Urethral Pressure Tomography

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MORITA, T. and TSUCHIDA, S. *Urethral Pressure Tomography*. Tohoku J. exp., 1984, **142** (4), 391-398 — A new method of examination whereby urethral pressure profiles are recorded from the anterior, right, posterior and left urethral walls and tomographically expressed has been devised. The system facilitates three-dimensional delineation of the functional morphology of the urethra, requires no more time and work than dose the conventional urethral pressure profile study, or causes no pain in the patient. Stereographic depiction of the continence mechanism of the bladder neck and the function of the external urethral sphincter was achieved by the method, and the degree of urethral oppression was assessed by application of this urethral pressure tomography in patients with prostatic hypertrophy. ——— urethral pressure profile ; three-dimensional expresion

Methods for morphological observation of the urethra include endoscopy, urethrography, ultrasonography, etc., and the urethral pressure profile technique (UPP) (Brown and Wickham 1969) has been developed as a means of assessing the function as well as the morphology of the entire length of the urethra. However, endoscopy lacks more or less in objectivity of findings and does not permit assessment of the urethral function, and the rest of the procedures facilitate observation of only one aspect of the morphology and/or function of the urethra. With the recent progress in anatomical study of the urethra, furthermore, it has become evident that the urethra has a muscular architecture asymmetrical in antero-posterior direction. Thus it is now to be questioned what the UPP really depicts. A new method of examination whereby pressure profiles are recorded separately in 4 radial directions from the urethral wall and tomographically displayed via a computer has been devised at this department. This report describes the urethral pressure tomography.

MATERIALS AND METHODS

The principle of the procedure is shown in Fig. 1. Ten to 12 Fr. 4-channel polyethylene catheters with 4 eyes arranged at angles of 90 degrees on the same circumference near the tip were made for trial (Fig. 2). The catheter was passed into the urethra and then gradually drawn out at a rate of 25 mm/min with continuous physiological saline infusion into its all 4 channels at a flow rate of 2.0 ml/min, making sound recording of UPPs of the anterior, right, posterior and left walls of the urethra on a data recorder (Fig. 3). The UPPs were corrected on a computer by reference to a correction pressure of 10 cmH₂O puffed to the

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Fig. 1. Diagrammatic illustration of the stereographic urethral pressure profile recording system.

Fig. 2. Four-channel polyethylene catheter with eyes, 1 mm in diameter, arranged at angles of 90° on the same circumferential plane.

data recorder and displayed on a video screen as true UPPs at all 4 regions with the vesical pressure set at zero level (Fig. 4). The 4-channel UPP records were sliced on the computer at intervals of 5 mm from the site possibly representing the neck of the bladder where the intraurethral pressure curve might rise first, and computed tomograms at consecutive sites were drawn on an X-Y plotter (Fig. 5). The urethral pressure tomograms were expressed as octagons utilizing median values for pressure at respective sites so as to mimic the actual transectional profile of the urethral lumen.

Urethral pressure tomograms were recorded from 3 female mongrel adult dogs with the

Fig. 3. Parallel urethral pressure profiles of the anterior, right, posterior and left walls of the tract.

Fig. 4. Parallel urethral pressure profiles corrected according to a pressure correction factor and with the bladder pressure set at zero level, and slice lines.

empty bladder and after intravesical infusion with 150 ml of physiological saline, to assess the function of the bladder neck and proximal urethra during storage of urine. The recording was carried out on the animal maintained under anesthesia with α -chloralose, 20

Fig. 5. Urethral pressure tomograms and parallel urethral pressure profiles in 4 radial directions, drawn on an X-Y plotter.

mg/kg/hr, after induction with 15 mg/kg of thiamylal sodium. To evaluate the function of external urethral sphincter, urethral pressure tomography was performed before and after pudendal nerve block with local injection of 10 ml of 5% procaine in a patient with neurogenic bladder complaint of dysuria and urinary incontinence. In addition, 2 patients with prostatic hypertrophy in whom the exact site of enlargement of the gland had been determined by echography were also subjected to urethral pressure tomography to examine the morphology of the urethra.

RESULTS

The pressure error was less than 1.0 cm H₂O at an infusion rate of 2.0 ml/min saline solution into each of the 4 channels of the catheter. The response time estimated on 50 cm H₂O pressure was less than 0.1 sec for every lumen of the catheter during an infusion at the rate of 2.0 ml/min.

Urethral pressure tomograms were recorded from 3 female mongrel adult dogs (I, II and III) with the empty bladder and when the bladder was filled by infusion with 150 ml of physiological saline. Essentially the same tomographic patterns were observed in all 3 dogs. Representative tracings and tomograms obtained in dog II are shown in Figs. 6a and 6b. It can be seen that, in the neck of the empty bladder (Tomogram 2 in Fig. 6a), the pressure rises early in the posterior wall and then in the anterior and both lateral walls. When the bladder was filled, the neck (Tomogram 2 in Fig. 6b) showed almost the same pressure in the posterior wall as

Fig. 6a : Urethral pressure tomograms, on the empty bladder, from a female adult dog.
The numbers in tomograms correspond to those assigned to slice planes.

b : Urethral pressure tomograms, on the filled bladder, from a female adult dog.

that in the neck of the empty bladder while the anterior wall had a greater pressure, indicating that it was more strained than other parts of the urethral wall. It can also be clearly noted that the external urethral sphincter exhibited greater tension when the bladder was filled (Tomograms 6 to 7 in Fig. 6b) than when the bladder was empty (Tomograms 6 to 8 in Fig. 6a).

A male patient, aged 70 years, admitted to this hospital because of dysuria was diagnosed as having normal function of the urinary bladder and dyssynergic hyperactivity of the urethral sphincter on urodynamic study. Despite transurethral resection of the bladder neck and prostate, the dysuria persisted and a mild

Fig. 7a: Urethral pressure tomograms from a patient with neurogenic bladder.

b: Urethral pressure tomograms from the patient after right pudendal nerve block.

Fig. 8. Urethral pressure tomograms from a patient with prostatic hypertrophy.

incontinence developed. Urethral pressure tomograms of the patient obtained at this stage revealed abnormally increased pressure on the right side of the external urethral sphincter (Tomograms 4 to 6 in Fig. 7a). Fig. 7b shows data obtained after right pudendal nerve block. The pressure in the external urethral sphincter became virtually equal on both lateral walls (Tomograms 4 to 6 in Fig. 7b), and the patient became substantially relieved of dysuria and incontinence.

Urethral pressure tomograms of a 74-year-old patient with a complaint of dysuria, diagnosed as having hypertrophy of the right prostatic lobe by echography, are presented in Fig. 8. These clearly depict significantly increased pressure on the right wall of the urethra from the bladder neck to the external urethral sphincter (Tomograms 2 to 8).

DISCUSSION

There has been practically no means for three-dimensional assessment of the morphology of the urethra in the clinical practice. Morphologic observation of the urethra, indeed, can be accomplished by such procedures as cystoscopy, ultrasonography and radiographic examination, but these methods have disadvantages of lacking more or less in objectivity of findings and of permitting evaluation of only one aspect of morphology and/or function of the urethra. The urethral pressure profile technique (UPP) (Brown and Wickham 1969) which has become extensively applied as a means of evaluating urethral function through the entire length of the tract has been increasingly bereft of its diagnostic significance since recent studies suggested disparity in muscular architecture between the anterior and posterior walls of the urethra. In view of the importance that would lie in the diagnostic approach by stereographic delineation of the intraurethral pressure distribution, the authors have developed a simple diagnostic procedure based on the principle of UPP whereby pressure profiles of the anterior, posterior and both lateral wall of the urethra are simultaneously recorded, which are then tomographically expressed by synthesis, on a computer, of each set of synchronous slices of UPPs into an octagonal plane. The system, though requiring the use of 4 pressure transducers, a conventional catheter withdrawer for UPP, 4 amplifiers for pressure measurement, a simple computer unit and an X-Y plotter, provides an incomparably greater quantity of information than does the conventional UPP. It has remarkable diagnostic usefulness in that it facilitates stereographic delineation not only of function but also of morphology of the urethra. The instant tomographic illustration of the intraurethral pressure distribution through the entire length of the canal represents an advantage which cannot be found with any of the currently available procedures. Experiments conducted to evaluate the urethral pressure distribution at the bladder neck when the bladder was empty and when filled, disclosed an noticeable increase of anterior wall pressure of the urethra on filled bladder, thus suggesting that the urethral anterior wall tonicity at the bladder neck may possibly play an important part in the

continence mechanism. As the procedure measures the intraurethral pressure of the right and left lateral walls of the tract separately through the external urethral sphincter, it seems to serve as a particularly useful means for evaluation of the effect of pudendal nerve block in the treatment of neurogenic bladder. The method has also proven to permit some diagnostic assessment as to degree of urethral oppression and as to which prostatic lobe is adenomatous to cause the oppression in patients with prostatic hypertrophy; hence applicability as a means of delineating the morphology of urethra in such cases. Studies aimed at modification of the computerized urethral pressure tomographic system into a more compact unit are in progress.

Reference

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