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Urethral pressure – which one?

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Summary. Urethral pressure was investigated by a method which allowed simultaneous measurement of the cross-sectional area. In healthy women a pressure range of 25–140 cm H_2O was recorded at one urethral site as a response to the circumstances under which the measurement was performed. The pressures obtained were related to the degree of urethral distension and to the time after the change in distension. Measuring urethral pressure at one specific degree of distension results in one specific pressure value according to the dimensions of the measuring probe. However, this specific pressure value cannot be considered to supply more information on urethral sphincter function than any other pressures included in a range which can be obtained by changing the circumstances under which the measurement are carried out. More provocative methods of pressure measurement which simulate some of the physiological conditions of the urethra may provide more information on sphincter efficiency.

Key words: Urethral pressure – Cross-section area – Urethral distension – Sphincter efficiency

Pressure measurement has been widely used to characterize the urethral closure function [10, 13, 20]. Using a conventional perfusion technique or microtip catheters a number of variables such as anatomical and funtional length, maximum pressure and maximum closure pressure have been described. Urethral pressure parameters have shown great overlap between healthy females and patients with urethral pathology, even though statistically significant differences have been demonstrated in some studies [5, 9, 20, 21]. Accordingly, conventional urethral pressure measurement has emerged to be of limited value as a diagnostic aid and in resolving the pathophysiology of urethral malfunction. This does not mean, however, that urethral pressure per se is without importance. On the contrary, it is assumed to be of paramount importance for the continence mechanism. Therefore, increasing the amount of information obtained from appropriate measurements should provide more information about normal and pathological conditions. Using conventional techniques pressure is measured at one specific degree of distension determined by the measuring probe and urethral pressure increases with increasing distension [2, 11, 12, 18]. Furthermore, recording of urethral pressure during distension leads to a transient increase in pressure. Likewise, urethral pressure is low during closing [2, 11, 12]. Consequently, measuring urethral pressure at different degrees of distension and during changes of distension will reveal a range of pressures. Such procedures may provide more information on the urethral sphincter mechanism as they simulate some of the physiological conditions under which the urethra functions. The focus of this study is the influence of distension on the pressure in the female urethra and its implications for the applicability of conventional measuring techniques.

Materials and methods

A specially developed probe, which has been described previously, was used for the measurements [4, 16]. The probe enabled distension of the urethra by inflation of a small, fully deformable balloon mounted on the catheter. The cross-sectional area (CA) of a 2-mm-long slice of the balloon was measured according to the field gradient principle. Simultaneous pressure was recorded either by an external pressure transducer [4] or by a microtip inside the ballon [16] providing a balloon CA of 0.07–0.79 cm^2 and 0.13–0.79 cm^2, respectively.

Thirty-one female volunteers with a median age of 42 years (range 29–63 years) were investigated. None of the women had present or previous urogynaecological complaints. They were all examined in the supine position with an empty bladder. At each site of measurement the urethra was subjected to stepwise inflation and deflation of the balloon (Fig. 1). Measurements were carried out either at intervals of 0.5 cm along the urethra or at the bladder neck, in the high-pressure zone and distally in the urethra. At the same time, measurement of the bladder pressure and EMG from the pelvic floor were performed.

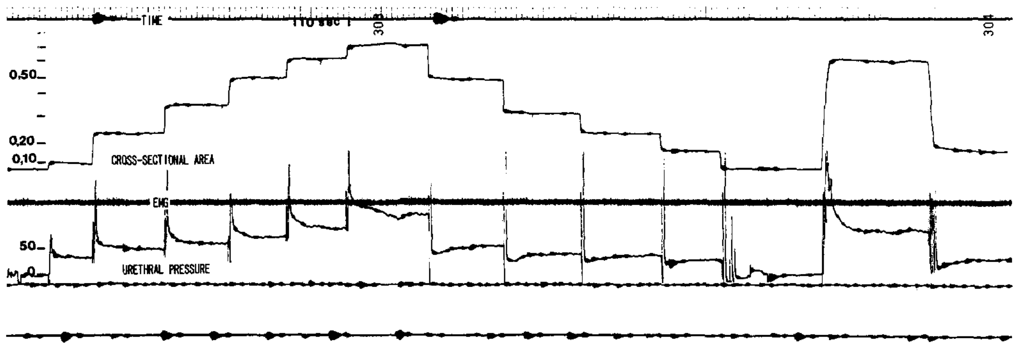

Fig. 1. Recording of related values of urethral pressure and cross-sectional area during stepwise inflation and deflation of the balloon. The measurement was obtained from a healthy 42-year-old female (same person in Figs. 1–7)

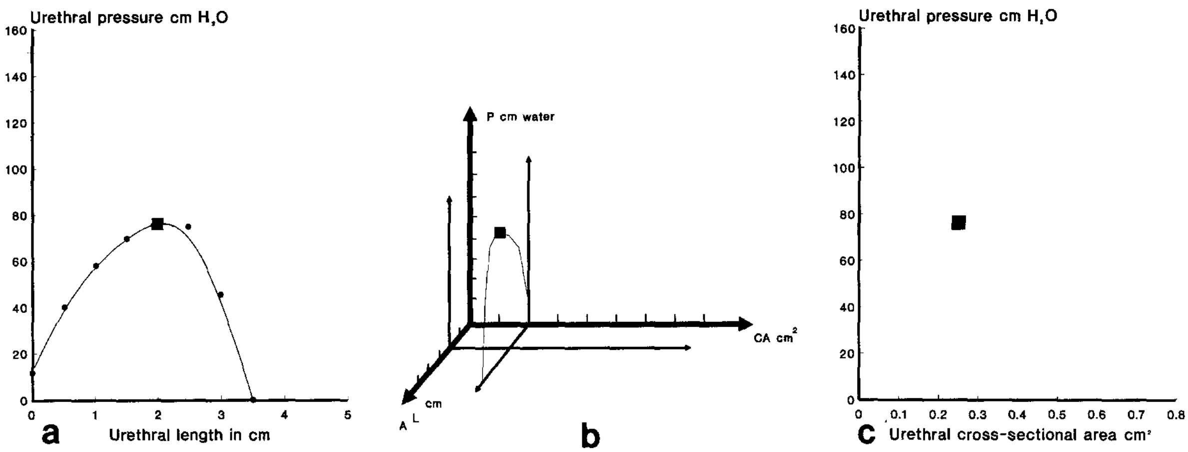

Fig. 2. **a** Resting urethral pressure profile obtained with a cross-sectional area of the measuring probe of 0.25 cm^2. The *black square* indicates the maximum pressure obtained 2 cm from the bladder neck. **b** Three-dimensional diagram of the relation between (1) urethral pressure (*P*), (2) urethral distension measured as cross-sectional area (*CA*), and (3) site of measurement along the anatomical length (*AL*) of the urethra. The *black square* indicates the same position as in **a**. **c** Related urethral pressure and cross-sectional area measured at the same site (2 cm from the bladder neck) as in **a** and **b**. The *black square* indicates the same degree of distension as in **a** and **b**

Results

Measurements from one female volunteer are used to illustrate in detail the range of pressure recorded at one site of measurement (Figs. 1–7).

During volume induction of the balloon the urethral pressure increased rapidly and then decreased to a new equilibrium pressure given by the CA of the balloon (Fig. 1). Figure 2A demonstrates the resting urethral pressure obtained by the balloon catheter at a CA of 25 cm^2, which is 3–4 times the CA of a conventional profile catheter but within the physiological range of urethral distension [2]. Figure 2B presents the pressure profile in a three-dimensional diagram where the urethral CA is added. As shown in Fig. 2C, urethral pressure recorded with one specific dimension of the measuring probe gives one specific pressure at a given site of measurement. The diagram in Fig. 2C represents the relation between urethral pressure and CA at one site of measurement. The same site is used in Figs. 3–5.

Figure 3 shows the urethral equilibrium pressure obtained by a stepwise increase of the CA. In Fig. 4 the stepwise decrease of CA has been added. Figure 5 includes the pressure responses 0.5 s after increase and decrease of CA. When these pressure measurements are performed throughout the entire urethra a whole spectrum of pressure profiles appears (Fig. 6).

Figure 7 demonstrates the range of pressures along the urethra obtained in 30 healthy females.

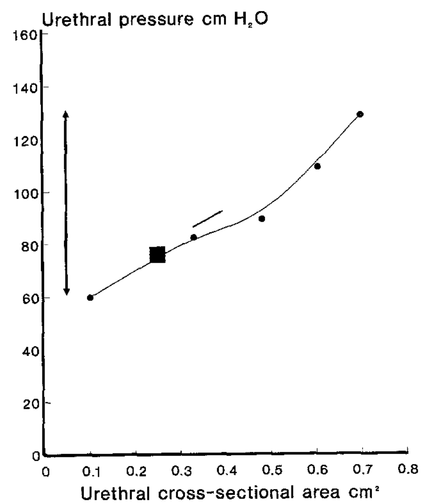

Fig. 3. Urethral pressure recorded during stepwise distension 2 cm from the bladder neck. *Black square* indicates the same values as in Fig. 2. *Double arrow* indicates the range of pressure obtained

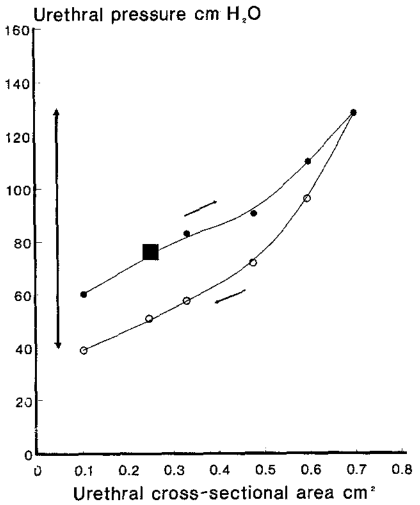

Fig. 4. Urethral pressure recorded during increasing (•—•) and decreasing (O—O) distension in a stepwise manner. The *black square* indicates the same values as in Fig. 2. *Double arrow* indicates the range of pressure obtained

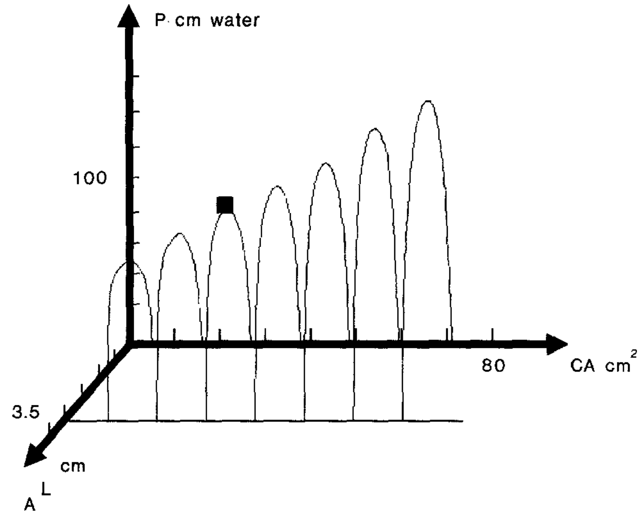

Fig. 6. Three-dimensional diagram of urethral pressure profiles obtained with increasing cross-sectional area (*CA*) of the measuring probe. *AL* represents the urethral anatomical length. The *black square* indicates the same values as in Fig. 2

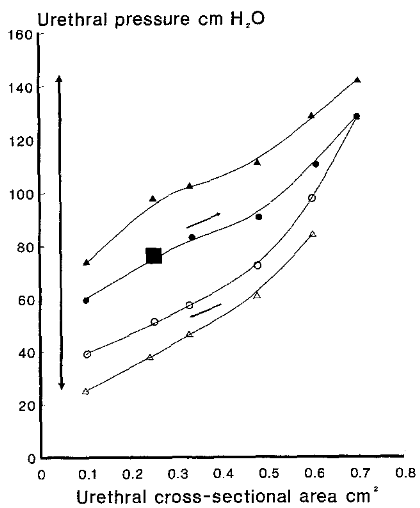

Fig. 5. Urethral pressure recorded upon increasing and decreasing distension in a stepwise manner. The pressures were measured 0.5 s after an increase in distension (▲—▲), at equilibrium (•—•) and (O—O), and 0.5 s after a decrease in distension (△—△). The *black square* indicates the same values as in Fig. 2. The *double arrow* indicates the range of pressure obtained.

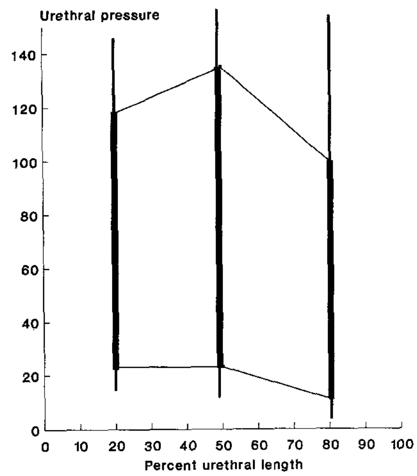

Fig. 7. Ranges of urethral pressures obtained in 30 healthy female volunteers. *Thick bars* indicate the pressure ranges of the median values. *Thin bars* indicate the total pressure ranges recorded

Discussion

When pressure is recorded using conventional urethral profilometry, one specific pressure is obtained at a given site of measurement. It can be well standardized with a fair degree of reproducibility [6, 17]. However, limited information about normal functional conditions is gained from a resting pressure profile. This study demonstrates a whole spectrum of urethral pressures according to the measurement conditions. There is no evidence available that any of these pressures is more representative of the urethral closure function than the others.

The method used in this study is able to produce a series of pressures in relation to the degree of urethral distension at a given site of measurement with a high degree of reproducibility [15]. This relation, which may also be time dependent, provides new information about the physiology and pathophysiology of the urethral sphincter function. It is able to differentiate between urethral rigidity and hyperlaxity and thereby differentiate between normal subjects and patients with genuine stress incontinence and even among different groups of patients with genuine stress incontinence [11–13]. The relation between urethral pressure and CA may also supply information on intra-and extramural structures, as it correlates with the relation between length and tension.

The measurements were carried out with the women at rest. However, the pressure variations due to striated muscular contractions and/or passive pressure transmission during stress episodes increase the range of pressures obtained. Analyses of these factors may be important in the assessment of the urethral closure function [3, 8, 14].

The influence of spontaneous urethral pressure variation has not been taken into account in previous studies [19].

It is not our purpose to advocate the specific probe used in this study, as other methods are available [7, 18]. However, for evaluation of the urethral sphincter mechanism a urethral pressure obtained at one specific degree of distension provides only limited information. Consequently, a reproducible method delineating related pressure responses to varying degrees of distension should be preferred, as it simulates some of the physiological conditions under which the urethra functions, hereby increasing the amount of information on urethral sphincter efficiency.

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