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Urethral pressure variations in healthy male volunteers

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Summary. Urethral pressures are usually considered to be static and only few authors have emphasized time-related pressure changes. We conducted a study on 10 healthy male volunteers, monitoring the urethral pressures at maximal urethral closure pressure, 2.5 cm proximal (bladder neck) and 2.5 cm distal (pars bulbosa) respectively over 30 min periods. At the bladder neck only sporadic waves were seen. At maximal clusure pressure alsmost permanent oscillations were found, the wavelenghts and amplitudes showing big differences. At the pars bulbosa 2 persons showed only sporadic oscillations and in 7 we found permanent pressure variations. The pressure variations are proposed to represent peristaltic activity with the ability of expelling the last drops of urine after micturition and posing a mechanical barrier to ascending microorganisms.

Key words: Urethral pressure variations – Urethral peristalsis

Introduction

Urethral pressure profilometry has been used in the male for the last two decades to assess the degree of prostatic enlargement [1, 13], and to diagnose strictures [4] and post-surgical sphincter mechanism lesions [5, 8]. The urethral pressure profile in the male has a presphincteric part which delineates the bladder neck region and prostatic part of the urethra, and a maximum on the profile which delineates the external sphincter. Distal to the profile maximum is the dynamically insignificant part in the normal urethra.

At an early point in the measurement of urethral pressures it was established that just distal to the maximal urethral closure pressure (MUCP) is the zone of high pressure response during coughing and squeezing. This part is attributed to the pelvic floor impact on urethral pressures. The resting pressure of urethra is supposed to reflect a summation of the mucosal vascular bed, smooth and striated muscles [11]. In the female it has been shown that the urethral pressures may vary in a rhythmical fashion [12]. The resting urethral pressure during continuous measurements undergoes significant variation the nature of which is still to be established [6, 7, 9]. The pressure variations have been described as intrinsic to the urethral musculature itself since they are unimpaired by sympathetic, parasympathetic and striated muscle blockade [6]. In the male it is generally unknown whether such pressure variations exist.

The present study was undertaken to answer the following questions, 1) were rhythmical variations present in the normal male urethra, 2) were these pressure variations present in all parts of the proximal urethra.

Materials and methods

Ten healthy male volunteers, aged 21–37 years were investigated. They were selected after exclusion of ongoing medication, a history of urinary tract disease and after negative screening for urinary tract infection.

After spontaneous flow measurements a catheter with two microtip transducers (Dantec 21K XX5F) with a fixed distance between the sensors of 2.5 cm were introduced into the urethra. Initially they were placed at MUCP and at 2.5 cm proximal to MUCP. After measurements at that position for 30 min the catheter was withdrawn so that the proximal sensor was placed at the MUCP and the distal sensor was 2.5 cm distal to the maximal pressure.

Simultaneously a needle electrode was placed in the anal sphincter for electromyographic (EMG) recording and the rectal pressure was measured by an open-side-hole catheter.

All tracings i.e. the two pressures from urethra, the rectal pressure and the anal sphincter EMG-activity was recorded on ink-recorder. All tracings were analysed manually by measurements of pressure wave amplitude and wave length for each well-defined pressure wave. In Fig. 1 the urethral measuring points together with the pressure profile and characteristic pressure tracings are depicted.

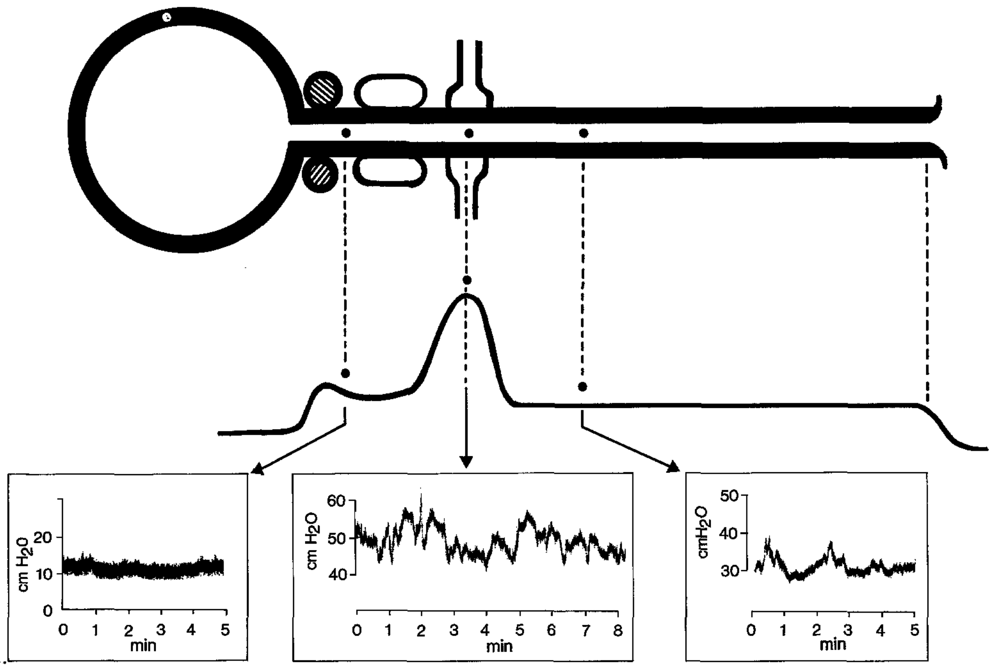

Fig. 1. Schematic presentation of bladder-urethra, pressure profile and typical pressure tracings from posterior urethra

Table 1. Ranges of amplitudes of pressure waves at 3 different points in the male urethra

Type of waves	Pressure amplitudes (cm H_2O)		
	Bladder neck	MUCP	2.5 cm distal to MUCP
Short (10–50 s)	1–10	1– 30	1–15
Mean (50–120 s)	1–11	5– 65	2–23
Long (120–400 s)	3– 8	8–110	5–30
Overall pressure ranges	6–32	13–150	2–48

MUCP = maximal urethral closure pressure

Results

In 1 volunteer the investigation was hindered bacause of displacement of the catheters. The remaining volunteers performed normal spontaneous micturition. The anal sphincter EMG activity was constant, showing no activity which could be related to pressure variations in urethra. Increased EMG activity was only observed during voluntary pelvic floor contraction. The rectal pressure was stable during all measurements.

The pressure waves from the 3 measuring points in urethra showed a consistent inter-individual pattern (Figs. 2 and 3). At the bladder neck 2.5 cm proximal to the MUCP an almost constant baseline pressure of 10–25 cm of H_2O was registered with very few pressure excursions unrelatable to pulse and respiratory excursions. At the 2 other measuring points at the MUCP and 2.5 cm distally there was no essential baseline pressure. In nearly all tracings from MUCP and 2.5 cm distally the pressure was found to be under constant undulation, with the amplitudes at MUCP being high. On rare occasions periods of stable pressure were encountered showing a baseline pressure of 50–80 cm H_2O at the MUCP and 10–25 cm H_2O 2.5 cm distal to the MUCP.

With pulse and respiration synchroneous pressure excursions could be registered at all 3 measuring points most pronounced at the bladder neck and at the point of MUCP and to a lesser degree 2.5 cm distally (Fig. 4). Only waves with peak-to-peak interval more than 10 s were analyzed and the single excursions were classified as short, intermediate or long based on periods of 10–50 s, 50–120 and 120–140 s (Table 1). Within the same subject the pressure waves were not of the same

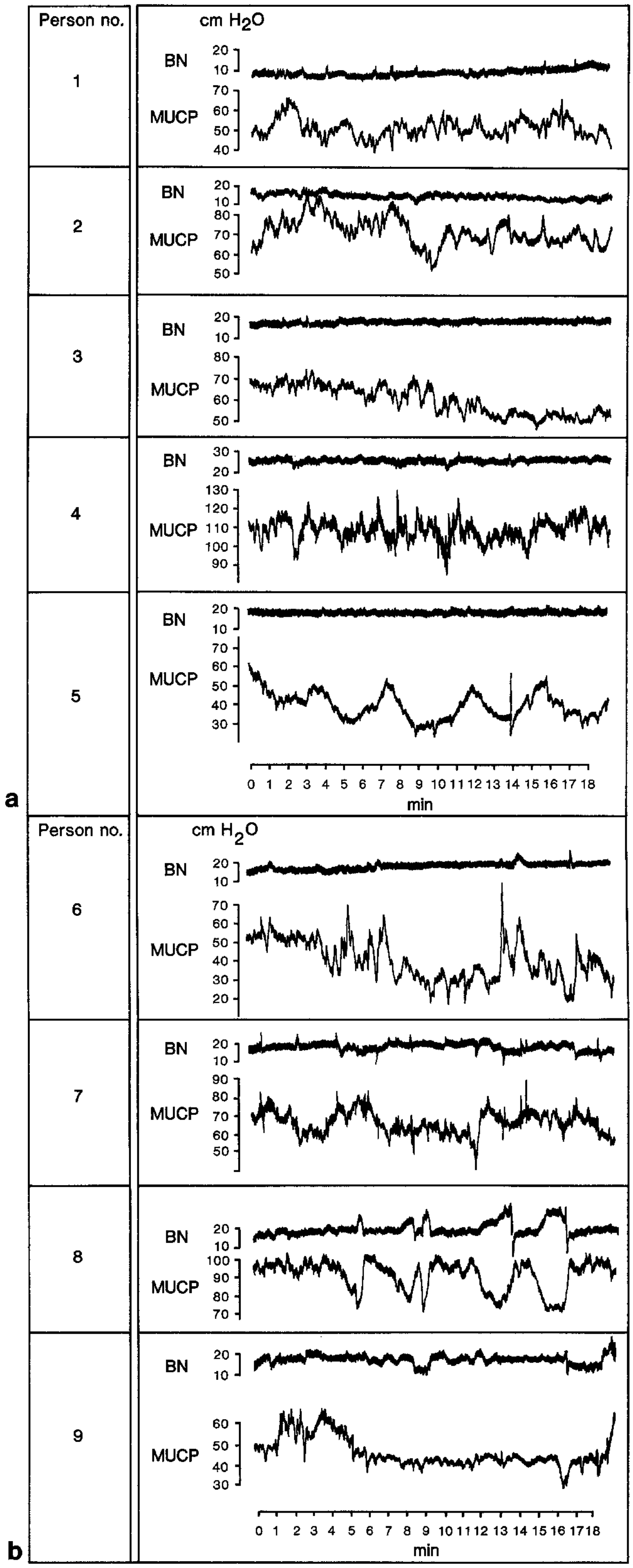

Fig. 2a and b. Pressure tracings from bladder neck (BN) and maximal urethral closure pressure (MUCP)

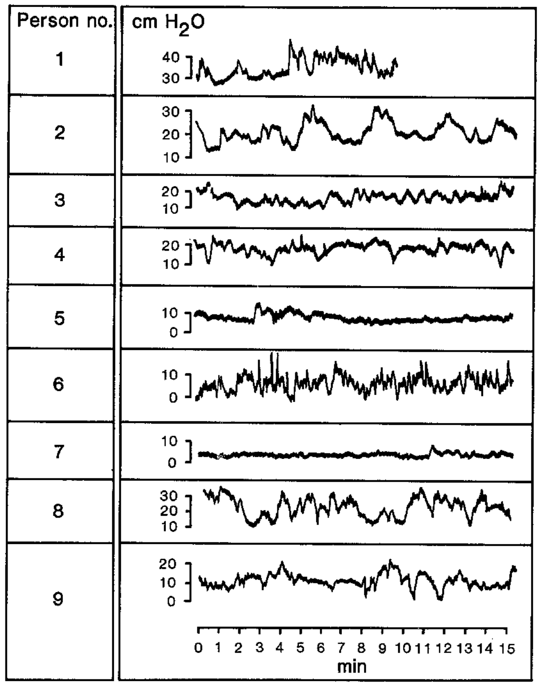

Fig. 3. Pressure tracings from urethra, 2.5 cm distal to MUCP

character at the MUCP and in the pars bulbosa. We found that the MUCP tracings were mainly dominated by waves of high amplitude and long wavelenght, while the tracings from the pars bulbosa were dominated by waves with small amplitude and short wave length.

The bladder neck

A regular pattern of pressure variations was not found although sporadic oscillations were seen (Fig. 2). In 3 volunteers we only found pressure waves related to pulse or respiration. In 5 of the volunteers the pressure at the bladder neck showed excursions of 7–12 cm H_2O. One patient (no. 8) had pressure variations of 26 cm H_2O at the bladder neck where the pressure ranked between 6 and 32 cm H_2O. The almost regular pressure waves observed in this person were accompanied by significant simultaneous pressure drops at the MUCP. Neither of the other 8 persons showed any correlation between the pressure waves at the bladder neck and at the MUCP.

MUCP

At the MUCP rhytmic pressure oscillations were registered in all the volunteers (Fig. 2). The pressure at

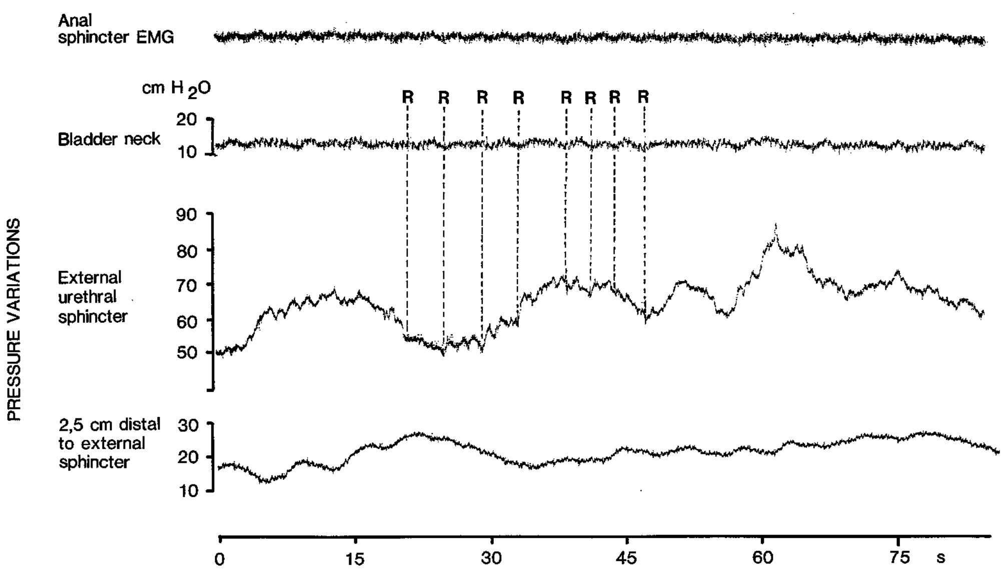

Fig. 4. Respiratory influence on urethral pressure. Pressure variations at 3 different points in urethra of the male

the MUCP showed major variations with the lowest pressure at 13 cm H_2O and the highest at 150 cm H_2O. The low pressure was measured during sleep and showed a spontaneous increase on arousal without manipulation of the catheters. A baseline pressure at the MUCP was not to be estimated except for two volunteers (no. 3 and 9) where a period of 8–10 min showed stability of the pressure. In all other persons ongoing and pronounced pressure waves were encountered throughout the total investigation. Some tracings were dominated by pressure waves with large amplitude and long wavelength (no. 2, 5, 8) while others were dominated by small-amplitude, short-wavelength waves (no. 3), or a mixture of both (no. 1, 4, 6, 7 and 9).

Pars bulbosa urethrae (2.5 cm distal to the MUCP)

Pressure waves were observed in all volunteers at that point (Fig. 3). The pressure pattern showed variations; 2 subjects showed only small and sporadic pressure waves (nos. 5 and 7), while one had almost regular waves of high amplitude and long wave length (no. 2). Two had regular short duration waves with small amplitude (nos. 3, 4). In four tracings we found a mixture of these pictures. The lowest pressure measured at that point in urethra was 2 cm H_2O and the highest 48 cm H_2O.

Discussion

The term "urethral peristalsis" was introduced by Mayo et al. in 1974 [6] to describe urethral contractile activity observed in female dogs. Their elegant experiments were performed by use of 4 canal catheter and contractions with pressure amplitudes of 60–100 cm H_2O were demonstrated. As the contractions were not influenced by pharmacologic blockade of autonomic nerves and striated muscles the suffix "intrinsic" was added.

Investigations of human females with irritative symptoms in lower urinary tract have shown pressure variations of 10–40 cm H_2O at MUCP, and urethral instability has been suggested as a diagnosis. This however is conflicting the observations made on healthy female volunteers [12] who showed regular pressure variations of 8–75 cm H_2O at MUCP. Thus evidence is accumulating that regular pressure variations are a part of normal urethral physiology with the implication that the diagnoses "unstable urethra" has to be revised.

Concerning the male urethra no attempt has hitherto been made to demonstrate urethral pressure-time relations. The pressure variations demonstrated in our study is thought to mirror a physiological phenomenon but, these variations my be purely artefactual. Our investigations were performed with micro-tip-transducer catheters in contrary to the Brown and Wickham method usually used. A direct comparison between the two methods has shown the two methods to be in accordance with each other, the open end system being more sensitive to technical disturbances (air bubbles, coagula etc.) and to changes in withdrawal rate [3].

Anterior orientation of the micro transducer within the urethra has been shown to give significant higher pressure readings than lateral orientation [2]. This however cannot explain the time related pressure variations observed in our study. The mere presence of a catheter in the urethra may induce some pressure changes as also seen while introducing it. At that time pressures of 150–250 cm H_2O were observed at MUCP in all volunteers and urethral discomfort was apparent at that time. After $^1/_2$–2 min however no discomfort was registrered and the pressures fell to oscillate around a steady state, as shown in Figs. 2 and 3.

Regarding the pressure variations as true changes in urethral pressure, other factors than urethral musculature could be responsible. In the anal canal similar pressure variations are attributed to the smooth muscle sphincter. Different frequencies in different parts of the anal canal have been observed, the distal part showing highest frequencies indicating retrograde peristaltic activity [10]. The rectal pressure tracings in our study showed only sporadic and minor oscillations without relation to the urethral pressure tracings. Also the anal sphincter EMG-activity was devoid of such activity which might explain the urethral pressure variations.

The significance of urethral pressure variations still is obscure. Mayo et al. [6] were able to demonstrate an antegrade propagation of the pressure waves in dogs, but hitherto no clear evidence in favour of antegrade propagation in humans has been presented. In the human male however the expulsion of semen is conveyed through antegrade urethral peristalsis, and it is hard to believe the peristalsis to be in different directions in different situations. The functions of antegrade peristalsis in the resting male urethra could be 1) expulsion of the last drops of urine after micturition and 2) a mechanical barrier to ascending microorganisms.

Urethral pressure-time tracings have been obtained from a number of males with bladder neck dysfunction. No overt discrepancies between these and the normal males with regard to urethral pressure variations have been observed, but electronic analysis is proposed for a more thorough investigation.

References

1. Abrams PA, Torrens MJ (1977) Urethral pressure profiles in the male: an analysis of 280 patients. Urol Int 32:137
2. Anderson RS, Shepherd AM, Feneley RCL (1983) Microtransducer urethral pressure profile methodology: variations caused by transducer orientation. J Urol 130:727
3. Asmussen M (1975) Urethro-cystometry in women. Thesis, University of Lund, Sweden. Studentlitteratur
4. Brown M, Wickham JEA (1969) The urethral pressure profile. Br J Urol 41:211
5. Gleason DM, Reilly RJ, Bottaccini MR, Pierce MJ (1974) The urethral continence zone and its relation to stress incontinence. J Urol 112:81
6. Mayo M, Heine JP, Hinman F (1974) Intrinsic urethral peristalsis. Invest Urol 12:1
7. Mayo M, Hinman F (1972) Spontaneous myogenic activity and viscoelastic properties of the urethra. Surg Forum 23:524
8. McGuire E (1977) Combined radiographic and manometric assessment of urethral sphincter function. J Urol 118:632
9. Plevnik S, Janez J (1983) Urethral pressure variations. Urology 21:207
10. Read NW, Bannister JJ (1985) Anorectal manometry: Techniques in health and ano-rectal disease. In: Henry MM, Swash M (eds Coloproctology and the pelvic floor. Pathology and management. Butterworths, London, p 65
11. Reed T, Andersson KE, Asmussen M, Hunting A, Ulmsten U (1980) Factors maintaining the intraurethral pressure in women. Invest Urol 17:343
12. Sǿrensen S, Kirkeby HJ, Stødkilde-Jørgensen H, Djurhuus JC (1986) Continuous recording of urethral activity in healthy female volunteers. Neurourol Urodyn 5:5
13. Turner-Warwick R (1979) A urodynamic rewiev of bladder outlet obstruction i the male and its clinical implications. Urol Clin North Am 6:171

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