

# Standardisation of Urethral Pressure Measurement: Report from the Standardisation Sub-Committee of the International Continence Society

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## INTRODUCTION

Urethral pressure measurements are used to assess urethral closure and voiding function. The lack of general agreement on an explicit definition of urethral pressure and standardisation of the methodology for measurement has limited the utility of urethral pressure measurements. This report defines urethral pressure and recommends standards for measurement methodology to facilitate communication between investigators and to improve the quality of clinical practice and research. The document can be integrated with earlier reports of the International Continence Society (ICS) Committee on Standardisation with special reference to the collated 2002 report [Abrams et al., 2002] and the ICS recommendations on good urodynamic practice [manuscript in preparation].

## DEFINITION OF URETHRAL PRESSURE

Urethral pressure is defined as *the fluid pressure needed to just open a closed (collapsed) urethra* [Griffiths, 1985]. This definition suggests that the urethral pressure is similar to an ordinary fluid pressure, i.e., is a scalar (does not have a direction) quantity with a single value at each point along the length of the urethra.

The concept of urethral pressure is only useful if the urethra collapses easily at attainable pressures to zero cross-sectional area, as is normally the case. The use of a catheter introduces a non-zero cross-sectional area (given by the probe) and changes the natural shape of the lumen. The effect on the measured urethral pressure is small for highly distensible/collapsible tubes [Griffiths, 1985].

Microtip or fiber-optic catheters do not measure the urethral pressure directly; they measure the normal stress component on the surface of the transducer. This stress is due to the interaction between the urethral tissue and the transducer surface. It depends in part on the stiffness of the catheter and the form of the probe. It may cause directional variations in the measured "urethral pressure" when the catheter is rotated within the lumen. From the definition it follows that directional variations are artefacts.

## MATERIALS AND METHODS

Urethral pressures can be measured at individual locations within the urethra (point pressures) or along the whole length of the urethra (urethral pressure profile). Registration may be over a short period of time or over a protracted period (ambulatory). Measurement can be carried out at different bladder volumes and different subject positions (1) with the subject at rest, or (2) during coughing or straining. "Pressure measurements made in the urethra during the process of voiding yield an ordinary fluid pressure, not the urethral pressure defined above."

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The intravesical pressure ( $p_{ves}$ ) is by definition piezometric. The simultaneous recording of both urethral ( $p_{ura}$ ) and intravesical pressure enables calculation of urethral closure pressure, i.e.,  $p_{ura} - p_{ves}$ .

### Specify Parameters

Reports of urethral pressure measurement should specify the (1) type of measurement (point, profilometry, ambulatory), (2) period of time over which the measurement was recorded, (3) constant (given by the probe) or variable cross-sectional area of the urethra (i.e., inflation of a balloon), (4) patient position, (5) bladder volume, (6) maneuvers (coughing, Valsalva, other), (7) withdrawal speed (for profilometry), (8) infusion medium and rate of infusion (for fluid perfused catheters), and (9) rate of pressure rise when perfusion is continued against blocked orifices (for fluid-perfused catheters). This rise is the maximum rate of increase of urethral pressure (cm H<sub>2</sub>O/s) that can be measured. When divided by the withdrawal speed, it yields the maximum rising gradient of urethral pressure (cm H<sub>2</sub>O/mm) that can be measured).

### Technique

Documentation of the technique used for urethral pressure measurements should specify (1) type of catheter, (2) size of catheter, (3) catheter material—flexibility, (4) orientation of a directional sensor, (5) sensor position fixation (for point pressures or during coughing/straining), (6) zeroing of pressure sensors, and (7) recording apparatus.

### Zeroing of Pressure Sensors

When using external transducers and fluid-filled catheters (superior edge of the symphysis pubis, piezometric), viscous pressure losses within the catheter should be allowed for when establishing the zero of pressure.

When using microtip transducers (atmospheric pressure; there is no fixed reference point) to calculate closure pressure, the difference in vertical height between the two microtip transducers should be taken into account. When calculating closure pressure by using multisensor microtips, any difference in vertical height between the “bladder” transducer and urethral transducer(s) should be taken into account, although this may be difficult in the clinical situation since the difference in height is difficult to estimate.

### Recording Apparatus

The type of recording apparatus should be described. Also the frequency response of the total system should be stated. Equipment with a sampling rate of 18 Hz can satisfactorily record cough-produced pressure changes in the urethra [Thind et al., 1994], provided this is not limited by other factors (see Specifics section, step 9).

### Methods of Measuring the Urethral Pressure

Catheters should be as thin and flexible as possible. Several methods are applicable, as follows.

#### *Infusion [Brown and Wickham, 1969] Method*

The measured quantity can be very close to the local urethral pressure, provided that the urethra is highly distensible [Griffiths, 1980]. If an aqueous liquid is used and the external pressure transducer is at the right level, piezometric urethral pressures are obtained.

#### *Balloon Method*

The balloon method involves a cylindrical balloon mounted concentrically on a catheter. The balloon requires pressure of *only* a few centimeters of water to be inflated to its maximum diameter. A balloon that is too long in comparison with the axial distances tends to average out differences in pressure along the length of the urethra as well as pressure variations. Urethral planimetry enables a more point-specific measurement (e.g., of a 2-mm-long segment of the urethra) when using a balloon [Lose et al., 1988]. A true hydrostatic pressure is measured. If the catheter is liquid-filled and the external pressure transducer is at the right level, piezometric pressures are obtained.

#### *Microtip/Fiber-Optic Catheters*

Weight or bending or inhomogeneities in urethral wall tissue can lead to a local directional tissue/transducer interaction, which will modify the desired urethral pressure signal. Thus the recorded quantity is a qualitative measurement, which emphasizes changes in pressure rather than absolute values. To minimize the directional artefacts, the catheter should be as flexible as possible (“like cooked spaghetti”). Failing this degree of flexibility, a lateral orientation of the (side-mounted) transducer is to be preferred as it minimizes bending. Placement of the microtip transducer inside a balloon enables measurement of a true hydrostatic pressure [Lose et al., 1988].

### Reliability

The investigator should provide reliability data or indicate their absence.

## CLINICAL MEASUREMENTS AND PARAMETERS

The parameters in common use are previously defined by the ICS Standardization Committee [Abrams et al., 1988]. At the present moment, the clinical utility of urethral pressure measurement is unclear. There are no urethral pressure measurements that (1) discriminate urethral incompetence from other disorders; (2) provide a measure of the severity of the condition; (3) provide a reliable indicator to surgical success,

and return to normal after successful intervention. Thus urethral pressure measurement is still first and foremost a research tool.

The urethral pressure and the urethral closure pressure are idealised concepts that aim to represent the ability of the urethra to prevent leakage. There is no doubt that the urethral pressure is of significant importance for the continence mechanism. However, it remains a challenge to define the optimal way to characterize the urethral closure mechanism in terms of pressures.

## REFERENCES

- Abrams P, Blaivas JG, Stanton SL, Andersen JT. 1988. The standardisation of terminology of lower urinary tract function. The International Continence Society Committee on Standardisation of Terminology. *Scand J Urol Nephrol Suppl* 114:5–19.
- Abrams P, Cardozo L, Fall M, Griffiths D, Rosier P, et al. 2002. The standardisation of terminology of lower urinary tract function. The International Continence Society Committee on Standardisation of Terminology. *Neurourol Urodyn* 21:167–78.
- Brown M, Wickham JEA. 1969. The urethral pressure profile. *Br J Urol* 41: 211–7.
- Griffiths DJ. *Urodynamics*. Bristol: Adam Hilger Ltd. 1980.
- Griffiths D. 1985. The pressure within a collapsed tube, with special reference to urethral pressure. *Phys Med Biol* 30:951–63.
- Lose G, Colstrup H, Sandager K, Kristensen JK. 1988. New method for static and dynamic measurement of related values of cross-sectional area and pressure in the female urethra. *Neurourol Urodyn* 6:465–76.
- Schäfer W, Abrams P, Liao L, Mattiasson A, Pesce F, Spangberg A, Sterling AM, Zinner NR, van Kerrebroeck P. 2002. Good urodynamic practices: Uroflowmetry, filling cystometry, and pressure-flow studies. *Neurourol Urodyn* 21:261–74.
- Thind P, Bagi P, Lose G, Mortensen S. 1994. Characterization of pressure changes in lower urinary tract during coughing with special reference to the demands on the pressure recording equipment. *Neurourol Urodyn* 13:219–25.