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NONINVASIVE MEASUREMENT OF DETRUSOR MUSCLE CONTRACTIONS USING RADIOFREQUENCY ULTRASOUND STRAIN IMAGING

Hypothesis / aims of study

Lower urinary tract symptoms (LUTS) are divided into storage phase, voiding phase or post micturition phase symptoms. Bladder outlet obstruction (BOO) is characterized by increased detrusor pressure with decreased urine flow rate during voiding. Twenty five percent of men >60 y require surgical treatment for BOO. Overactive bladder (OAB) symptoms in the storage phase are often associated with detrusor overactivity (DO). OAB is highly prevalent in the western community, 13% of women and 11% of men >18 y have OAB symptoms [1]. Pressure flow studies and filling cystometry are currently the standard diagnostic urodynamic tests for BOO and OAB, respectively. However, these tests are invasive with potential morbidity. A non-invasive method to quantify detrusor activity could make diagnostic procedures more patient friendly.
With radiofrequency (RF) ultrasound it is possible to estimate deformation (strain) in biological tissue under compression [2]. This technique has also been used to measure contractions in skeletal muscles and the heart. To investigate the use of ultrasound strain imaging in monitoring detrusor activity we applied this technique in four men, two asymptomatic volunteers and two patients with LUTS/BPH.

Study design, materials and methods

In two men with LUTS/BPH and two healthy volunteers (study approved by the local ethical committee and all subjects signed an informed consent) we acquired RF ultrasound data during voiding using a linear array transducer (11-3L, centre frequency = 8.7 MHz, pitch = 135 µm) and a Philips iE33 ultrasound system (Philips Medical Systems, Bothell, WA, USA) with a custom designed RF-interface. The RF ultrasound data were acquired at three beam-steering angles: -6, 0 and +6 degrees. In each patient and volunteer ~5 seconds of data was acquired and stored for offline analysis. In all subjects, the RF ultrasound data were acquired retrospectively at time of Qmax. The urinary flow rate was recorded using a weight-based urine flow meter (MMS Medical Measurement Systems, Enschede, The Netherlands).
Displacement of the detrusor muscle during voiding was estimated from the RF ultrasound data using a coarse-to-fine strain estimation algorithm. The displacement estimates from the three beam-steering angles were then compounded and from the compounded estimates the strain components were derived [3]. Strain estimation was corrected for detrusor movement using a tracking algorithm. On the first B-mode image of the acquired time-series a Region-Of-Interest (ROI) was drawn and the mean axial strain (i.e. strain in the direction of the ultrasound beam) in this ROI was calculated.

Results

Patients with LUTS had IPSS of 25 and 16. Both patients had a Qmax of 7 ml/s at voiding and an obstructive pattern on pressure flow nomograms. While the two volunteers had a Qmax of 14 and 16 ml/s. In all four subjects the axial strain in the detrusor muscle varied with the flow rate. In both volunteers (voided volume: 170 and 155 ml) and both patients the axial strain appeared to decrease with an increase in the flow rate and increase with a decrease in flow rate (see figure 1).

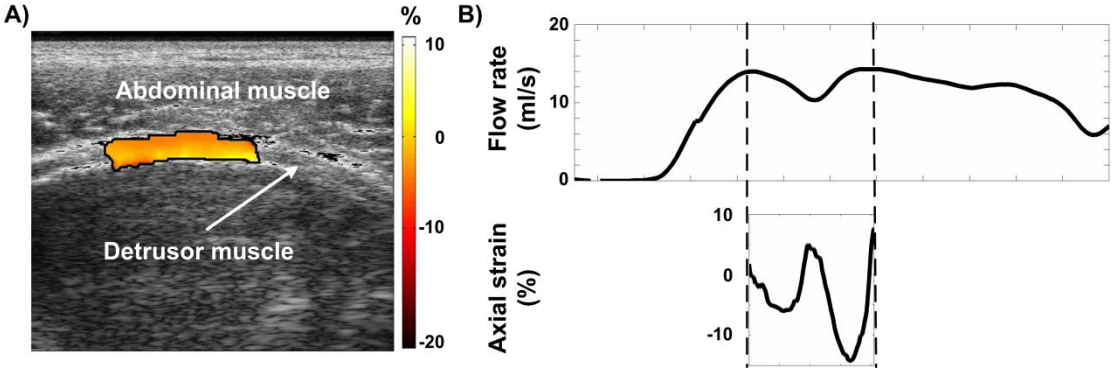

Figure 1: Example of a B-mode image of the detrusor muscle during voiding with the axial strain pattern in the selected ROI (A) and the flow rate and mean axial strain in the selected ROI as a function of time (B) in a volunteer.

Interpretation of results

For the interpretation of the results bear in mind that the presented values of strain were cumulated with respect to the first acquired ultrasound image. An increase in axial strain therefore indicates 'expansion' of the detrusor muscle during voiding with respect to a previous deformation state of the tissue (i.e. in the first acquired image). Whereas a decrease indicates 'compression' of the detrusor muscle with respect to a previous state. An increase in flow rate is preceded by detrusor muscle contraction with an increase in intravesical pressure. This contraction seems to be leading to a 'compression' of the detrusor muscle with respect to a previous state as detected by strain imaging in our study.

Concluding message

Strain in the detrusor muscle during voiding can be estimated using RF ultrasound strain imaging. The estimated strain varied with the urinary flow rate and hence with the detrusor pressure. This suggests that strain imaging could be used in monitoring detrusor muscle activity during filling and voiding. This is a new imaging modality to study the pathophysiology of functional lower urinary tract disorders. RF ultrasound monitoring of strain in the detrusor muscle can be a potential noninvasive diagnostic tool for BOO and DO in patients with LUTS.

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What were the subjects in the study?	**HUMAN**
Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**CMO Arnhem-Nijmegen**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**