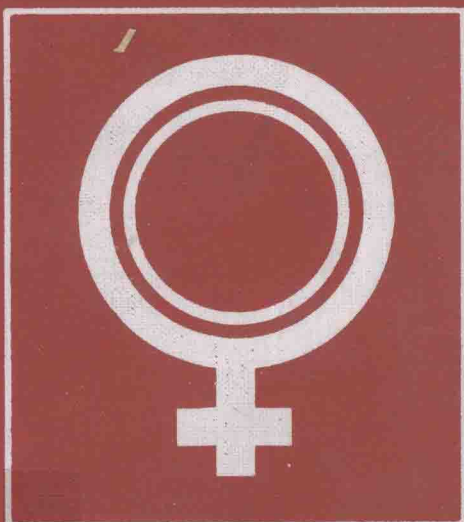


# **Disorders of the Female Urethra and Urinary Incontinence**

**Second Edition**



**William G. Slate, M.B., Ch.B., M.S., EDITOR**

# Disorders of the Female Urethra and Urinary Incontinence

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SECOND EDITION

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# Disorders of the Female Urethra and Urinary Incontinence

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SECOND EDITION

# *Dedication*

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**To Carole**

## ***Ode to the Urethra***

*Oh fair urethra sitting there  
Between the bladder and the air  
Bruised by many an unkind blow  
From fetus passage to libido.*

*Oh fair urethra you're wounded too  
When catheters, scopes and sounds prod you  
We act as if trauma were our goal  
It's no wonder you sometimes lose control*

*And just when you think you're finally healing  
Past your exposed meatus comes stealing  
Trich and coli and even G.C.  
That you function at all amazes me.*

*But fair urethra don't despair  
Your unjust burden bravely bear  
For though your fate may cause conjecture  
At least you have your very own lecture.*

***-Fritz C. Westerhout, Jr., M.D., F.A.C.O.G.***

# Preface to Second Edition

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The female urethra is now beginning to receive the attention it deserves by gynecologists and urologists. If compared with the first edition, a minor change will be detected in the opening sentence of this preface. This slight change represents a dramatic reorientation and a vast increase in knowledge and understanding of the physiology and pathology of the bladder and urethra. Although merely a few years have passed since publication of the first edition of *Disorders of the Female Urethra and Urinary Incontinence*, the need became apparent for a new edition to incorporate new information, to describe the profusion of technical advances, and to place emphasis on subject material, some of which received only passing reference in the first edition.

While the title for the second edition remains unchanged, due to tradition and copyright restrictions, the discerning reader will recognize that the title should correctly be *Disorders of the Female Urethra and Urinary Continence*. Nevertheless it is hoped that the message contained is clear. If past developments are any indication of future expectations, sections will become outdated rapidly. This places a responsibility on the physician to be vigilant in keeping abreast of most recent information and technical advances. Patients will be best served by the use of contemporary methods, but, at the same time, they should be treatments and techniques which are well tried.

In this edition, the subject material has been reorganized, chapters rearranged, and an attempt made to reduce duplication. There are 13 new chapters, and three were replaced or rewritten. The number of chapters nearly doubles that of the first edition.

The former panel of distinguished contributors has been joined by others of renown; namely, Michael J. Daly, Jr., Harvey E. Duchin, J. Andrew Fantl, Alex E. Finkbeiner, Raymond A. Lee, Douglas J. Marchant, and Stuart L. Stanton, thus permitting an assemblage of subject material which broadly encompasses the embryology, anatomy, physiology, pharmacodynamic actions, and psychosomatic aspects of the female urethra and bladder, and disorders of the female urethra and continence—their pathogenesis and treatment. The additions reflect the tremendous growth and better understanding in gynecologic urology. The most dramatic extension of knowledge and technology is in the field of urodynamics and in pharmacology as applied to bladder and urethral function. Exciting innovations have taken place in diagnostic techniques. There is a better comprehension of the importance of the relative pressures in bladder and urethra for continence and the need for accuracy in diagnosis so that appropriate distinction can be made between those patients who should be treated medically and those best suited for operative correction. There has been an important change in understanding regarding the significance of the urethrovesical angle.

The text is intended to provide a reasonably comprehensive, convenient review and reference for practicing physicians, particularly gynecologists and urologists. Because of the authoritative material it contains, it will be of value to specialists as well as physicians in training.

The authors represent both the basic and clinical sciences, and their work reflects a broad background of research and extensive study of the anatomic, physiologic, pharmacologic, neurologic, psychiatric, and pathologic relationships of bladder and urethra. In addition, they bring wide clinical experience and expertise in both nonsurgical and surgical methods of treatment.

Controversial issues persist and will be resolved only by further investigation and the

test of time. Marchant, in an editorial on *Urinary Incontinence* (Obstet. Gynecol., 58: 372, 1981) comments on the complexity of the physiology and pharmacology of micturition and notes the existence of conflicting theories and incomplete understanding. He states "there is no doubt that instrumentation has advanced beyond our knowledge to comprehend the information obtained," and cautions us "to be wary of simple solutions to what appears to be a very complex hydrodynamic problem." Further advances in knowledge, instrumentation, and techniques hopefully will fill the gaps in our understanding and remove some of the confusion which now exists, but this must be accompanied by carefully controlled and long-term evaluations. Sonography has demonstrated its value in diseases of the upper urinary tract, but whether or not it has a role in relation to the lower tract remains to be determined. Premature application of incompletely understood information can be more harmful than beneficial. The study of the urethra is far from complete.

The Editor thanks each contributor whose originality and imagination, and sometimes even artistic talents, have made possible this text which should enable physicians to have a better understanding and be better prepared to determine the appropriate diagnosis and treatment of urinary disorders in women.

I am grateful to Mrs. Ruth Boone, my secretary, for her patience, carefulness, and precision in working on the manuscript; to Mrs. Helen St. Clair, Wilmington Medical Center Librarian, for her assistance in obtaining and verifying references; to Donald Russell and Douglas Bugel of the Wilmington Medical Center Audiovisual Department for their work on illustrations and, not least, to the many "silent" contributors (wives, companions, secretaries, and others) for their assistance and tolerance.

Appreciation is extended to the Williams & Wilkins team for cooperation, patience, efficiency, and expertise which facilitated the production of this edition.

*William G. Slate, M.B., Ch.B., M.S., F.A.C.O.G., F.A.C.S.*

# *Preface to First Edition*

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The female urethra has not received the attention it deserves by gynecologists or urologists. Controversy has surrounded its treatment including how and by whom. Anatomists have debated its support and opinion has been divided regarding which discipline should be responsible for treatment of urethral disorders including urinary incontinence. During recent years there has been an increasing awareness of the need to better understand the anatomy and pathophysiology of the urethra and urethrovesical junction. There has been a greater realization of the diversity with which disorders of the urethra may present and their crippling sequelae as manifested by sexual dysfunction, urinary tract infections, and especially urinary incontinence now recognized to occur in about 50% of all primigravid patients and 85% of multigravidas.

That the urethra deserves a place of prominence in gynecology is portrayed in an "Ode to the Urethra," written by Fritz C. Westerhout, Jr., M.D., and presented as a part of his lecture on the Urethra given to medical students at Loma Linda University, California in 1967.

This monograph is an outgrowth of a Symposium on "Treatment of Disorders of the Urethrovesical Junction", held at the Wilmington Medical Center, Wilmington, Delaware, November 10 and 11, 1976. It has been compiled to provide a convenient review and a ready reference for practicing physicians, particularly gynecologists and urologists who want a condensation of current concepts of problems related to the urethra, especially urinary incontinence, and a guide to their management. As a reference, the coverage is not exhaustive but it contains authoritative information of value to both specialists and physicians in training. The authors represent both the basic and clinical sciences, as well as a broad background of research and extensive study of the anatomy, physiology and pathology of the bladder and urethra, in addition to wide clinical experience and expertise in both nonsurgical and surgical methods of treatment.

Differences of opinion detected by the reader, and the persistence of failures in treatment, indicate that the study of the urethra is not complete and that there is need for additional investigation, clarification, and improved techniques.

*William G. Slate, M.B., Ch.B., M.S., F.A.C.O.G., F.A.C.S.*

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# Anatomy and Embryological Development of the Urethra and Bladder

Kermit E. Krantz, M.D., Litt.D., F.A.C.O.G., F.A.C.S.

### HISTORICAL ASPECTS

The first adequate anatomic treatise concerning the musculature of the urethra, the anterior vaginal wall, and the bladder may be attributed to Galen,<sup>15</sup> who described the urinary bladder as composed of longitudinal, transverse, and oblique fibers with a sphincter in the region of the urethral meatus. Fallopius was the first to substantiate the muscular nature of these fibers and was supported in his findings by Vicary<sup>15</sup> a century before Vesalius,<sup>15</sup> the latter of whom also identified longitudinal, transverse, and oblique fibers and noted that the urethra was continuous with the bladder. In the early 16th century, Spiegel<sup>15</sup> named the longitudinal fibers of the bladder “detrusor urinae” and asserted that they were responsible for the mechanism of urination. Cowper<sup>15</sup> agreed with the findings of Spiegel,<sup>15</sup> but believed the bladder was merely a dilatation of the ureters, and Cheselden<sup>15</sup> proposed that not simply a group of fibers but the entire muscular coat of the bladder was responsible for holding the urine.

Few additional investigations were completed until the late 19th century. Anatomists of this era continued to describe the bladder as having three muscular strata, two of which they identified as thicker than

the third. They noted that the outer layer coursed longitudinally from the apex to the base, the middle circularly, and the inner in an oblique direction. All layers were believed to insert in the region of the internal urethral meatus.

Although it was Galen<sup>15</sup> who first conceived of a sphincter in the region of the bladder neck, it was Vicary<sup>15</sup> who identified the ability of the bladder neck to retain and let go urine and Vesalius who first identified the sphincter as a separate muscle. This muscle was later termed the “sphincter vesicae internus” by Bell.<sup>15</sup>

Through the centuries, many varied opinions arose as to the functional mechanisms of the urethra and bladder. Kohlrusch<sup>15</sup> noted that the longitudinal fibers of the bladder spread like a paintbrush between the fibers of the sphincter vesicae, an arrangement that he believed gave the detrusor urinae the capacity to act as an antagonist to the latter. Barkow<sup>15</sup> asserted the presence of a “planum elasticum infundibulum” consisting of two parts that separated the ureters from the trigone and the urethra from the bladder musculature. Henle<sup>8</sup> proposed that the elastic rings described by Barkow<sup>15</sup> were composed essentially of smooth muscle. Arnold<sup>15</sup> and Luschka<sup>20</sup> believed that the trigone was formed by longitudinal muscle fibers of the

## 2 DISORDERS OF THE FEMALE URETHRA AND URINARY INCONTINENCE

ureters coming in contact with the vesical sphincter. Charpy<sup>15</sup> proposed that the longitudinal musculature of the ureters and of the urethra actually merged.

Finger<sup>4</sup> supported the theory that no sphincter existed in the vesical neck and that, instead, urine was retained through contraction of the urethral musculature, an opinion similar to that held by Jarjavay.<sup>15</sup> On the other hand, Versari<sup>15</sup> agreed essentially with the previous works of Barkow and others, describing the longitudinal musculature of the bladder not only as inserting into a sphincter in the vesical neck, but as acting as the sphincter's mechanism of control. Uffelmann<sup>15</sup> asserted that the vesical sphincter blended into the bladder wall and was, therefore, an integral part of it. Sappey<sup>24</sup> and Jurie<sup>15</sup> believed that the vesical sphincter arose from an accumulation of transverse bundles of bladder muscle in the region of the internal urethral meatus. Hyrtl<sup>11</sup> believed the sphincter in this region was formed by the circular fibers of the detrusor urinae; Krause,<sup>19</sup> like Pansch-Stieda,<sup>15</sup> defined the sphincter as something originating from the circular-patterned middle layer of the bladder muscle; and Testut<sup>15</sup> described the circular muscle of the bladder and of the urethra as continuous, the thickening of these fibers at the vesical neck constituting the sphincter. Pillet contended that no smooth muscle sphincter was identifiable and that urinary control was achieved solely through the action of the striated sphincter of the urethra.

In 1891 and after, Griffiths<sup>7</sup> described the muscle of the bladder as collected into two broad bands, 1 to 2 inches in width and coursing in a longitudinal direction from the apex to the vesical neck. He termed these bands, located in the middle of the anterior and posterior surfaces, the "detrusor urinae muscles." He also observed that there was no thickening of the middle circular muscle coat of the bladder such as would constitute an internal sphincter at the vesical neck. It was his opinion, therefore, that the striated musculature around the genital portion of the urethra developed in relation to sexual function.

In 1900, Kalischer<sup>12</sup> divided the muscu-

lature of the urethra into smooth and striated fibers. He termed the striated fibers the "sphincter urogenitales", originating in the region of the introitus and lying medially and posteriorly, independent of the bulbocavernosus and ischiocavernosus muscles. These fibers were described as forming a hood-like arrangement over the urethra in the lower third of its course, passing laterally and inferiorly onto the lateral vaginal wall. Utilizing the dog for his dissections, it was Kalischer,<sup>12</sup> therefore, who first observed that the lower two-thirds of the urethra and the anterior vaginal wall in the female are basically inseparable. He noted that in the middle third of the urethra, the course of the muscle changed so that the striated fibers then encircled the urethra to form a sphincter. He further noted that a small number of fibers coursed as they approached the bladder along the longitudinal axis of the urethrovaginal septum.

Kalischer<sup>12</sup> described the smooth muscle as assuming an entirely different pattern. He cited the circular fibers as becoming apparent in the middle third and continuing along the urethra to the bladder, where they attached posteriorly with muscle fibers of the ureters to form the trigone. He noted that these circular fibers stopped abruptly at the vesical neck, which he termed the "muscle sphincter trigonalis." He described this muscle as oblique in shape, coursing diagonally and superiorly over the urethra and inferiorly toward the lateral vaginal wall. He believed its posterior, better developed component to arise from the bladder and emphasized that the two muscle groups did not meet, the longitudinal muscle fibers coursing into the trigone to form the anterior component of the sphincter and the posterior longitudinal bladder muscle sending fibers to the urethra but directing the greater portion toward the pubic symphysis.

Basing his findings on the work of Kalischer, Zangenmeister<sup>15</sup> added his own observations concerning the structure of the urethra and anterior vaginal wall. He believed that the striated musculature was functionally accessory to closure of the bladder, originating from the musculature of the pelvis. He termed this the "urogenital

sphincter." As he described it, this sphincter, composed of striated muscle in its anterior portion, encircled both the urethra and vagina; the posterior portion, or that located toward the bladder, was cited as encircling the urethra only. The smooth muscle was observed to encompass in its anterior portion both the urethra and the vagina, inserting into the urethral-vaginal septum approximately halfway along its course and thickening in the region of the internal orifice to form the "sphincter trigonalis." At this point, its bundles traversed obliquely into the bladder. The muscle fibers were depicted posteriorly as traversing obliquely to form a ring that encompassed the entire trigone. In the opinion of Zangenmeister, the anterior portion of the smooth musculature at the internal urethral meatus belonged to the bladder musculature; and, unlike the posterior portion, it had no direct connection with the smooth muscle of the urethra. In support of this assertion, he indicated that a cross-section through the region of the internal urethral meatus showed bladder musculature superiorly and urethral musculature inferiorly, contrary to previous opinions proposing that the musculature around the bladder neck originated entirely from either one source or the other.

In 1921, Young and Wesson<sup>25</sup> described the bladder as containing poorly defined internal circular and external longitudinal muscle layers with an entirely unrelated muscle in the region of the trigone. They depicted the muscle fibers of the longitudinal layer as coursing downward toward the internal urethral meatus, forming a large muscle band laterally that looped anteriorly over the urethra and became continuous with the longitudinal fibers of the anterior surface were described as continuing to the urethra to form the longitudinal smooth muscle of that organ, but most were cited as terminating at the internal urethral meatus, those posteriorly in the trigone. They described the circular fibers as coursing downward and forward to the bladder in an oblique direction, passing to the region of the internal urethral meatus, where part formed a loop similar to the longitudinal muscle, although beginning beyond

the meatus and extending farther along the course of the urethra. They depicted the trigonal muscles as passing down over the posterior border of the vesical orifice and spreading out in a fashion similar to an internal longitudinal layer over the urethra's posterior aspects. Again, their description of the striated musculature coincided with that of Zangenmeister and Von Ludinghausen.<sup>15</sup>

Bonney stated in 1923 that the bladder trigone rested on a sheet composed of smooth muscle. He named this sheet the "pubocervical sheet", and many observers have since termed it "pubocervical fascia." He described its lower surface as lying against the anterior vaginal wall and then blending into the block of tissue through which the urethra passes. He further indicated this block to be triangular in shape and composed of a circular fibromuscular coat surrounding the urethra and containing a layer of scattered muscle fibers coursing transversely in the urethrovaginal septum. He described the fibrous muscle layer as very vascular, giving the appearance of erectile tissue. He observed the circular layer to become more apparent as a sphincter at the urethrovesical junction. Finally, he believed that the front of the bladder was apparently attached to the inferior surface of the pubic bone by many thin connective tissue fibers.

In 1936, Douglass<sup>3</sup> expressed the opinion that the anatomy of the urethra and the anterior vaginal wall was still insufficiently understood. He proposed further that the vesical neck was produced by a thickening of the musculature and submucosa that, in turn, formed a ring about the internal orifice. He believed that this entity functioned as a sphincter and termed it the "sphincter vesicae internus." He also cited the existence of an external urethral sphincter composed of striated muscle.

Kennedy<sup>13, 14</sup> described the true sphincter of the urethra 10 years later as composed of smooth muscle fibers that surrounded the middle and inner thirds. He indicated that these were associated with longitudinal smooth muscle fibers that coursed the length of the urethra. He further described a striated muscle of two origins that formed