Research Article,

A Mathematical Simulation of the Influence a CMG Catheter's Frequency Response on Urodynamic Diagnosis

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Introduction:
Urodynamics comprises urine flow testing, ultrasound estimation of post-void residual, and Cystometry with filling and voiding phases [1]. Cystometry is the concurrent pressure measurement from the bladder and an abdominal control site, with parallel urine flow measurement. Using conventional water filled catheters; pressures are referenced to atmospheric pressure and the physical height of the external pressure transducer. Cystometry facilitates assessment of detrusor strength, and weakness or obstruction in the tract below.

Video Urodynamics (VUDS) adds fluoroscopy to these physiological measurements, and allows differential diagnosis of pathology in Stress Urinary Incontinence (SUI) as well as surveillance of upper tract integrity [2]. A cysto-urethrogram is a non-invasive alternative to VUDS, allowing the whole urinary tract to be visualised during micturition. [3] It sacrifices pressure data, but can include a measurement of flow rate [4]

Historically, cystometry with internal placement of water-perfused catheters (WPCs) to assess detrusor and abdominal pressure (Pdet and Pabd) have provided the gold standard in assessing Bladder Outlet Obstruction (BOO) [5]. A CMG is also the only way to differentiate between sensitive bladder (SB), Detrusor Over activity (DO) and SUI as causes of incontinence. However, WPCs are subject to test-retest variation related to their placement, errors related to changes in the patient’s position, and poor alignment between symphysis pubis and pressure transducer. Additionally, air-bubbles in the transducer and handling of the catheter will create positive pressure artefacts, while blockage of the catheter’s lumen by stones, debris, faeces, or the organ wall will reduce pressure erroneously.

Air charged catheters (ACCS) avoid most of these artefacts as they measure pressure locally and don’t have lumen. Like micro-tip solid-state lines, this tends to create a systematic Measurement difference with respect to WPCs [6], and so conversion could be possible for clinical comparisons.

ACCs are also reported as being easy to use, and comfortable across cohorts [7,8] however in a clinical situation the total number of technical issues for each catheter was found to be the same [9]. The one negating factor is the low-pass filtering effect of ACCs presented by Cooper and co-authors [10], and this presented the need for the present study. The aim here is to characterise, simulate, and apply this filtering effect of ACCs to local clinical data recorded using WPCs. Any resulting (theoretical) changes to Urodynamic parameters and diagnoses will then be identified.

Methods:
A Chi-squared test of independence was performed to confirm the equivalence of recording quality for the catheters using the data of Abrams et al [11]. Next, the frequency response published by Cooper et al. [10] was enlarged allowing resolution to be added to both frequency and pressure axes. The exact frequency (Hz) at which the response was reduced to 50% of its peak amplitude (the 3dB point) could then be identified. A range of digital filters with this cut-off [12,13] were programmed into individual
The differences seen in some other studies that there were no differences between ACCS and WPC's [6]. Another exclusively female study found good overall correlation between WPC's and ACCS but, somewhat surprisingly, greater variability when bladder volume was less than 50ml [17]. A recent clinical study of a mixed cohort found that ACC pressure was generally larger, but its relationship with WPC's was inconsistent [18]; again, this could reflect a wide bandwidth during pressure recording.

Finally, a range of pathologies call for the addition of Fluoroscopy (Video Urodynamics) and this is heading towards standardisation [2]. Contrast media is a viscous and sticky substance that absorbs x-rays. The long-term effect of these phenomena on the reusable portion of air-charged catheters may have to be tested in the lab before they can be considered for VUDS.

**Conclusion:**
There is no difference between ACCS and WPC’s when used with the equipment specifications typical of a clinical urodynamics service and within the technical recommendations of the International Continence Society.
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References:


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