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A NON-INVASIVE METHOD TO IDENTIFY DIRECTIONAL GEOMETRIC AND STRAIN PATTERNS IN WOMEN WITH OVERACTIVE BLADDER USING TRANSABDOMINAL ULTRASOUND

Hypothesis / aims of study

Overactive bladder (OAB) is characterized by changes in the filling phase of the bladder. Currently, there are limited non-invasive methods to evaluate OAB. Changes in geometry as the bladder fills are expected to play an important role in the development of bladder wall tension which is linked to tension-sensitive afferent nerves that relay sensations of filling [1]. The purpose of this study was to measure dynamic changes in the geometry of the bladder over a complete fill during urodynamic testing in OAB patients. The hypothesis was that the bladder would fill non-uniformly (non-spherically) and that some individuals would have significantly lower or higher strain levels in certain directions than typical OAB patients.

Study design, materials and methods

Fourteen women with high urgency OAB as characterized by scoring 3 ("most of the time) or 4 ("always") on question 5a of the ICIq-OAB ("Do you have to rush to the toilet to urinate?") were enrolled in this IRB approved prospective study after giving informed consent. They underwent extended urodynamic testing at an infusion rate of 10% cystometric capacity per minute based on an initial fill. Throughout filling, transabdominal 3D ultrasound images were acquired once every minute. Diameters were measured in the latero-lateral (width, W), antero-posterior (depth, D), and cranio-caudal (height, H) orientations (Fig. 1). The absolute change in diameter length and the engineering strain (change in length/initial length) were tracked over filling. Initial length was defined as the length at 10% capacity. A two-tailed power study with significance level of 0.05 and power of 80% was performed in R using published data [2] comparing longitudinal and circumferential maximum strains in rat bladders. This yielded a sample size of 7 (6.72) participants, but this study aimed to recruit 14 to account for participants who may fail to complete the protocol or to have non-usable data.

Results

Of the fourteen women, seven were Caucasian and seven were African American. The mean and standard deviation of their ages was 53.6 ± 10.2 years old (mean ± SE), BMI was 34.3 ± 9.2 kg/m^2, and cystometric capacity was 531.1 ± 282.4 ml. Compared by paired t-tests, the depth was significantly different than the width and the height ($p = 0.012$ and 0.006) at the beginning of the fill but was only significantly different than the width at 100% capacity ($p = 0.002$) (Fig. 2A). In the engineering strain (Fig. 2C), the highest strain was seen in the height direction, which was significantly higher than the other strains at 90% capacity ($p = 0.006$ compared to width and $p = 0.04$ compared to depth) but not significant at 100% capacity ($p = 0.06$ and 0.13). Examining data from individuals in the height direction, the absolute diameter increased fairly linearly in all individuals (Fig. 2B), and two individuals were noted as having strain in that direction lower than the mean strain by at least 1.9 standard deviations (Fig. 2D).

Interpretation of results

The increased strain in the cranio-caudal direction is consistent with literature on changes in bladder geometry during filling based on CT imaging [3]. The two individuals who had decreased strain in the height direction (Fig. 2D) were not outliers in any other way examined (cystometric capacity, age, or BMI). The 3D ultrasound image at 100% capacity of the individual with the smallest strain in the height direction is shown in figure 1. The posterior portion of the bladder as seen in the sagittal view (B) is more pointed than other participants.

Concluding message

This study demonstrates a method that is non-invasive and does not use ionizing radiation to measure dynamic changes in bladder geometry and strain throughout the filling process. The average overactive bladder changes shape significantly as the bladder is filled during urodynamic testing, particularly in the cranio-caudal direction. The diameter strains of two participants did not follow the typical pattern, which may identify them as having some form of shape-mediated subtype of OAB.

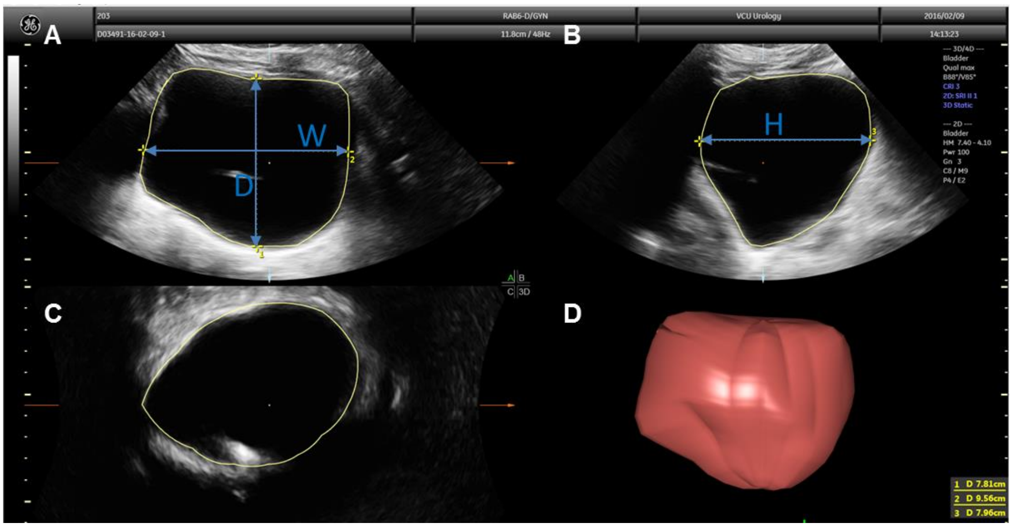

Fig. 1 3D ultrasound image of a bladder showing A) the transverse plane, B) the sagittal plane, C) the coronal plane, and D) a rendered volume of the bladder. The blue lines indicate the diameters measured indicating width (W), depth (D), and height (H).

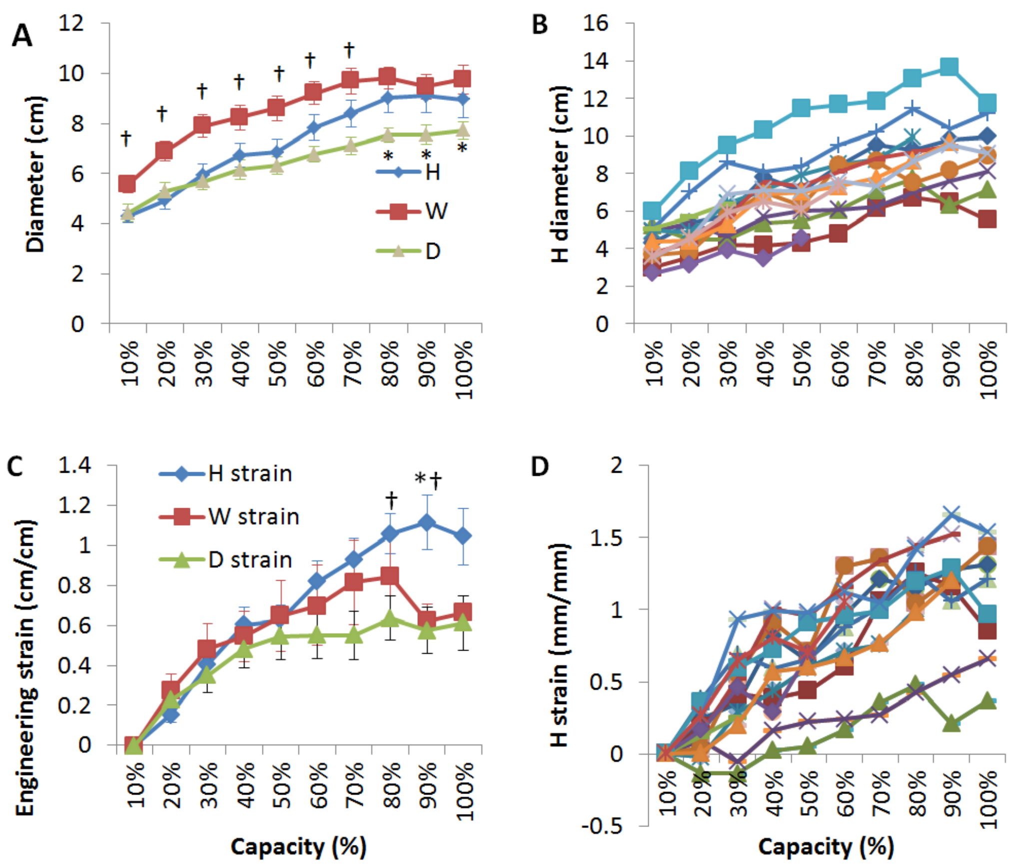

Fig. 2. In filling from 10% to 100% cystometric capacity, the absolute diameter is shown as the mean and standard error in the three directions (A) and individually in the height (H) direction (B) for the 14 participants. The engineering strain shows the normalized changes in these diameters in the three 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.

References

1. Kanai A, Andersson KE. Bladder afferent signaling: recent findings. The Journal of urology. 2010 Apr 30;183(4):1288-95.
2. Muren LP, Smaaland R, Dahl O. Conformal radiotherapy of urinary bladder cancer. Radiotherapy and oncology. 2004 Dec 31;73(3):387-98.
3. Lotz HT, van Herk M, Betgen A, Pos F, Lebesque JV, Remeijer P. Reproducibility of the bladder shape and bladder shape changes during filling. Medical physics. 2005 Aug 1;32(8):2590-7

Disclosures

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