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COMBINATION OF NON-INVASIVE URODYNAMIC PARAMETERS FROM A SINGLE PENILE CUFF TEST FOR DIAGNOSIS OF BLADDER OUTLET OBSTRUCTION.

Hypothesis / aims of study

The penile cuff test is a recently developed non-invasive urodynamic investigation which relies upon automated inflation of a penile cuff to interrupt urine flow. The cuff pressure required to stop flow ($p_{cuff,int}$) provides an estimate of isovolumetric bladder pressure (1).
Two methods are established by which the cuff test can diagnose bladder outlet obstruction (BOO). First, $p_{cuff,int}$ can be plotted in conjunction with maximum urine flow rate on a non-invasive equivalent to the ICS nomogram (2). Alternatively, BOO can be diagnosed from the same cuff test using Sullivan & Yalla's Penile Compression-Release (PCR) index (3).
The aim of this study was to investigate the diagnostic value of combining non-invasive nomogram data (2) and PCR index (3) from a single cuff test into one diagnostic parameter, using ICS standard classification from invasive cystometry as the gold standard.

Study design, materials and methods

Ethical approval and informed written consent for the penile cuff test were obtained. Data from 116 men with lower urinary tract symptoms attending two UK Urology centres for invasive cystometry were analysed retrospectively.
Gold standard classification Each subject underwent conventional cystometry according to the ICS guidelines, and was classified as *obstructed* or *other* (*equivocal* or *unobstructed*) according to the provisional ICS nomogram.
The penile cuff test Each subject then underwent a penile cuff test (2), where we measured overall peak urine flow rate (Q_{max}, excluding surges), and cuff interruption pressure ($p_{cuff,int}$) for each cuff inflation. Where more than one cuff inflation was possible, we took the highest value of $p_{cuff,int}$ across all inflations.
Calculation of PCR Index The PCR method relies upon comparison of the surge in urine flow (Q_{surge}) seen at cuff release following penile urethral compression, with the steady-state flow rate (Q_{ss}). For each cuff inflation we measured Q_{surge} and Q_{ss}, then calculated mean PCR index across all inflations;

$$\text{PCR index} = \frac{Q_{surge} - Q_{ss}}{Q_{ss}} \times 100$$

Assessment of test performance For many clinical tests there is a trade-off where sensitivity can be improved at the expense of specificity, by moving the threshold used to delimit the normal and diseased states. The receiver-operator characteristic (ROC) curve shows this trade-off graphically. The area under the ROC curve is a pragmatic indicator of the test's performance, and ranges from 0 (the test is always wrong) to 1 (always right). Using the ICS classification of obstruction as gold standard, we calculated ROC curves for:
(i) Peak urine flow rate (Q_{max}) alone;
(ii) PCR index alone;
(iii) the non-invasive cuff test nomogram, incorporating Q_{max} and $p_{cuff,int}$;
(iv) the combination of Q_{max}, $p_{cuff,int}$ and PCR, using linear discriminant analysis as below.
Linear discriminant analysis Each subject was plotted on a 3-dimensional nomogram (figure 1) with axes of Q_{max}, $p_{cuff,int}$ and PCR index; linear discriminant analysis establishes the plane best separating *obstructed* from *other* subjects. In order to generate the ROC curve, we altered the position of the plane while keeping its gradient constant (figure 2).

Results

49 (42**%**) of the subjects were *obstructed* according to the provisional ICS nomogram. The combination of Q_{max}, $p_{cuff,int}$ and PCR index improves the discriminating ability beyond that of the simpler tests (Table 1, figures 1 & 2).

Non-invasive test	Area under ROC curve	Best diagnostic accuracy	
		Sensitivity	Specificity
Q_{max} alone	0.79	65%	85%
PCR index alone	0.88	80%	90%
Cuff test nomogram (Q_{max} & $p_{cuff,int}$)	0.82	73%	75%
Combined nomogram (Q_{max} & $p_{cuff,int}$ & PCR)	0.92	86%	87%

Table 1 *Diagnostic performance for four non-invasive tests. We also give the best overall diagnostic accuracy (ie. at which the most subjects were correctly classified).*

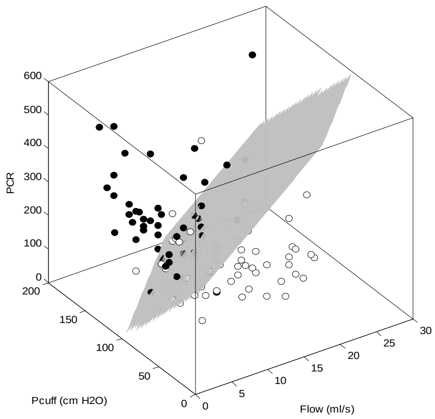
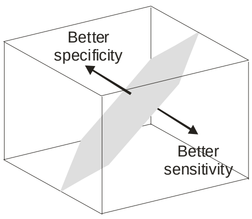


Figure 1 *(**left**) shows the 3D nomogram. The best diagnostic accuracy is obtained using the shaded plane to discriminate obstructed (●) from other (○) subjects.*

As with the ICS nomogram, we can define a diagnostic parameter corresponding to the AG number:

$$N = p_{cuff,int} - 6.4\, Q_{max} + 0.35\, PCR$$

where N>100 indicates obstruction.



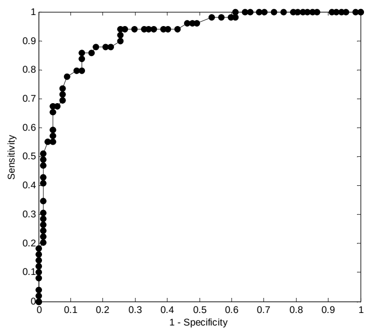


***Figure 2 (above** and **right)** shows the movement of the parallel plane to generate the ROC curve, and the ROC curve thus generated.*

Interpretation of results

The addition of PCR index to the data plotted on the non-invasive nomogram improves the diagnostic accuracy of the cuff test. The combined parameter diagnosed BOO with good accuracy in relation to the gold standard of invasive cystometry.

Concluding message

The combination of flow rate, penile cuff interruption pressure and PCR index measured from a single cuff test shows promise in the non-invasive diagnosis of bladder outlet obstruction. Given the test's simplicity it could be utilised in the outpatient or prostate assessment clinic setting as an adjunct to uroflowmetry.

References

(1) J Urology 2002; 167: 1344-47.
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(3) Neurourol Urodyn 2003; 22: 369-70.

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