A non-invasive method to identify directional geometric and strain patterns in women with overactive bladder using transabdominal ultrasound

Clark S[1], Nagle A[2], Vince R[1], Bernardo R[2], Carucci L[1], Carroll A[1], Klausner A[3], Speich J[2]
1. Virginia Commonwealth University Health System, 2. University Virginia Commonwealth University School of Engineering, 3. Virginia Commonwealth University Health and Hunter Holmes McGuire Veterans Affairs Hospital.

Hypothesis / aims of study

Overactive bladder (OAB) occurs during the filling phase of the bladder. Changes in geometry as the bladder fills are expected to play an important role in the development of bladder wall tension. The purpose of this study was to measure dynamic changes in the bladder geometry over a complete urodynamic fill in OAB patients. The hypothesis was that the bladder would fill non-uniformly and that some individuals would have significantly different strain patterns. This would identify them as potentially having shape-mediated OAB.

Study design, materials and methods

- 14 women with high urgency OAB
- Extended urodynamic testing with infusion rate of 10% cystometric capacity per minute
- Transabdominal 3D ultrasound images were acquired every 60s
- Diameters measured in the latero-lateral (width, W), antero-posterior (depth, D), and cranio-caudal (height, H) orientations (**Fig. 1**)
- Engineering strain (change in length/initial length) was calculated using initial length as the length at 10% cystometric capacity

Results

- Depth was different than width and height ($p = 0.012$ and 0.006) at the beginning of the fill but was only different than width at 100% capacity ($p = 0.002$) (**Fig. 2A**).
- Engineering strain in the height direction was significantly greater than width ($p = 0.006$) and depth ($p = 0.04$) at 90% capacity (**Fig. 2C**).
- In the height direction, absolute diameter increased linearly in all individuals (**Fig. 2B**), and two individuals were noted as having strain in that direction lower than mean strain by ~2 STD (**Fig. 2D**).

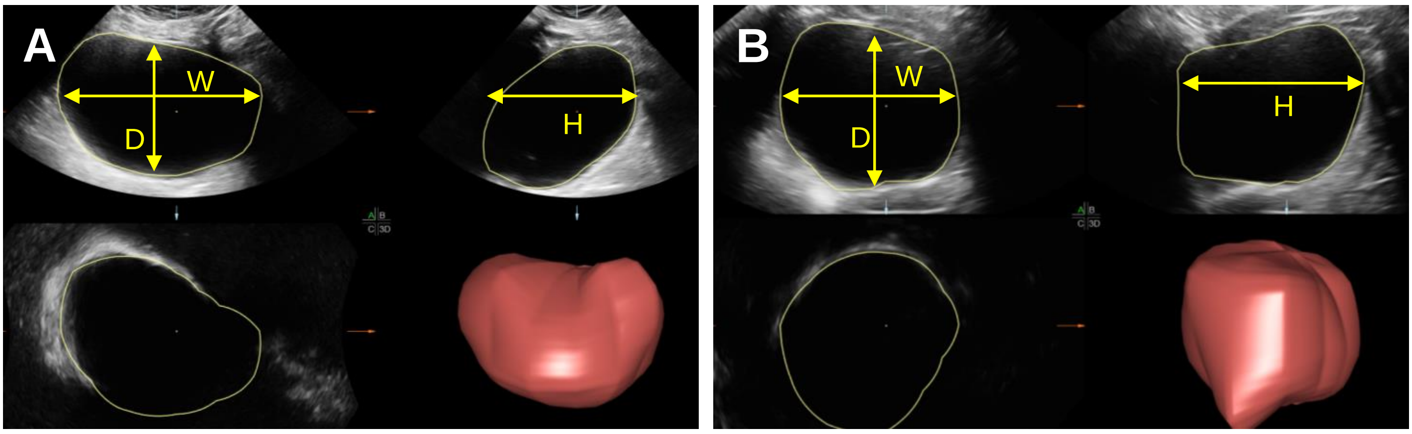

Fig. 1 3D ultrasound images of two bladders at 100% cystometric capacity showing the transverse plane (top left), the sagittal plane (top right) the coronal plane (bottom left), and a rendered volume of the bladder (bottom right). The blue lines indicate the diameters: width (W), depth (D), and height (H). (**A**) a bladder that followed the typical strain patterns. (**B**) a bladder that had decreased strain in the height direction.

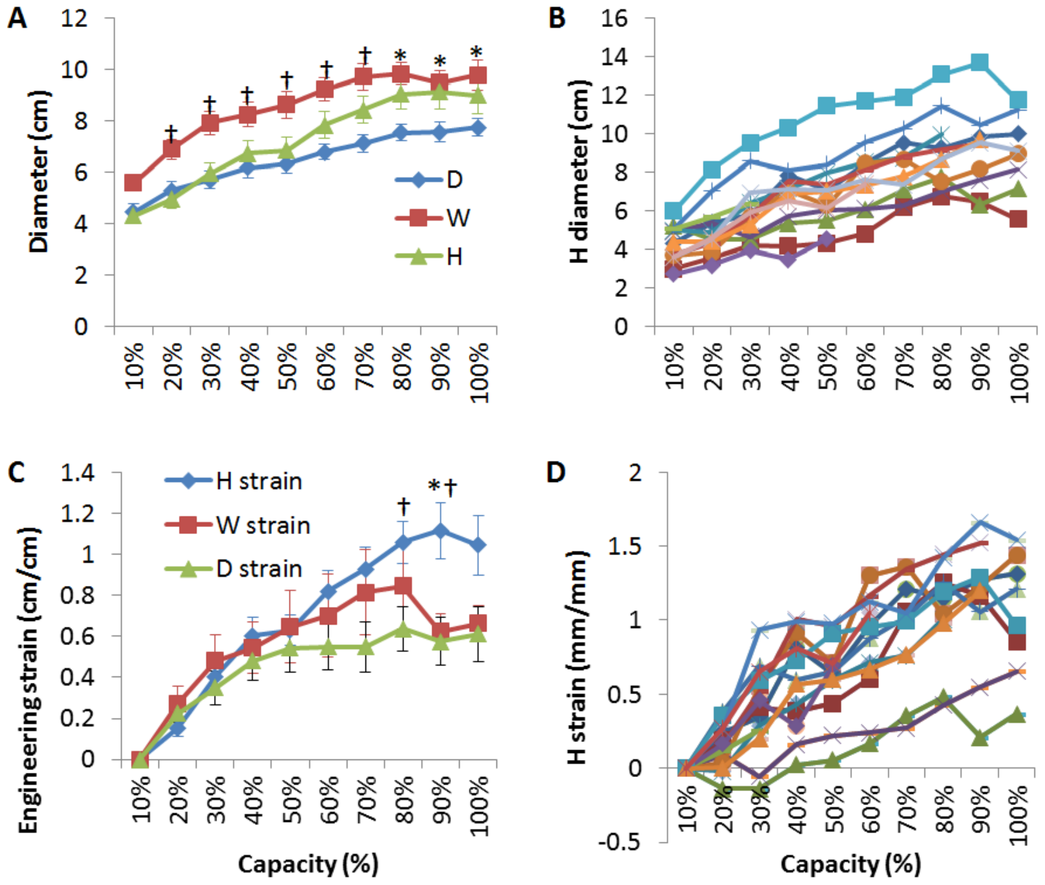

Fig. 2. In filling from 10% to 100% cystometric capacity, the absolute diameter is shown as the mean and standard error in the three directions (**A**) and individually in the height, H, direction (**B**) for the 14 participants. The engineering strain shows the normalized changes in these diameters in the three directions (**C**) and individually in the height direction (**D**). Significant differences between height and the other directions are indicated with * compared to W and † compared to D.

Disclosures Statement
Support provided by NIH R01DK101719, VCU Presidential Research Quest Fund, and VCU Dean's Undergraduate Research Initiative

Interpretation of results and concluding message

This study demonstrates a non-invasive method to measure changes in bladder geometry and strain throughout filling. The average OAB bladder changes shape significantly as the bladder is filled during urodynamic testing, particularly in the cranio-caudal direction. The two individuals who had decreased strain in the height direction (**Fig. 2D**) were not outliers in any other way (capacity, age, or BMI). The 3D ultrasound image of the individual with the smallest strain in the height direction is shown in **Fig. 1B**. The diameter strains of these two participants did not follow the typical pattern, which may identify them as having some form of a shape-mediated subtype of OAB.