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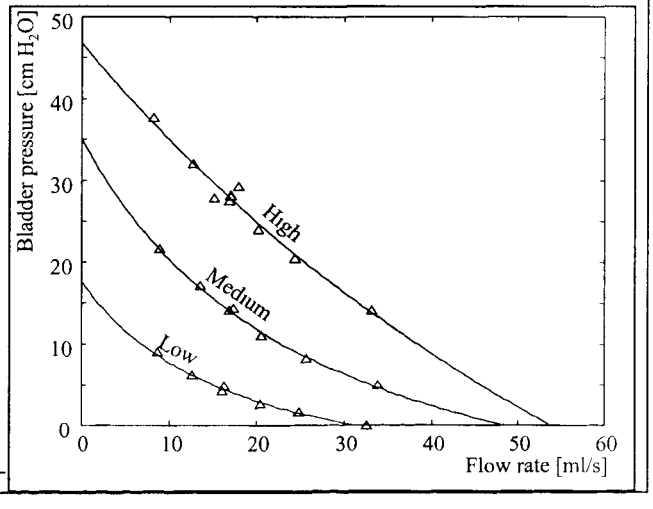
THE BLADDER OUTPUT RELATION : DEPENDENCE ON DEGREE OF BLADDER ACTIVATION

Aims of study

The bladder output relation describes the relationship between the pressure generated by the bladder and the flow rate out of it. The intersection of the bladder output relation with the the urethral resistance relation determines the actual pressure and flow rate during voiding. In itself, the bladder output relation depends on myogenic and geometric factors, which may be called the intrinsic contractility of the detrusor, and on its degree of activation. It is known that the neurogenic activation of the bladder varies during voiding, and that it is not maximal in normal voiding. For a correct diagnosis and treatment of dysfunctional voiding it is therefore important to be able to discriminate between myogenic and neurogenic causes for a weakly contracting bladder. As a first step towards this goal, we have studied the dependence of the bladder output relation on bladder activation in complete pig urinary bladders in vitro.

Methods

Male pig urinary bladders were obtained from the slaughterhouse, and suspended in a heated and aerated 3 liter organ bath containing modified Krebs solution. A stainless steel cannula was inserted via the proximal part of the urethra and connected to an external pressure transducer and a high performance roller pump. The volume in the bladder was controled by pumping in and out of a reservoir that was continuously weighed. The bladders were repeatedly stimulated to contract by applying alternating pulses of 50 V amplitude, 100 Hz repetition rate and 5 ms pulse duration to the cannula and a stainless steel cage surrounding them. When, during stimulation, the pressure in the bladder was maximal, a small amount of fluid was withdrawn at a preset flow rate. This procedure was repeated at different flow rates. The pressure measured during shortening was plotted as a function of the flow rate applied, as shown in the figure ("High" curve). A hyperbolic



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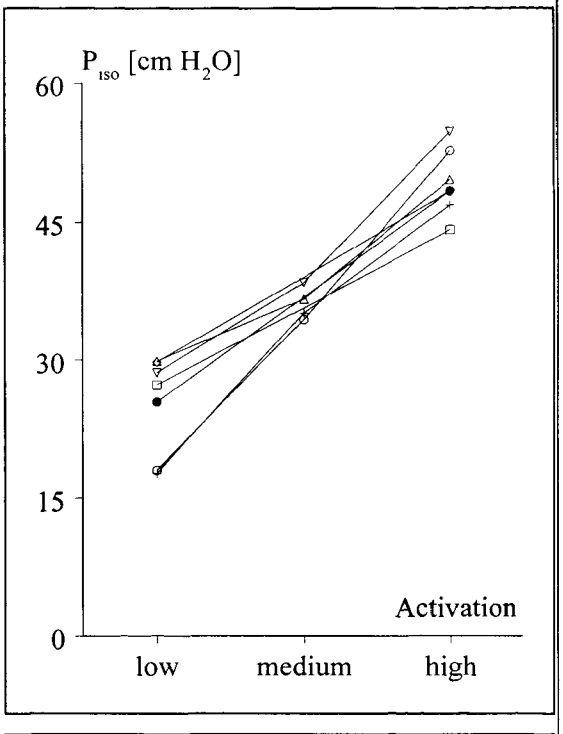
Hill equation was fitted to the data. Subsequently the procedure was repeated at a lower stimulation voltage ("Low"), and at an intermediate voltage ("Medium").

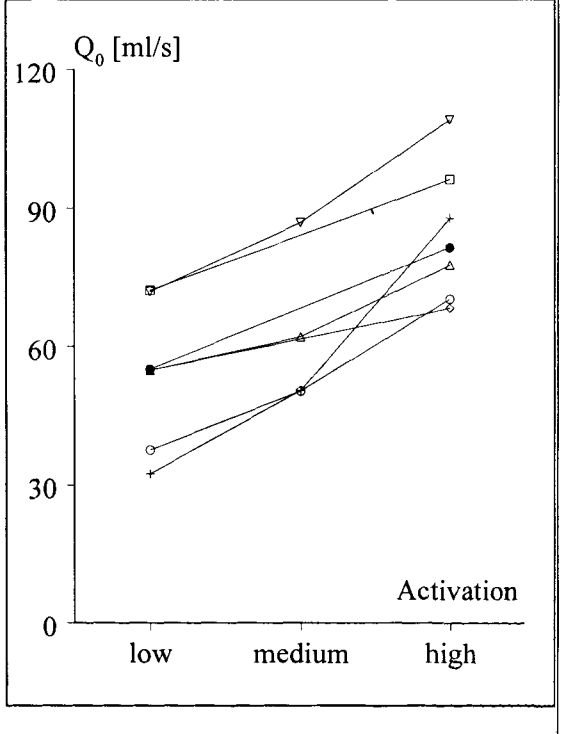
Results

Seven series of measurements were completed in five bladders. Mathematically, the bladder output relations were described using three parameters : the isovolumetric pressure P_{iso}, the maximum flow rate Q_0, and the "curvature" of the relation. The latter was found to vary with the degree of activation, most often at higher activation the bladder output relation was less curved than at lower activation as in the example shown. However, allowing for a variable curvature of the relation made the estimation of the maximum flow rate unreliable. Therefore a relation with an average curvature was fitted to the data. As shown in the figures, both the isovolumetric bladder pressure and the maximum flow rate increased consistently with the level of bladder activation, these increases were significant (Wilcoxon matched pairs, p=0.018).



Conclusion and discussion

The (isovolumetric) pressure developed by a contracting bladder depends on the number of cross-bridges connecting the contractile proteins. It is not surprising that this number depends on the degree of activation of the bladder, regardless whether an increased activation results from a larger number of smooth muscle cells contracting or from an increased activation level at the subcellular level. It is however not obvious, and not known, if and how the degree of activation affects the cross-bridge turnover, which determines the maximum flow rate Q_0 of the bladder. Notice that this parameter is not the maximum flow rate Q_{max} attained during voiding, but a theoretical maximum that would be achieved if urethral resistance were negligible. We found Q_0 to increase with increasing bladder activation, and we intend to develop a method of estimating the degree of bladder activation from urodynamic measurements, based on this finding.



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