389

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BLADDER VISCOELASTICITY CONTRIBUTES TO URINARY CONTINENCE

Hypothesis / aims of study
It has been previously demonstrated that normal viscoelasticity is critical to bladder function (1). However, it is not known if bladder viscoelasticity is also important in preventing urinary leakage during stress events such as coughing or valsalva. To investigate the bladder viscoelastic response to a rapid increase in abdominal pressure, we simultaneously measured bladder pressure (P_{det}) and intra-abdominal pressure (P_{abd}) during a rapid increase in abdominal pressure using electrical stimulation of abdominal muscles in female rats.

Study design, materials and methods
Under urethane anesthesia in a supine position (1.2g/kg, i.p.), the abdominal muscles were electrically stimulated (50 Hz, 0.5ms, 30mA) below the costal arch to induce urinary leakage 23 times for 1s duration in each of 6 normal female Sprague-Dawley rats (2). P_{det} and P_{abd} were simultaneously recorded via retropubic cystostomy and via a small saline-filled balloon in the abdomen, respectively. The water-filled catheters were each connected to a pressure transducer and a digital data collection system (sample frequency 500Hz). The abdominal wall was closed after the pelvic nerve was transected bilaterally to prevent bladder contraction, and the catheters were tunnelled subcutaneously to the dorsal neck where they exited the skin. The bladder was palpated to empty completely and refilled to 0.5ml (5ml/h, 6min) before each electrical stimulation. Abdominal and bladder pressure increase in response to electrical stimulation were calculated at the beginning (P_{abd}-S and P_{det}-S) and end (P_{abd}-E and P_{det}-E) of each stimulation as in Figure 1A. Two way ANOVA followed by a Student-Newman-Keuls posthoc test was used for statistical analysis with $p<0.05$ indicating a significant difference. A mean of each variable from all 23 stimulations in each animal was calculated and used to create group means and standard deviations.

Results
P_{det} showed a slow rise to peak during 1s duration electrical stimulation (Figure 1A), demonstrating the viscoelastic characteristics of the bladder. In contrast, P_{abd} demonstrated a rapid increase to peak pressure and maintained this pressure until stimulation ended, typical of striated muscle stimulation and the elastic properties of the measurement balloon. P_{det}-S was significantly decreased compared to P_{abd}-S (Figure 1B). P_{det}-E was not significantly different from P_{abd} -E. However, P_{det}-E was significantly increased compared to P_{det}-S (Figure 1B). There was no significant difference between P_{abd}-S and P_{abd}-E.

Interpretation of results
The slow rise of bladder pressure (P_{det}) to peak in response to a rapid abdominal pressure (P_{abd}) increase is indicative of the viscoelastic characteristics of the bladder. The rapid increase in P_{abd} can be rapidly transmitted to the bladder neck and urethra, providing additional resistance to leakage and facilitating continence. The delayed bladder pressure increase during a stress event such as a cough may also facilitate continence by allowing enough time for the urethral pressure to increase before bladder pressure reaches its peak. The contribution of P_{abd} pressure transmission is not a major factor in urinary continence and the delayed pressure increase of P_{det} is relatively short during a stress event. However, the delayed time due to bladder viscoelasticity could be critical if other major active factors involved in maintaining continence were impaired, such as occurs with urinary striated or smooth sphincter deficiency. Furthermore, if bladder viscoelasticity changed due to dysfunction of the neurogenic or myogenic pathway or fibrosis, any decrease in the time it takes for P_{det} to reach a maximum would further impair urinary continence.

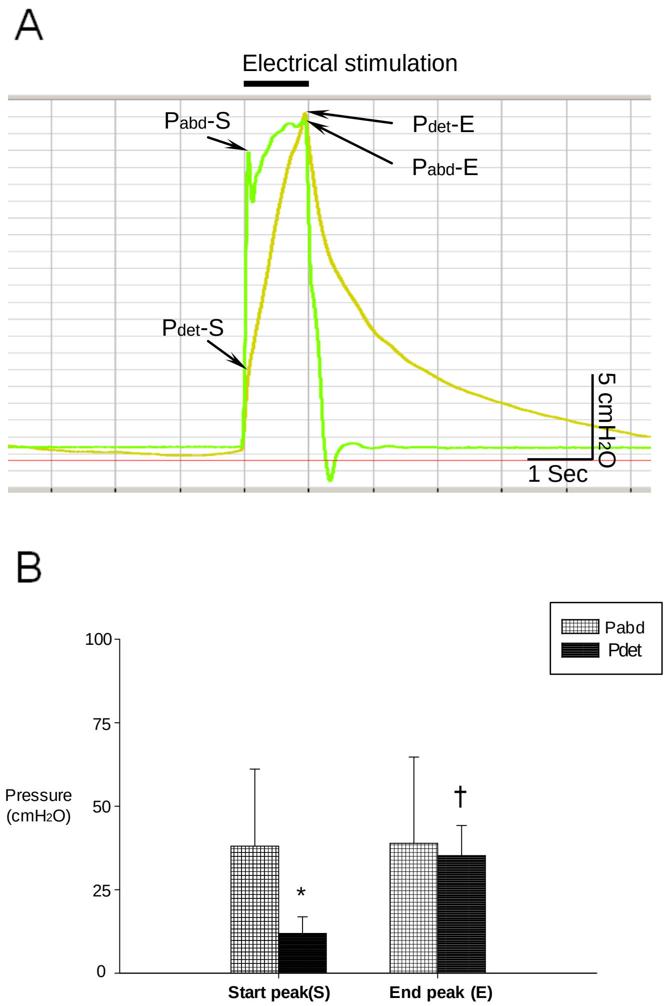

Figure 1.
A. Example of simultaneously recorded abdominal (P_{abd}) and detrusor (P_{det}) pressures during a electrical stimulation of the abdominal muscles. The horizontal bar indicates timing and duration of stimulation. Outcome variables include abdominal pressure increase in response to electrical stimulation at the beginning (P_{abd}-S) and end (P_{abd}-E) and detrusor pressure increase in response to electrical stimulation at the beginning (P_{det}-S) and end (P_{det}-E).

B. Abdominal and bladder pressure increase (P_{abd} and P_{det}) in response to electrical stimulation at the beginning (Start peak, S) and end (End peak, E). Each bar represents the mean $\pm$ standard deviation of 6 animals. * indicates a significant difference compared to P_{abd}-S. † indicates a significant difference compared to S and E within the P_{det}-S.

Concluding message

Besides proper urethral and pelvic floor function, maintaining urinary continence during a stress may also require normal bladder function, including normal bladder viscoelasticity.

References

1. Am J Physiol Regul Integr Comp Physiol 284: R1296–R1305, 2003
2. Am J Physiol Renal Physiol 293: F920–F926, 2007

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Is this a clinical trial?	**No**
What were the subjects in the study?	**ANIMAL**
Were guidelines for care and use of laboratory animals followed or ethical committee approval obtained?	**Yes**
Name of ethics committee	**the Institution Animal Care and Use Committee of the Cleveland Clinic**