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A NON-INVASIVE METHOD FOR THE MEASUREMENT OF URETHRAL OPENING PRESSURES.

Hypothesis / aims of study

Urethral opening pressure (p_{uo}) is the minimum fluid pressure required to open the urethra during voiding. For a given intravesical pressure (p_{ves}) and an ideal fluid, urine flow rate is determined by p_{uo} and cross sectional area at the "flow controlling zone" (FCZ). The FCZ is located at the level of the pelvic floor in normal men and in the prostatic urethra in those with benign prostatic obstruction (BPO).

p_{uo} may be estimated during invasive pressure flow studies (PFS) by measurement of the vesical pressure at the start of flow ($p_{ves}Q_{beg}$). In practice vesical pressure is often lower at the end of flow and may represent a closer estimation to p_{uo}. This may be measured as the vesical pressure 10mls prior to the end of flow ($p_{ves}Q_{end}$). (1)

Theoretically it is possible to estimate p_{uo} directly using the technique of voiding urethral pressure profile (VUPP) measurement. During voiding, pressure falls along the urethra from bladder neck to distal urethra. The total available pressure is p_{ves}, which can be split into driving pressure (p_{dp}), converted into velocity, and p_{uo}, i.e. $p_{ves} = p_{dp} + p_{uo}$.(2)

Experimental work using a penile cuff suggests that the "knee pressure" ($p_{cuff,\ knee}$) taken from plots of flow rate against cuff pressure may give an estimate of p_{uo} (3).

We set out to test the hypothesis that "knee pressure" corresponds to urethral opening pressure as estimated from invasive PFS and VUPP.

Study design, materials and methods

Men with LUTS were recruited. Each patient underwent invasive PFS, simultaneous invasive PFS and cuff test and VUPP measurement. Invasive urodynamics were performed in accordance to the recommendations of the International Continence Society. A 6Ch double lumen Urethral Pressure Profile catheter (Mediplus, UK) was used throughout.

Cuff pressure vs. flow rate traces were analysed for the presence of a knee pressure (Fig1A).

Bland – Altman Limits of agreement plots have been used to compare knee pressures with $p_{ves}Q_{beg}$ and $p_{ves,}\ Q_{end}$, taken from invasive PFS, and with urethral pressures at bladder neck, prostate, pelvic floor and distal urethra as well as pressure gradients between these points measured using VUPP (Fig1B).

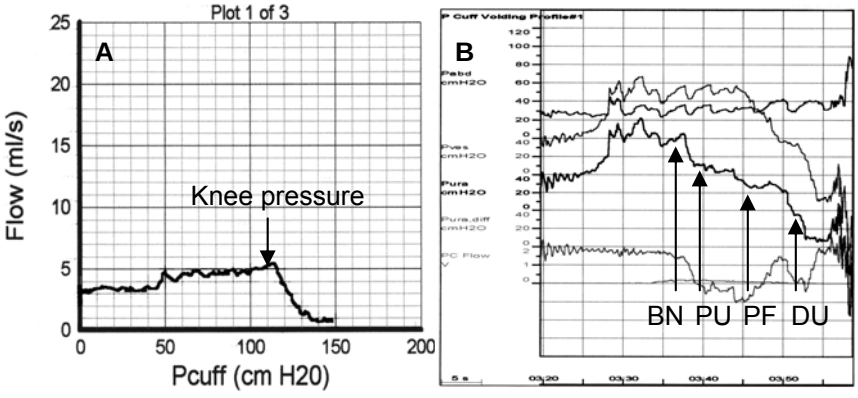

Figure 1.A. Plot of cuff pressure against flow rate, knee pressure indicated. B. VUPP trace showing pressure change from the bladder neck (BN) across the prostatic urethra (PU) and pelvic floor (PF) to the distal urethra (DU).

Results

From the traces of cuff pressure against flow, $p_{cuff,\ knee}$ was recorded. Of the 113 patients who successfully underwent simultaneous PFS and cuff test 103 (91%) produced an identifiable knee pressure. In those patients in whom a knee pressure was seen in more than one cuff inflation cycle then the highest value was recorded.

Theoretical urethral opening pressures were measured; vesical pressures at the start and end of flow $p_{ves}Q_{beg}$ and $p_{ves}Q_{end}$ were available for all 113 patients. In 23 patients an after contraction was seen at the end of voiding which would have given a falsely elevated value for $p_{ves}Q_{end}$, these values were therefore discounted.
After a third fill patients underwent VUPP measurement. 88 patients produced interpretable results.
Limits of agreement between $p_{cuff, knee}$ and urethral opening pressures derived from invasive PFS, and between $p_{cuff, knee}$ and urethral pressure measurements and pressure gradients derived from VUPP are shown in the table.

	$p_{cuff, knee} - p_{ves}Q_{beg}$	$p_{cuff, knee} - p_{ves, Q_{end}}$	$p_{cuff, knee} - p_{(bladder neck)}$	$p_{cuff, knee} - p_{(prostate plateau)}$	$p_{cuff, knee} - p_{(pelvic floor plateau)}$	$p_{cuff, knee} - \Delta p_{(bladder neck – prostate plateau)}$	$p_{cuff, knee} - \Delta p_{(bladder neck – pelvic floor plateau)}$	$p_{cuff, knee} - \Delta p_{(bladder neck – distal urethra)}$
Mean difference (cmH_2O)	-20.5	-3.2	-9.9	26.1	52.6	54.8	26.2	-16.1
95% confidence interval	-27.5 to -13.5	-12.2 to 5.9	-16.3 to -3.6	18.0 to 34.8	45.0 to 60.2	46.4 to 63.2	19.3 to 33.2	-23.6 to -8.5
SD(cmH_2O)	35.4	41.2	28.2	32.6	33.9	32.6	31.2	33.5
Lower limit of agreement (cmH_2O)	-91.4	-85.4	-66.4	-38.7	-15.2	-10.3	-36.1	-83.1
Upper limit of agreement (cmH_2O)	50.4	79.1	46.5	91.5	120.5	120.0	88.6	51.0

Interpretation of results

When $p_{cuff, knee}$ are compared with $p_{ves, Q_{end}}$ the 95% confidence levels of the mean difference include the value zero, representing equivalence. Thus there is evidence to suggest a statistically significant relationship between the two. This suggests that knee pressure may represent a method of measuring p_{uo}. However, in view of the wide limits of agreement $p_{cuff, knee}$ may not be a very precise measure for individuals.
From the VUPP measurements $p_{cuff, knee}$ lies consistently between the pressures measured at bladder neck and prostate. $p_{cuff, knee}$ is also slightly less than the total pressure change from bladder neck to distal urethra. If $p_{cuff, knee}$ does represent opening pressure, as suggested by the $p_{ves}Q_{end}$ comparison, then it would appear that the opening pressure component of the FCZ lies between the bladder neck and prostate, where pressure is falling rapidly, and may exist over a short distance that we are not able to measure using VUPP, rather than over a longer distance producing a plateau of pressure. This is a reasonable proposition as one would expect to see pressure changing across the FCZ.

Concluding message

Knee pressures measured using a penile cuff inflated during voiding may represent a non-invasive technique for the estimation of urethral opening pressure.

References
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