#20639: Depth from Abdominal Ultrasound Probe to Bladder Wall: Variation with Bladder Volume, Body Position and BMI Determines Suitable Positioning for Wall Micromotion Detection Using Near Infrared Spectroscopy

Sarah I Tensen[1], Adam P Klausner MD[2], Lynn Stothers MD[3], Andrew J Macnab MD[3], John Speich PhD[4]

[1]Department of Biomedical Engineering, Virginia Commonwealth University, Richmond, VA, USA
[2]Department of Surgery/Division of Urology, Virginia Commonwealth University, Richmond, VA, USA
[3]Department of Urologic Sciences, University of British Columbia, Vancouver, BC, Canada
[4]Department of Mechanical & Nuclear Engineering, Virginia Commonwealth University, Richmond, VA, USA

Hypothesis/aims of study

- Transabdominal **near infrared spectroscopy (NIRS)** analysis of changes in the concentrations of oxygenated and deoxygenated hemoglobin during bladder voiding is an effective non-invasive screening tool for bladder outlet obstruction [1]
- Bladder wall micromotion due to detrusor contractions during bladder filling are elevated in patients with overactive bladder (OAB) [2]
- NIRS may provide valuable information about bladder filling, including potential noninvasive, ambulatory, at-home estimation of bladder wall micromotion for OAB assessment
- Unlike NIRS assessment of skeletal muscle activity during exercise or brain activity, the distance from the NIRS probe to the target tissue in bladder applications is expected to vary significantly with bladder volume, patient body position, and body mass index (BMI)
- Implementation of NIRS to analyze bladder function requires an appropriate distance between the skin at the probe location and the anterior bladder wall
- **Objective:** Determine the variation in the distance between the skin and the anterior bladder wall as a function of bladder volume, body position and BMI

Study design, materials and methods

- 18 women participated in this prospective bladder geometry study
- All completed a multiple-fill urodynamics protocol
- An initial fill-active void cycle was performed to determine cystometric capacity (CCap)
- Bladder ultrasound images were recorded at 40% and 100% CCap during one fill
- During another fill, images were recorded at 40% CCap with participants in four positions: supine, sitting at 45°, sitting upright at 90°, and standing
- Depth from the ultrasound probe to the anterior bladder wall was measured in the transverse plane for each image (Fig 1)

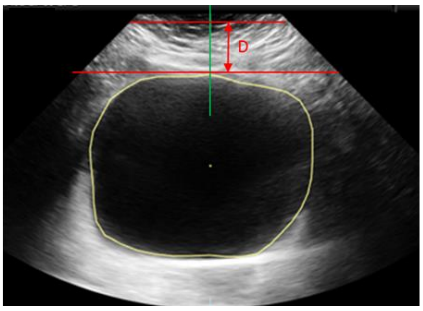

Fig 1. Transverse bladder ultrasound image illustrating the depth "D" along the mid-line from the contact point between the ultrasound probe and the skin to anterior bladder wall which has been traced in yellow.

Disclosures Statement: Support provided by NIH grant R01DK101719.

Results

- Women were divided into groups with relatively low and high BMI (26.6±1.8 and 40.0±2.3, kg/m^2, respectively, median = 32.7)
- Depth (D) from the probe to the anterior bladder wall decreased with increased bladder volume (Fig 2A)
- Depth was greater in participants with higher BMI (Fig 2B)
- Body position changes did not significantly affect the depth at 40% CCap (Fig 3)
- The minimum and maximum depths were 0.8 and 6.3 cm,
- Only two high BMI participants (BMIs of 40 & 54) had a depth >4.5 cm for an image

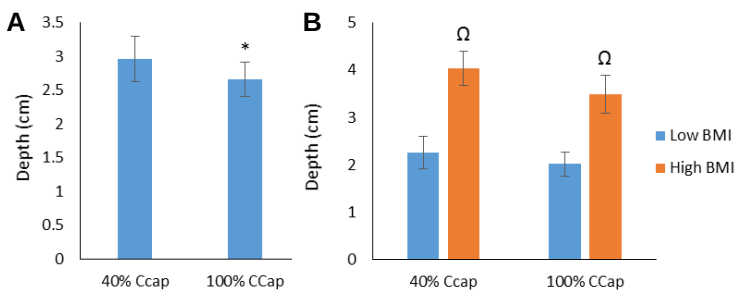

Fig 2. (A) Depth at 40% and 100% CCap while sitting at 45° (* indicates significant difference, paired t-test, p<0.05, n=18). (B) Depth for low and high BMI groups while sitting at 45° (Ω indicates significant difference between groups, t-test, p<0.05, n=9 per group).

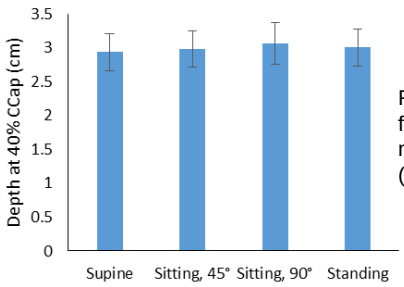

Fig 3. Depths at 40% CCap for positional changes were not significantly different (paired t-test, p>0.05, n=18).

Interpretation of results and concluding message

- NIRS has been used to measure tissue oxygenation at depths of at least 4 cm [3].
- Application of NIRS for assessment of bladder filling should be feasible in most women
- Application of NIRS could be limited in women with very high BMI
- Variation in bladder wall depth due to bladder volume changes and body position changes should not prevent ambulatory assessment of bladder filling using NIRS

1. Macnab AJ, Stothers L. Near-infrared spectroscopy: validation of bladder-outlet obstruction assessment using non-invasive parameters. Can J Urol. 2008;15(5):4241-8.
2. Drake MJ, Harvey IJ, Gillespie JI, Van Duyl WA. Localized contractions in the normal human bladder and in urinary urgency. BJU Int. 2005;95(7):1002-5.
3. McManus CJ, Collison J, Cooper CE. Performance comparison of the MOXY and PortaMon near-infrared spectroscopy muscle oximeters at rest and during exercise. J Biomed Opt. 2018;23(1):1-14.