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COMPLIANCE OF THE URETHRA: A POSSIBLE CONTRIBUTION TO THE DIFFERENCE IN MAXIMUM FLOW RATE BETWEEN MEN AND WOMEN?

Aims of study

On average women void at a higher maximum flow rate than men, the difference is approximately 5 ml/s [1]. One factor that might contribute to this difference in maximum flow rate is the difference in length of the male (around 17 cm) and female urethra (around 4 cm) [2]. A second possible factor is that women do not have a prostate. Our hypothesis is that the compliance of the urethra could also contribute to the difference in maximum flow rate. A short stiff tube accommodates a smaller flow rate than a longer more flexible tube with the same calibre. For developing a biophysical model of the humane male urethra we studied the viscoelastic properties of pig urethras as a reference and we found a difference in elastic properties between male and female pig urethras.

Materials and methods

We used the proximal part of 7 male pig urethras (53 ± 17 mm in length) and 9 female pig urethras (47 ± 14 mm in length). The urethras were extracted from freshly killed pigs. One side of each urethra was connected to a 5 ml syringe and the other to a pressure transducer. By manually injecting a known volume of water, strain was applied to the urethral wall. In each urethra stepwise increasing volumes, with increments of 0.2 ml, were injected. The pressure in the urethra was sampled with a frequency of 1000 Hz and stored on a PC.

We calculated the stress at each applied level of strain from the pressure rise in the urethra, after the viscoelastic transients had faded. The applied strain was calculated from the injected volume. For each pig urethra the measured stress was plotted against the applied strain. We characterised the stress-strain data in male and female pig urethras by fitting exponential functions to the data and calculated the 95% confidence interval of the fitted functions.

We also made a cross section of the proximal part of a female and a male pig urethra and stained elastin, collagen and muscle tissue using elastic Von Gieson staining. We used image analysis to measure the amounts of collagen/elastin tissue and muscular tissue in both the cross sections.

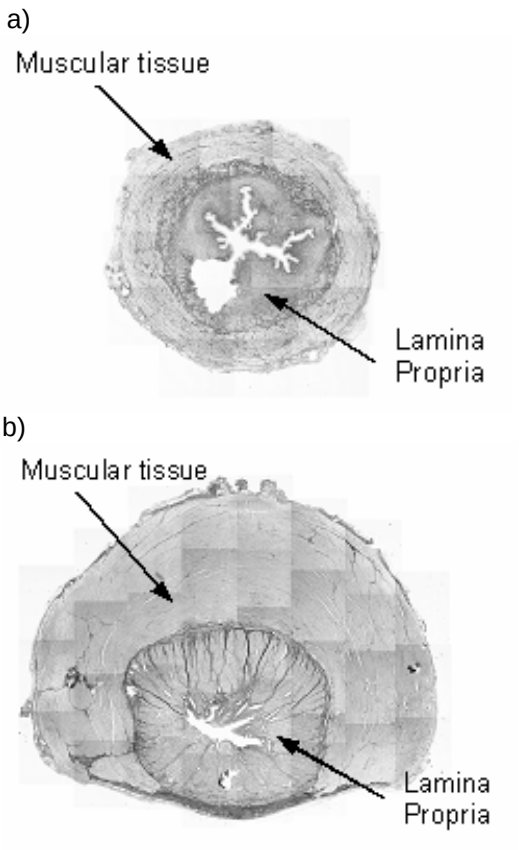

Figure 1: Cross section in the proximal part of a female (a) and a male (b) pig urethra. Scaling is equal in both cross sections.

Results

Cross sections of the proximal part of a female (a) and a male (b) pig urethra are shown in Figure 1. In the cross sections dark grey lines denote the elastin and collagen tissue and the muscular tissue is shown by a light grey colour. The amount of collagen/elastin tissue is approximately equal in the male and female cross section, whereas the total amount of tissue in the male cross section is approximately twice as large as that in the female cross section.

The measured stress-strain data for male and female pig urethras are plotted in Figure 2. There is no overlap between the 95% confidence intervals of the fitted functions, which

means that there is a significant difference in elastic properties between the proximal parts of the male and female pig urethra. In the male urethral wall stress increases steeper and at a lower strain than in the female urethral wall.

Interpretation of results

The difference in elastic properties between the male and female pig urethra suggests that the female urethral wall is easier to stretch and can be stretched to a larger extent than the male urethral wall. There is also a difference in cross section of the proximal part of the urethra between male and female pigs. Assuming a lamina propria of equal size in the male and female cross section, the approximately equal amount of collagen/elastin and double amount of total tissue in the male cross section suggest that the amount of muscular tissue surrounding the lamina propria is larger in the proximal part of male pig urethras than in that of the female pig urethras. This difference in the amount of muscular tissue might be responsible for the difference in elastic properties of the proximal part of the urethra between male and female pigs.

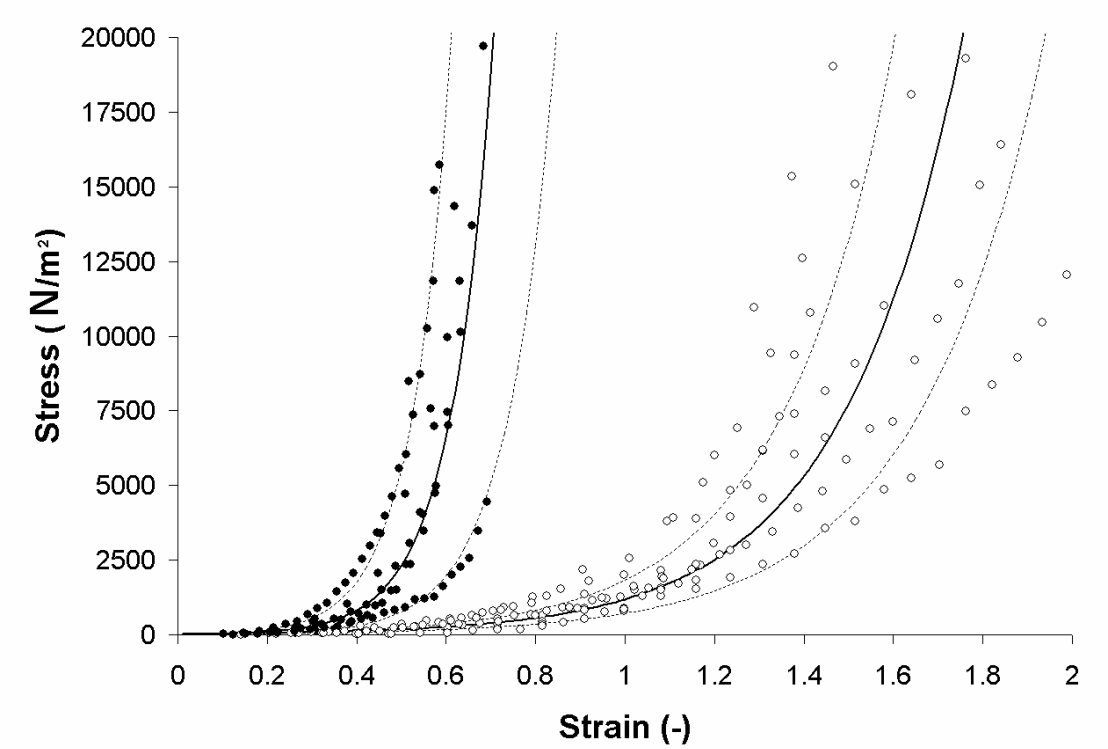

Figure 2: Stress in the urethral wall of male (•) and female (o) pig urethras as a function of the applied strain with fitted exponential (solid lines) and 95% CI of these fits (dashed lines).

Concluding message

There is a significant difference in elastic properties between the female and male pig urethra. This difference implies that it is easier for urine to pass through a female pig urethra than through a male pig urethra. When this difference in elastic properties is extrapolated to the human situation, it follows that the compliance of the urethra might be a factor contributing to the difference in maximum flow rate between men and women.

References

[1] Neurourology and Urodynamics, Macmillan Publishing Company New York, p. 169;
[2] Urodynamics, Adam Hilger Ltd. Bristol, p. 5 – 6.

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