook diagrams. While male urogenital anatomy is easier to investigate because of its more external or superficial position, except for the labia, glans clitoris and vaginal introitus, the female urogenital tissues are internal and relatively obscured by overlying subcutaneous fat.

#### CONCLUSIONS

A dissection based study of female cadavers suggests that current anatomy texts do not accurately display female per-

ineal anatomy. Cadaveric dissection has facilitated an increased understanding of the gross anatomy of the urethra and surrounding erectile tissue as well as its neurovascular supply. We found the clitoris to be intimately related to the perineal urethra and more extensive than typical diagrams indicate. The bulbs of the vestibule appear to be inappropriately named because of their constant relationship to the urethra and clitoris, and we recommend they be referred to as the bulbs of the clitoris.

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