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COMPARISON OF THEORETICAL AND EXPERIMENTAL BOR

Hypothesis / aims of study

Theoretical models of bladder contraction, based on the Hill equation, predict the relationship between the detrusor pressure and flow rate [1]. This is known as the Bladder Output Relation, BOR. It is, however, difficult to validate as urethral resistance must be controlled in order to vary the flow rate. Normally, $p_{det.Qmax}$ and Q_{max} can be measured, as well as $p_{det.isv}$ during a stop test, but these only plot two points on the curve and provide limited opportunity to validate the theoretical model.

We used an inflatable penile cuff to reduce flow to zero by increasing urethral resistance, whilst simultaneously measuring detrusor pressure (p_{det}) and flow rate (Q), to obtain an experimental measure of BOR which was then compared to the theoretically predicted BOR.

Study design, materials and methods

150 men undergoing invasive PFS for investigation of LUTS gave informed consent to have a cuff test after their routine assessment. After PFS, the bladder was refilled until urge to void and the cuff test was performed with catheters in place. On detection of flow, the cuff was inflated at $10cmH_2Os^{-1}$ until flow was interrupted or $200cmH_2O$ reached and then rapidly deflated. This was repeated until the end of the void. For each patient, the inflation with the highest interruption pressure was analysed. Voided volume and filled volume were used to infer bladder volume.

The Watts factor equation [2] was used to predict the p_{det} from the measured flow rate and bladder volume. Using detrusor contraction strength (WF) calculated from $p_{det.isv}$ and assumed to be constant, and published values for the constants *'a'* (corresponding to maximum isovolumetric pressure) and *'b'* (corresponding to maximum shortening velocity) [2] the experimental and theoretical BOR (p_{det} vs Q) were plotted. The prediction was compared to the measured values by evaluating the r.m.s. differences between the two.

In order to improve the fit of the predicted theoretical BOR to the experimentally obtained BOR, the constants *a* and *b* were optimised for each patient using a least squares method.

Results

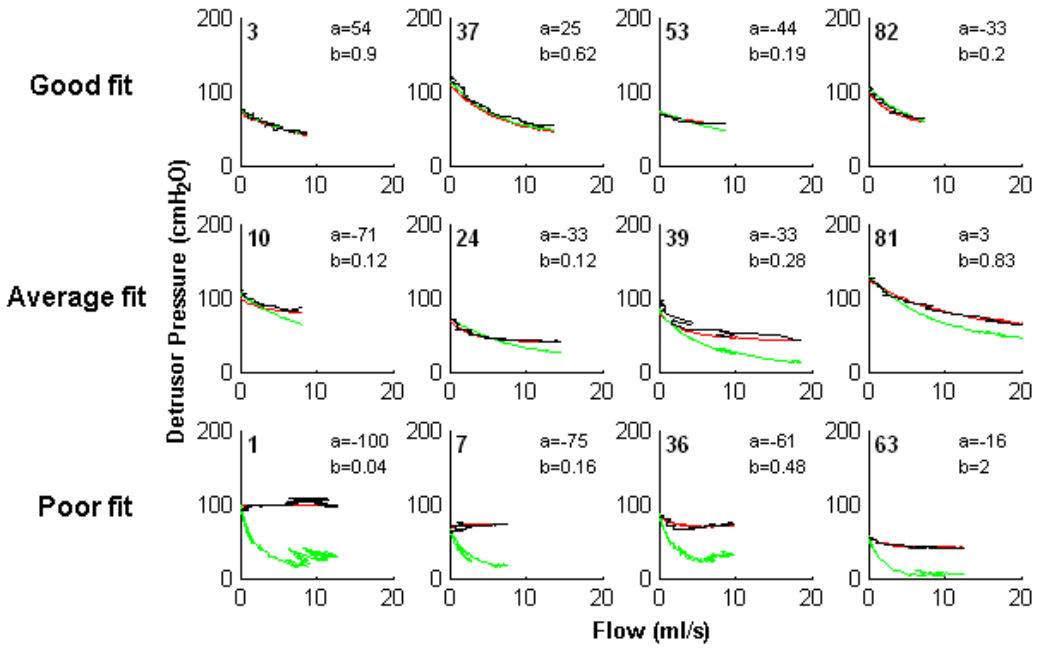

Fig 1, Pressure-flow data: Black: experimental BOR; Green: predicted BOR (using standard *a* and *b*); Red: 'best fit' BOR (using calculated *a* and *b* for each patient*)*

Results were obtained in 104 men, with representative traces plotted in Fig 1. Approximately a third of men fell into each category (Good, Average, Poor) according to r.m.s. value.

The values of *a* and *b* which produced the 'best fit' are plotted in Fig 2 below. This shows very little agreement between the 'standard' values of *a* and *b* and the best fit values. The majority of calculated values of *a* are negative.

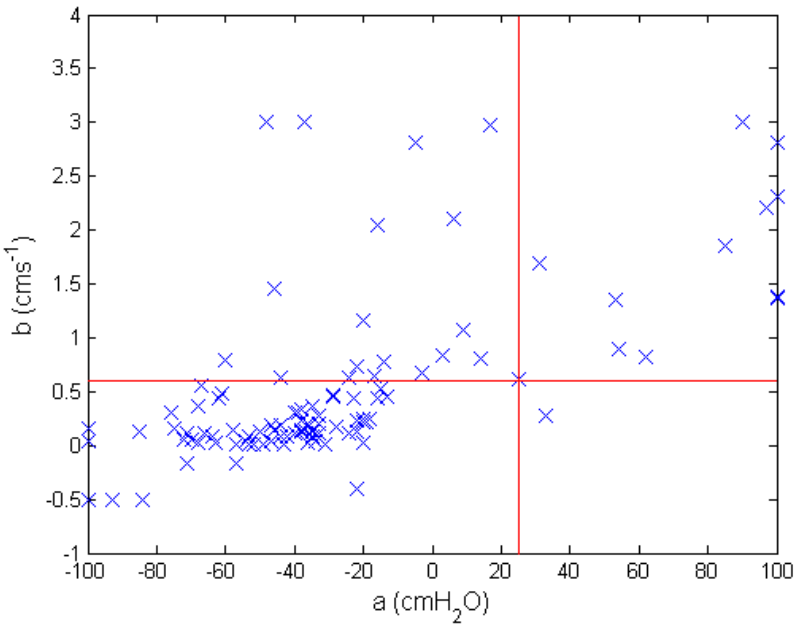

Fig 2, spread of the calculated 'best fit' *a* and *b* values, compared to the standard values (red lines)

Interpretation of results

In theory, the curves should tend towards zero pressure for higher values of flow rate, but this was not the case in many of the patients. In these patients, where BOR_{expt} did not agree with BOR_{theory}, the curve appears to level out at a positive pressure. Changing *a* and *b* to give a 'best fit' BOR yielded good fits, but many of the values of *a* were negative. This reflects the tendency of the curves to level out at a positive pressure, but is unphysiological according to the Hill equation.

The large spread of 'best fit' values of *a* and *b* suggests that these parameters differ substantially between individuals, and it would be inappropriate to use them to calculate a new average *a* and *b*.

A possible reason for disagreement between the results and the theory may be inhibition of the detrusor contraction during inflation of the cuff; however, previous studies have shown that using the penile cuff to interrupt the flow does not inhibit detrusor contraction [3]. Collection of data midstream, where the isovolumetric pressure is highest and the contraction strength is assumed to be stable, supports that we are making a representative measure of the BOR.

Concluding message

This method of using measurement of detrusor pressure whilst a cuff is being inflated to interrupt flow mid-void allows experimental BOR data to be obtained. The data we have collected, however, is not consistent with the WF equation based on the Hill equation. Further work and possibly further development of the theoretical model is required to explain our results.

References

1. Neurourol Urodyn (1985) 4;77-87
2. Am J Physiol (1986) 251;R225-230
3. J Urol (2003) 169;1003-1006

Specify source of funding or grant	**None**
Is this a clinical trial?	**No**
What were the subjects in the study?	**HUMAN**
Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**Newcastle and North Tyneside Research Ethics Committee**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**