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REVIEW PAPER / META-ANALYSIS

Urethral Profilometry – should it be discarded?

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Abstract

Background: Urethral profilometry was developed as a scientific research method rather than for everyday clinical use. However, it was implemented as an integral part of urodynamic diagnostics for clinical use. Although it has been used for over 70 years, there are still no clear guidelines, either for the technique or for the indications and interpretation of the data obtained in this study. There are many inaccuracies and doubts about the method.
Material and methods: The authors of this manuscript present a review of the options for urethral function diagnostics and the position of urethral profilometry among them. The literature and clinical aspects of their investigation are discussed in this article. The sources of the limitations of urethral profilometry and their importance in clinical practice and the interpretation of results are analyzed.
Results: Urethral profilometry has many limitations. Their sources are urethral anatomy and structure, equipment, patient collaboration and the examination technique. The repeatability is debatable, but doubts surrounding it seem to be exaggerated. Despite all this many valuable data can be obtained by performing an examination.
Conclusions: Despite the limitations, urethral profilometry is a useful clinical tool for functional diagnostics of the urethra. Developing precise guidelines regarding indications, technique and interpretation of the assessment would be essential in order to take advantage of this diagnostic method.
Keywords: incontinence, urethral profilometry, urodynamics, urethra

Introduction

In the 1970s, Patrick Bates uttered the famous sentence '[t]he bladder is an unreliable witness' [1]. In a significant percentage of patients, subjectively reported symptoms are difficult to reproduce during diagnostic tests, and the effects of treatment based solely on the history, physical examination and knowledge of the anatomy and physiology of the lower urinary tract have been unsatisfactory for many years. The prevalence of at least one lower urinary tract symptom (LUTS) at least 'sometimes' is 72.3% for men

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and 76.3% for women, and 47.9% and 52.5% for at least ‘often’ for men and women, respectively [2]. The group of patients that need to be properly diagnosed is large.

Therefore, a method was sought that would allow the function of the lower urinary tract to be objectively assessed and, therefore, the results of the treatment of lower urinary tract symptoms to be improved [3]. The technique of cystometric examination, the technique in [4], was first described at the end of the 19th century, but it was not until the middle of the 20th century that modern urodynamic diagnostics, including urethral profilometry, was fully developed as a method of detailed assessment of urethral function.

Urethral function is crucial in many LUTS – not only urinary continence but also bladder overactivity, which is secondary to urethral stricture or sphincter hyperactivity and dysfunction in proper emptying of the bladder. The function of the bladder, urethra, or pelvic floor needs to be well coordinated. In response to the need for functional assessment of the urethra, urethral profilometry was developed as a part of urodynamic diagnostics. It was supposed to be a research tool [5], but it was implemented in clinics as a routine part of urodynamics. The current standards for performing urethral profilometry are defined in the document of the Standardization Committee of the International Continence Society [6].

The Urethra

The urethra develops from the endoderm and from the visceral mesoderm. Around the seventh week of pregnancy, the cloaca separates into the urogenital sinus and rectum, then the lower part of the vagina and the bladder and urethra separate from the urogenital sinus, which occurs around twelve weeks of gestation.

The average length of this tubular structure in females is 2.5 to 5.1 cm [7,8], and the diameter is about 5 to 7 mm. The internal orifice of the urethra is connected to the neck of the bladder, and the external orifice ends anteriorly in the vestibule of the vagina.

The fascial tissues covering the urethra connect to the tendinous arches of the pelvic floor and the levator ani muscle. At rest, with normal pelvic floor tension and correct anatomical relations, they guarantee the anatomical position of the urethra.

Smooth muscle layers innervated by the cholinergic system, whose fibers are arranged along the urethra (outer layer) and around it (inner layer), do not seem to be of key importance in maintaining urethral tone [3]. However, the inner layer’s circular filaments help to maintain the basic urethral tonus. The urethral sphincter is made of type I striated muscle fibers (slow twitch fibers) that can maintain contraction and high tone for a long time. It surrounds the distal two-thirds of the urethra, but it is believed that most of these fibers are in the middle 1/3 of the urethra. The sphincter is horseshoe-shaped, opened dorsally, and the fibers are divided into intramural and periurethral ones. They are fixed to the anterior vaginal wall. The shape of the sphincter is not without significance in the mechanisms of urinary continence and their assessment [9]. Additional muscle fibers in the distal portion of the urethra form the urethro-vaginal sphincter, whose contraction is conditioned by the contraction of the bulbospongiosus muscle. The pubourethral ligaments are located between the twentieth and sixtieth percentile of the length of the urethra and attach to the lower arm of the pubic bone and the tendon arch of the pelvic floor fascia, where it meets the arch of the levator ani. They determine the proper mobility of the urethra and stabilize its position during an increase in abdominal pressure or provocative tests [10–13].

For many decades, the urethra was perceived only as a tubular structure dedicated to the outflow of urine from the bladder. The current understanding is much broader. The two main functions of the urethra are urinary continence during the filling phase of the bladder and to facilitate emptying of the bladder during physiological voiding. It seems, however, that the function of this organ is much more complex [14].

The correct urinary continence mechanism is based on balancing intravesical pressure and intra-abdominal pressure at rest, as well as counteracting increases in abdominal pressure during exercise by increased intraurethral pressure. Physiologically, between voids, intraurethral pressure slowly increases in response to the gradual filling of the bladder. During micturition, the relaxation of the urethra and pelvic floor, associated with an decrease in intraurethral pressure, precedes the contraction of the detrusor by about five seconds, being the mechanism that activates normal micturition physiology [15].

In the 1970s, the critical zone of the urethra, which is most important for urinary continence, was defined for the first time as the ‘continence zone’. This is the area where the highest intraurethral pressures are located [16], which is crucial for urinary continence.

Urethral pathology

The main function of the urethra is urinary continence on the one hand and bladder emptying on the other. Proper coordination of the urethra, pelvic floor and bladder is necessary for both continence and bladder emptying. A disturbance in one element will affect the function of the others. Impaired urethral stabilization by the pubourethral ligaments, weakness of the pelvic floor muscles and urethral sphincter leads to urinary incontinence. Bladder overactivity is a cause of urge incontinence. Disturbed neuroregulation of the lower urinary tract and pelvic floor leads to discoordination and vesico-urethral dyssynergia with different clinical manifestations possible, starting from frequency and nocturia, urgency, dysfunctional voiding and overflow incontinence.

In the diagnostic algorithm, there are a few steps to go through, depending on what pathology is suspected. Urodynamics with or without urethral profilometry is one of the elements of in-depth diagnostics, performed in its later stages rather than as basic research [17]. As it is optimal to avoid overdiagnosing and overtreatment in our daily clinical practice, it is worth knowing when to perform a particular test. Asking clinical questions based on anamnesis and a detailed clinical examination allows the diagnostics to be planned correctly and effectively.

Diagnostic tools

There are several methods for assessment of the lower urinary tract, particularly the urethra.

Ultrasonography

Using ultrasound imaging of the urethra, its anatomy, rather than function, can be examined. The parameters assessed by sonography are the total urethral length (TUL), urethral mobility that indirectly testifies to the function of the pubourethral ligaments, stabilization of the urethra in order to maintain continence, and such anatomical pathologies as urolithiasis, diverticula, periurethral cysts. These latter can, of course, influence the continence and bladder-emptying mechanisms, but are not strictly functional. In patients with stress urinary incontinence, the presence of bladder neck funneling and urethral hypermobility is more frequent than in continent women. These, however, are not phenomena that determine diagnostic and therapeutic decisions [18,19]. According to the latest guidelines, ultrasound is routinely used in the assessment of residual urine after voiding (PVR – post void residual) in patients with stress urinary incontinence (SUI) [20]. The International Continence Society does not recommend the routine use of ultrasonography in the diagnosis of urinary incontinence, considering it to be an additional examination in patients with recurrent symptoms or with complex symptoms [21]. Furthermore, the SUI diagnoses and transperineal ultrasound findings were not connected to the urodynamic findings [22].

More sophisticated imaging methods, such as MRI or CT, are not recommended in routine diagnostics of the urethral function as they are not cost-effective.

Urethrography

Retrograde urethrography (RUG) is used as the investigation method of choice to evaluate the stricture presence, location, length, and any associated anomalies (e.g., false passages, diverticula) [23]. However, it is not a method for functional assessment of the urethra. Combining RUG with voiding cystourethrography (VCUG) can allow adequate and meticulous visualization of the urethra and a more accurate assessment of stricture length in (nearly) obliterative strictures, stenoses and gaps in pelvic fracture urethral injury (PFUI) [24]. This method can be used as an element of videourodynamics, which is rarely performed (among others, in the diagnosis of neurogenic LUTS). A functional radiological examination may show diverticulosis of the bladder and urethra, bladder obstruction (both functional, e.g., lack of relaxation of the bladder neck during micturition, and anatomical, e.g., urethral stenosis), static disorders of the pelvic organs affecting the anatomy of the lower urinary tract, and can assess the presence and nature of any fistulae. As an initial imaging test, ultrasound is more often used as a less invasive test than urethrocystography.

Endoscopy

Endoscopic examination – urethrocystoscopy – is a useful method in the assessment of the anatomy of the urinary tract, but it is of limited use in functional examination. Apart from oncological diagnostics, urethrocystoscopy may be useful in the diagnosis of fistulas, urethral diverticula, as well as in the diagnosis of hematuria, pain, and in the case of suspected bladder obstruction. As an invasive procedure, it is rarely recommended as a first-line diagnostic tool [25].

Urodynamics

A urodynamic study is the most detailed functional assessment tool for the lower urinary tract. Precise and comprehensive assessment of urethral function is based on urethral pressure profilometry (UPP). Resting (static urethral pressure profile at rest – UPPR) and dynamic (dynamic urethral pressure profile at stress – UPPS) profilometry tests are performed. Voiding profilometry is rarely performed (the test is used rarely and only in selected centers in the diagnosis of bladder obstruction) [3,26,27]. Maximal urethral pressure (MUP), the primary measured parameter, is defined as the fluid pressure required to open a collapsed urethra. It is possible to measure the pressure values at specific points of the urethra (point pressures), but the essence of urethral profilometry is the measurement of individual parameters along the entire length of the urethra, which gives the urethral pressure profile [6]. The resting profilometry test consists of measuring the intraurethral pressure along the entire length of the urethra, with the simultaneous measurement of the intravesical pressure at rest. Based on these measurements, the function of the urethra is comprehensively assessed. Simultaneous measurement of intravesical pressure allows the the maximum urethral closure pressure (MUCP) to be assessed, the other, apart from intraurethral pressure, basic parameter in urethral profilometry. During stress profilometry, the catheter is withdrawn along the urethra while intraurethral and intravesical pressures are continuously measured, and the patient repeatedly coughs or performs Valsalva maneuvers. This test allows the transmission of abdominal pressures to the urethra to be assessed. If the pressure in the urethra during stress testing and at rest surpasses the intravesical and abdominal pressures, the condition for proper urinary continence is met. Stress profilometry is a more reliable test in the assessment of patients with urinary incontinence compared to resting profilometry [26]. SUI is not the only condition in which profilometry can be used. Urethral sphincter hyperactivity and relaxation impairment, leading to bladder outflow functional obstruction, are common but rarely correctly diagnosed conditions that can be assessed only by performing urethral profilometry with intraurethral pressure measurement. Although there is a lot of medical data concerning it, urethral profilometry is criticized for being of low reproducibility and unreliable as a diagnostic tool.

To discuss the clinical utility of urethral profilometry, one must take into account different factors that can influence the method and its results.

Potential problems

The first problem is the anatomy of the urethra. One thing that generates intraurethral pressuresis is the urethral sphincter. It does not surround the whole urethral circumference but has a horseshoe shape opened dorsally. Thus, pressure values in the urethra depend on which point in its circumference the pressure is measured. In our study, using three-dimensional urethral profilometry, we detected differences in the pressure values of as much as 50% [28]. Routinely used catheters, with only one channel serving to measure intraurethral pressure, will be a source of classic method limitation. The construction of the catheter (only one channel for urethral pressure, and a lack of marks on the catheter) led to significant bias in subsequent examinations. Placing the catheter with a urethral pressure channel difference of as little as fifteen degrees in comparison to the previous attempt yields a completely different examinaton result in the same patient.

The patient's reaction during the examination is another source of potential deviations. Urethral profilometry, according to ICS guidelines [27], should be subsequently repeated two or three times. However, one must take into account that pelvic floor muscles keep reacting to any intervention, which leads to pressure changes. Similarly, when retesting patients at longer time intervals, differences are also detected [29].

Urethral profilometry potentially has a lot of limitations. But is it really worthless enough to be completely discarded from our diagnostic portfolio?

Urethral profilometry clinical value

In correlation with anamnesis, patient's symptoms and the question of urodynamics, urethral profilometry can be a valuable supplement to our diagnostic process. It is crucial to correctly choose the patient or clinical situations in which it can be useful. For example, in SUI, it is not valuable, as it can rarely change the diagnosis or treatment pattern. In SUI, the key urodynamics parameters are Valsalva, cough leak point pressures (VLPP / CLPP) and post-void residual. For suburethral sling implantation, the length of the urethra can be easily and non-invasively assessed by sonography. In overactive bladder (OAB), unless it is secondary to bladder outlet obstruction, the intraurethral pressure measurement is of no significance for implementing the therapy either. Therefore, for this vast number of patients with the most common LUTS, profilometry, apart from its reproducibility, is really neither needed nor useful. However, we must remember that there is a range of symptoms related to impaired urethral function.

In 2% of patients with SUI, urethral instability is the only, and in about 12%, a coexisting cause of urinary incontinence, and it can be present in as many as 56% of patients with OAB syndrome [27,30]. Urethral instability is defined as a drop in intraurethral pressure of 15 to 25 cm H20 or 1/3 of the maximum value and clinically manifested by leakage of urine without a feeling of urgency.

In 70 to 80% of patients with pelvic pain syndrome, a component of pelvic floor hyperactivity is present. In 17% of patients with voiding dysfunction, the underlying cause is poor sphincter relaxation, and in 42%, bladder outlet obstruction (BOO) [31]. Functional BOO, which is either hyperactivity, dyssynergia, or poor relaxation, is one of the main reasons for dysfunctional voiding and secondary bladder overactivity in women without pelvic organ prolapse. It can be successfully treated with botulinum injections [32]. This can be perfectly diagnosed with urethral profilometry.

The above examples are clinical situations where urethral profilometry is an essential part of the diagnostic pattern, vital for implementing causal treatment.

Discussion

Lower urinary tract symptoms concern about 60% of women worldwide. [33]. Almost 30% of the symptoms concern the voiding phase, which is possibly connected to impaired urethral function. The symptoms' characteristics and intensity change with age, parity, body mass, and other factors. However, a vast number of women are affected by these troublesome symptoms, lowering their quality of life, self-esteem, social, professional, and family life. Moreover, the average time from first symptoms to correct diagnosis is 7 to 9 years. During this time, patients suffer the symptoms of withdrawing from different aspects of life and everyday activities. This difficult situation is exacerbated by difficulty in communication. Only about 25% of women report their urogynaecological complaints to their doctor [34]. On the other hand, only 4% to 16% of primary care doctors actively discuss the issue of pelvic floor symptoms [35]. Furthermore, more than 60% of specialists are not able to interpret the results of a urodynamic examination, 43% do not even perform urethral profilometry, and only 9% do so.

The result of the main profilometric parameter – MUCP – affects the decision on the technique used to operate on a patient with urinary incontinence. Thus, not using this valuable diagnostic tool in clinical practice seems to worsen the therapeutic approach in patients undergoing surgical treatment [36].

There are a few sources of uncertainty surrounding urethral profilometry. They result from both the anatomy and function of structures under examination as well as from the examination technique itself. Patient factors should be taken into account when interpreting the examination. The whole clinical picture should be interpreted when making therapeutic decisions. One must remember that additional tests are only a part of the case and serve to help the clinician confirm or exclude particular pathologies and decide what therapeutic method to use. The technique can be improved by using multichannel catheters and special sensitive software and by standardizing the examination technique. One cannot forget about the limitations on the therapist's side – the inability to either perform correctly and to interpret and exploit the data obtained from the examination underlies the depreciation of a given diagnostic method.

Conclusions

To summarize, the authors would like to emphasize that urethral profilometry, despite its limitations, is a valuable diagnostic tool. Correct patient selection, awareness of the data that can be obtained, and the ability to use them in clinical practice, as well as correct technical execution, are essential factors influencing the perception of the method and its clinical use. Developing new options, such as multichannel profilometry, is a way to improve its clinical value. Creating and adhering to a precise standard of examination will improve the repeatability and quality of data obtained. Thus, urethral profilometry should retain its established position in the portfolio of urogynaecological diagnostic tools.

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