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# USE OF REAL-TIME ULTRASOUND AND CONTINUOUS URGENCY METER DURING URODYNAMICS

Hypothesis / aims of study

Detrusor smooth muscle has been shown to be in-series with pelvic afferent nerves [1] and animal models have demonstrated increased pelvic nerve afferent firing with increasing intravesical pressure ($p_{ves}$) [2]. However, $p_{ves}$ in the urinary bladder with normal compliance typically increases minimally during physiologic filling or during non-physiologic filling as performed in urodynamic evaluation. Sensory symptoms at a given bladder volume and $p_{ves}$ can vary greatly amongst patients but because afferent nerve signaling reflects detrusor wall tension rather than $p_{ves}$, there is a pressing need for methods that evaluate detrusor wall tension.

Current urodynamic evaluation prompts patients to report the standard sensory thresholds of first sensation of bladder filling (FS), first desire to void (FD), and strong desire to void (SD) during filling cystometry. These thresholds are arbitrary, poorly characterized and can be influenced by investigator bias during the exam [3]. Furthermore, these thresholds are isolated points on a spectrum of sensation and only assess a small fraction of the filling phase.

We describe a novel method to determine detrusor wall tension during urodynamics by incorporating real-time bladder ultrasound during the filling phase. In addition, we described the use of a real-time "urgency meter" during filling cystometry to correlate continuous changes in patient sensation (as a percentage of urgency) to maximum cystometric capacity ($C_{cap}$).

Study design, materials and methods

In a single patient, $C_{cap}$ was determined by maximum voided volume recorded during three day frequency volume chart. The patient underwent filling cystometry with fill rate was set at 10% $C_{cap}$. Urinary bladder ultrasound images were obtained by a certified ultrasound technologist, holding the probe in a constant position throughout filling to capture mid−sagittal and maximum transverse urinary bladder images every 60 seconds. Images were time-linked to $p_{ves}$ data.

As part of an IRB−approved extended urodynamics protocol, individuals with overactive bladder syndrome (OAB) defined as ICIq−OAB question 5a ≥ 3 underwent urodynamic testing in accordance with best practice statements and simultaneously used a real−time "urgency meter" to record changes in sensation during filling cystometry. Prior to testing, patients were instructed on the use of the urgency meter. Patients' bladders were drained and confirmed empty with ultrasound prior to filling cystometry. Standard sensory thresholds (FS, FD, SD and $C_{cap}$) in addition to perceived percentage of urgency (0−100%) were reported verbally by the patient and time-linked to infused bladder volume. A visual urgency meter reflecting patient-reported percentage of urgency (**Figure 1**) was visible to the patient and was updated in real time. Patients who did not achieve all sensory thresholds were excluded from analysis. After testing, patients rated the urgency meter on ease of use and ease of understanding using a 10-point Likert scale. Infused volumes were normalized as a percentage of $C_{cap}$ for statistical analysis. Repeated measures one–way ANOVA and Holm-Sidak *post hoc* analysis were performed to compare sensory thresholds as percentage of $C_{cap}$.

Results

Using acquired ultrasound images and $p_{ves}$ data, we developed an objective technique to calculate detrusor wall tension, wall stress, and wall compliance as follows: From each transverse image acquired (**representative image, Figure 2**), we measured inner and outer bladder wall perimeters, allowing calculation of wall ($A_w$) and luminal ($A_L$) areas (**Figure 3**). Wall tension (T) was calculated as $P_{ves} \times A_L$ and wall stress (σ) as $T/A_w$. When compared to infused volumes, $p_{ves}$ increased minimally during filling as would be expected, however, wall stress increased exponentially (**Figure 4**).

Six patients (n=6) completed the extended urodynamics protocol with use of the urgency meter. Average infused volumes at time of reported standard sensory thresholds were 9±3 %$C_{cap}$ for FS, 24±7 %$C_{cap}$ for FD, and 52±10 %$C_{cap}$ for SD. There was no difference between FS and FD in relation to percentage of $C_{cap}$ ($p=0.29$). However, differences existed between FD and SD ($p<0.05$) and between SD and $C_{cap}$ ($p<0.01$). Continuous urgency recordings demonstrated both stronger linear and nonlinear relationships to percentage of $C_{cap}$ compared to standard sensory thresholds (**Figure 5**). Patients rated the real−time urgency meter as easy to use and easy to understand (10-point Likert scores: 1.57±0.72 and 1.14±0.67, respectively).

Interpretation of results

Detrusor wall tension and stress can be calculated during filling cystometery with the addition of real-time ultrasound. Wall stress increases exponentially with infused bladder volumes, similar to the correlation between patient sensations and percentage of $C_{cap}$ with use of the urgency meter. These findings demonstrate that changes (or lack thereof) in $p_{ves}$ measurements during urodynamics do not accurately reflect the underlying state of detrusor wall tension/stress or the patient's sensation during filling. In patients with OAB, there is significant overlap between FS and FD, limiting the diagnostic utility of these subjective metrics. A stronger correlation to bladder volume is seen with the use of a continuous urgency meter to assess patient sensation during filling compared to the isolated, qualitative values represented by the standard sensory thresholds.

Concluding message

Addition of real-time ultrasound and the use of a continuous urgency meter provide valuable data augmenting standard urodynamics and a more objective means of characterizing bladder sensation during filling cystometry than accepted standard sensory thresholds. These techniques may be useful in the diagnosis and treatment of OAB and other disorders of voiding dysfunction.

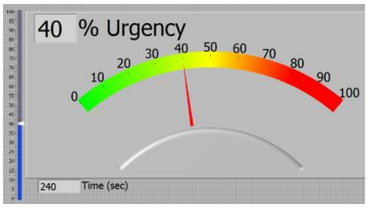


Figure 1

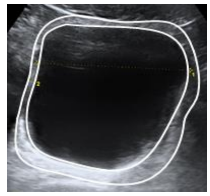

Figure 2

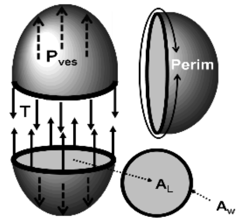


Figure 3

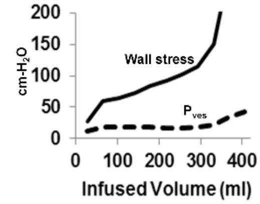


Figure 4

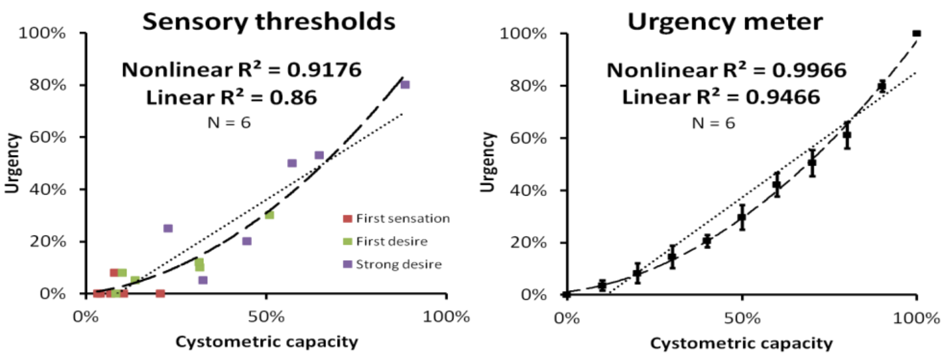


Figure 5


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Disclosures

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