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THE INNER AND OUTER DETRUSOR MUSCLE LAYER DIFFER IN CONTRACTILE PROPERTIES.

Aims of Study

The detrusor muscle consists of several layers with a different orientation of smooth muscle fibres. Recently, some studies on morphological and physiological differences between these layers were published [1,2]. In relation to these findings, we studied the contractile properties of the two main layers in pig urinary bladder: the outer layer (longitudinally orientated muscle bundles on the serosal side) and the inner layer (circularly orientated muscle bundles on the mucosal side). Contractility was characterised by the isometric force (F_{iso}) and the maximum shortening velocity (v_{max}). We used the stop test method [3] to measure these two properties in small smooth muscle fibres from both layers. One of the advantages of this method is that maximum shortening velocities can be determined at high passive forces that occur when the muscle fibre is stretched.

Methods

We used 2 urinary bladders of pigs freshly killed in the local slaughterhouse. In total, 8 small muscle fibres (4 of outer and 4 of inner layer) of about 3*0.7 mm were cut from the detrusor. Each fibre was clamped between two pairs of tweezers: one linked to a force transducer and the other to a length controller. The length controller was used to shorten the fibre from a pre-set start length (l_{start}) with a constant shortening velocity (v) to a pre-set stop length (l_{stop}). The smooth muscle fibres were stimulated using an electrical field generated between two platinum electrodes. The initial muscle fibre length was defined as the length required to measure a passive force of ~150µN in response to a slight change in length. L_{stop} was fixed at 200% of this length. Each fibre was measured twice, thus in total 8 measurements in each layer were done and used for data analysis.

Results

Figure 1 shows an example of a measurement. F_{iso} was measured after shortening each fibre to l_{stop}. Figure 2 shows that, on average, the F_{iso} (12.0 ± 2.2 mN; mean ± SD) of the outer layer was significantly higher than that (7.4 ± 1.6 mN) of the inner layer ($p < 0.001$; Mann Whitney test). To calculate the maximum shortening velocity, v_{max}, we shortened each muscle fibre at 4 different velocities to l_{stop} (v = 25, 50, 75 and 100 µm/s). We plotted the relative force, which is F_{short}/F_{iso}, as a function of v. For each v, the mean relative force of the inner and outer layer was calculated. To this average data set, a hyperbolic curve, similar to the Hill-curve, was fitted to calculate v_{max} for both layers, see figure 3. On average, we found that v_{max} of the inner layer was ~1.1 times higher than that of the outer layer (264 versus 238 µm/s). The analysis of variance showed that the relative force was significantly different between both layers ($p < 0.001$).

Conclusions

The contractile properties of the inner and outer detrusor muscle layer appear to be different in pig urinary bladder. The outer layer is stronger than the inner layer. Based on the limited data set, we cannot conclude that the maximum shortening velocity is significantly different between both layers. However, the differences found in both isometric and relative force are important in modelling the bladder, bladder neck and urethra complex. Recently, it was demonstrated that the urethral longitudinal smooth muscle layer appeared to be continuous with the detrusor [4]. Our findings suggest that also in bladder neck and urethral smooth muscle layers differences in contractile properties might exist.

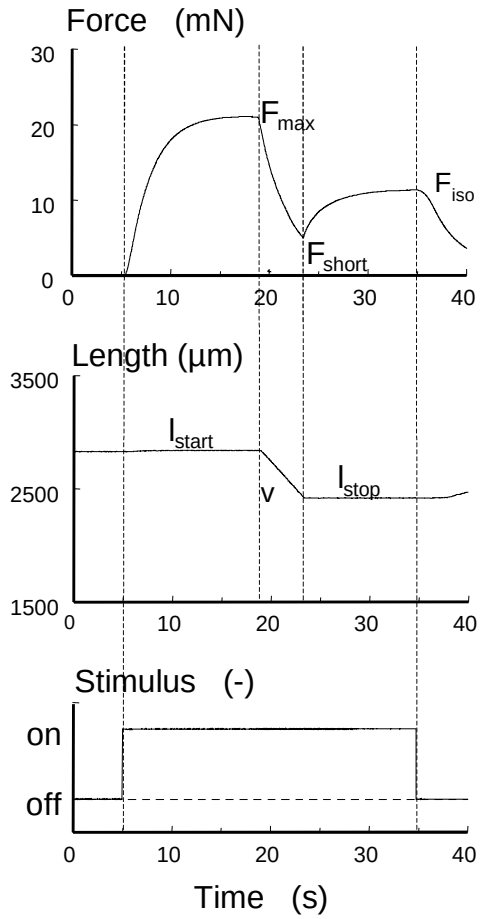

Figure 1: An example of a stop-test measurement. When the stimulus was turned on (lowest panel), the force increased to F_{max} (upper panel). Then the muscle fibre was shortened from l_{start} to l_{stop} (middle panel) with a pre-set velocity, v. During shortening the force decreased until a minimum was reached at l_{stop}. Then, the force at l_{stop}, F_{short}, recovered to an isometric value, F_{iso}.

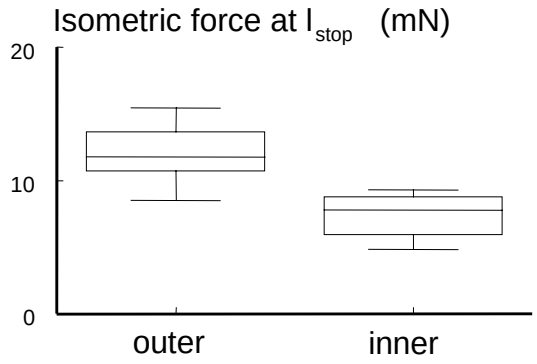

Figure 2: A Box-Whisker graph of the isometric force measured in muscle fibres taken from the inner and outer detrusor muscle layer. The box represents the 25th to 75th percentile of the data, the line in the box the average value. The error bars represent the 5th and 95th percentile of the data.

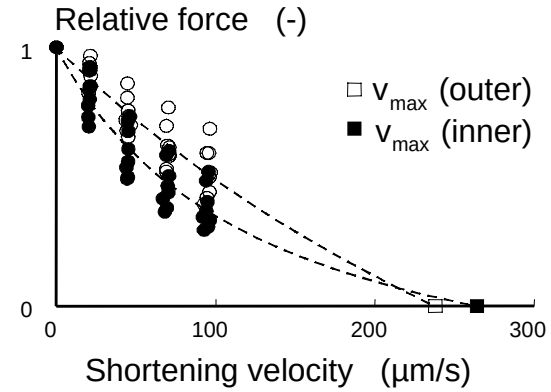

Figure 3: The relative force (F_{short}/F_{iso}) as a function of 4 different shortening velocities applied. The fitted curve intercepts the horizontal axis at the maximum shortening velocity, v_{max}, of the inner (closed circles) and outer (open circles) detrusor muscle fibres.

References

[1] Radiology 187:151-155,1993
[2] J Urol 166: 721-727,2001
[3] Urol Res 13:11-17, 1985
[4] J Urol 1294-1299, 2001

Acknowledgements

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