

TESTING THE BIOMECHANICAL THEORY FOR INTERPRETING VOIDING PRESSURE/FLOW PLOTS IN MEN WITH URINARY OUTFLOW OBSTRUCTION.

Hypothesis / aims of study

Men with symptoms of outflow obstruction describing hesitancy, poor stream, intermittent flow, terminal dribbling and incomplete emptying are likely to have either of two lesions:-

1. Benign Prostatic Hypertrophy (BPH)
2. Bladder Neck Obstruction

Sometimes they have both, occasionally other pathology.

It is common practice to assess such people by means of a voiding pressure/flow plot generated by a cystometrogram, which analyses the nature of the obstruction.

Medical physicists and biomechanical scientists have developed a theory for interpretation of this plot. Drawing on the hydrodynamics of fluid flow through elastic tubes, it is proposed that a plot of voiding detrusor pressure (P_{det}) against flow rate (Q) allows, amongst other things, the characterisation of the obstructed urethra as demonstrating varying viscoelastic properties. The principles are strong and have been carefully derived^{1,2}. A number of simplifications using nomographic interpretation of the point $P_{det,max,flow} / Q_{max}$ and the urethral resistance relation (URR) have been proposed. However, despite the excellent physics^{1,2}, rigorous clinical validation has been sadly lacking.

The voiding cystourethrogram (VCUG) obtained from a video urodynamic (VCMG) study offers an excellent means of discriminating bladder neck obstruction from prostatic obstruction:

1. Those obtained from a male with a bladder neck obstruction will demonstrate poor bladder neck opening and/or incomplete bladder emptying. The prostatic urethra fills well distal to the bladder neck, often giving the "Spinning Top" appearance.
2. Those obtained from a male with a prostate obstruction will demonstrate attenuation and/or posterior displacement of the posterior urethra. The prostatic urethra is narrowed and elongated. The contrast may be so thin as to be difficult to see

This imaging dichotomy provides an opportunity to examine the ability of the data, obtained from the voiding pressure/flow plot (PFP), to discriminate between the two imaging sets. If the biomechanical interpretation of the PFP makes claim to diagnostic power, then its application should demonstrate discriminatory properties when applied to these two fundamental, pathophysiological states.

The hypothesis stated that the clinical interpretation of a voiding pressure/flow plot, based on the currently accepted biomechanical theory of micturition, would prove to be in accord with a video imaging interpretation of a VCUG.

Study design, materials and methods

This study tested the validity of pressure flow/plot interpretation by using the images from a voiding cystourethrogram, obtained during videourodynamic studies. An experienced uro-radiologist, blinded to the pressure/flow plot trace, classified a set of VCUG images. A set where the radiologist had been confident about deciding on bladder neck obstruction or prostate obstruction was obtained.

The pressure/flow plot traces were analysed by two clinicians blinded to the radiology data. The $P_{det,open}$; $P_{det,close}$; $P_{det,max,flow}$; Q_{max} were measured and the calculation ΔP_{det} during voiding = $P_{det,open} - P_{det,close}$ effected. By scrutinising carefully the P_{det} / Time and Q / Time traces, the URR line was drawn onto the pressure flow plot (PFP). The gradient of the line $\Delta P_{det} / \Delta Q$ was calculated. In order to reproduce the constraints of clinical observation, the URR gradient was also measured with a protractor and the gradient assessed by taking the tangent of the result. The points $P_{det,max,flow} / Q_{max}$ were plotted onto a $P_{det,max,flow} / Q_{max}$ nomogram chart. The pressure/flow plots were then classed as demonstrating an elastic outflow or rigid outflow. *A priori*, The expectation was that prostatic obstruction would be rigid and bladder neck elastic.

Results

Pressure/flow plots and the VCUG reports were collected for 70 male patients with lower urinary tract obstruction. 41 showed bladder neck obstruction images and 29 prostate obstructions. The classification comparisons between PFP and VCUG are shown in table 1 (Spearman $R=0.06$ – Kappa $=0.05$ – $p=0.61$)

Table 1		VCUG		Total
		Bld. Neck	Prostate	
PFP Class	Elastic	16	10	26
	Rigid	25	19	44
Total		41	29	70

The between image group comparisons, using the variables, are shown in table 2. The nomogram plot failed to show any discriminatory power, the two imaging groups wholly intermingled. However, there were statistically significant between group differences. The $\Delta P_{det} / \Delta FR$ result showed that prostatic obstruction proved more elastic and bladder

neck more rigid, thus contracting the prior assumptions. Pdet.open fitted well with the imaging, being higher, as would be expected, in bladder neck obstruction.

Table 2 Statistics - Mann-Whitney U Test							
	Pdet.open	Pdet.close	Pdet.max.flow	ΔPdet during voiding	Maximum flow	Calculated gradient ΔPdet./ΔFR	Observed gradient using a protractor
Mann-Whitney U	352.00	428.00	439.00	482.00	473.00	111.00	567.50
Z	-3.01	-2.12	-1.99	-1.49	-1.59	-2.86	-0.50
Asymp. Sig. (2-tailed)	0.00	0.03	0.05	0.14	0.11	0.00	0.62

Grouping Variable: Imaging diagnoses – (A) Bladder neck obstruction versus (B) prostate obstruction

Interpretation of results

The statistically significant differences did not translate into clinically significant differences. Whilst the mathematics seemed to work and obey the mechanical theory, differences were insufficient to improve on or enhance the voiding cystourethrogram (VCUG). Observation and interpretation of the pressure/flow plot by the clinician did not discriminate. It would seem that the differences were too subtle to work at the level of the individual patient.

Concluding message

The applied biomechanics of the cystometrogram (CMG) pressure/flow plot confirmed the veracity of the voiding cystourethrogram (VCUG) image interpretation. That achieved, the CMG did not seem to provide added value. It may be best to focus on the VCUG and worry less about the CMG

References

1. *J.Urol.* 2003;169:1007-10.
2. *Urol.Clin.North Am.* 1996;23:279-97.

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HUMAN SUBJECTS: This study was approved by the Whittington and Moorfields Research Ethics Committee and followed the Declaration of Helsinki Informed consent was obtained from the patients.