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OPTIMUM BLADDER CAPACITY FOR MINIMUM BLADDER WORK IN NORMAL MALE MICTURITION

Aims of Study

Urodynamic studies are designed to enable the evaluation of lower urinary tract function during filling and characterize micturition; by measuring detrusor pressure and urine flow rate. Analysis of the relationship between pressure-flow, can quantify the bladder working function and estimate detrusor contractility. In comparison to normal voiding, obstruction invariably produces a reduction in urine flowrate and micturition takes longer for a given bladder pressure and volume. Because of the change in both pressure and flow, it is difficult to estimate the impact of obstruction, in relative to normal values, mainly because there is a paucity of reliable, and instrumentation free, data of normal detrusor contractily derived from unobstructed males. It is thus a potentially useful to define more specifically the contractility parameters involved in normal subjects and examine the variability of these parameters with bladder volume. In the present paper, analysis is made of the relationship between detrusor contractility and bladder volume, measured on normal males during consecutive micturitions of physiologically produced urine and in the absence of urethral instrumentation. Our working hypothesis is that bladder contractility is volume dependent, and its value is optimised at critical volume.

Methods

Ambulatory urodynamic studies were conducted on 17 asymptomatic male volunteers, mean age 25.8 years weighing 75.5Kg, instrumented to monitor intravesical bladder pressure (Pves), using a supra-pubic catheter and abdominal pressure, (Pabd), using a rectal balloon over an approximately 24 hour time period. Recorded data were transferred to a PC, for analysis using a MATLAB® program, and the following values were computed: Detrusor pressure Pdet, Urethral opening pressure: Puo Maximum detrusor pressure Pdetmax, CMG volume voided per micturition Vmax and urine flowrate were directly evaluated. The bladder Working Function (WF), was calculated from the digitised data of bladder pressure and flow, obtained from the voiding phase of the CMG, based on the principle that WF is a measure of the power generated (detrusor pressureXflow rate) during micturition. Bladder opening pressure was taken as the maximum pressure during the initial isovolumetric contraction phase (Pisv). Using this approach, WF was derived from:

$$WF = [(Pdet + Pisv,max/4) *(V + Vmax/4) – Pisv,max*Vmax/16)]/2\pi$$

Where: Pdet is the detrusor pressure calculated from the difference of Pves and Pabd
Pisv,max, or maximum pressure during the isovolumetric contraction phase, was considered to be identical to the bladder opening pressure described above.
The shortening velocity of the detrusor circumference for a volume V, was calculated from: $V= 0.5*Q/[3/(4\pi)*(Vmax)]^{2/3}$,assuming that the bladder is spherical, bladder volume was derived from the total voided. Pressure/flow data were pooled as a function of urine volume voided at 50 ml increments and the variation of WF with respect to time during voiding was calculated. Numerical values are given as mean±standard error.

Results

Figure 1 illustrates the volume dependence of detrusor contractility WF throughout the micturition cycle. As shown, WF is minimum at bladder volumes between 300-350 ml. The numerical values of WF were 11.43±1.14 Watts/m2 at a bladder volume 330±12 ml representing the optimum bladder volume. Significantly higher WF values, 15.2±1.4 Watts/m2 were evaluated at lower bladder 200-250ml volumes ($p<0.01$). Similarly significantly higher WF values 18.6.±1.5 Watts/m2 were evaluated at bladder volumes 400-550.

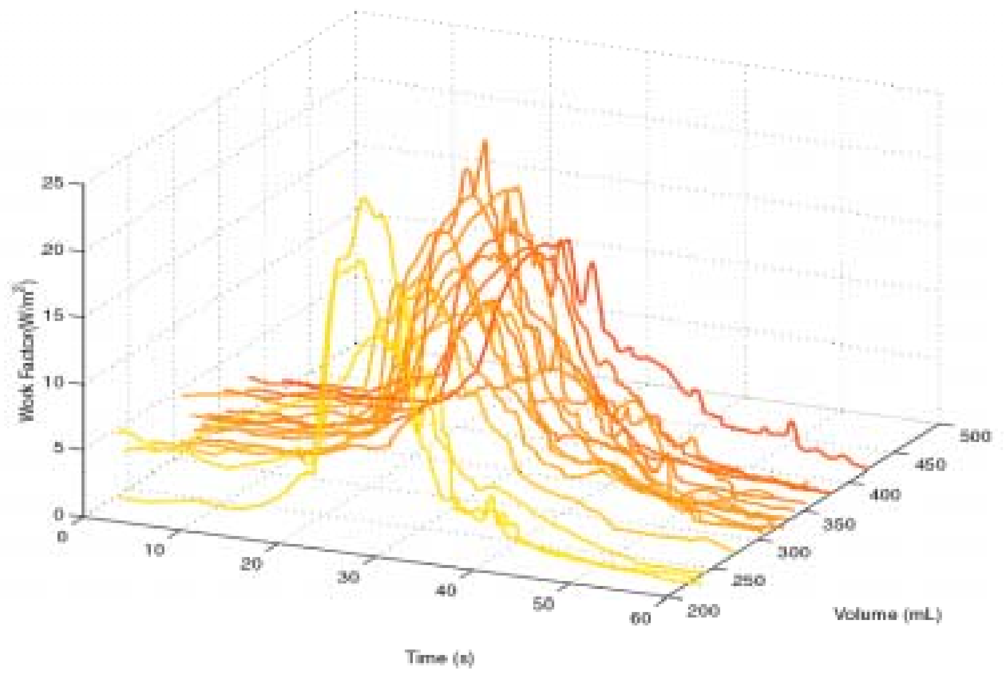

Figure 1 Variation of Work Function during micturition, Vertical axis, with respect to:
Time, horizontal axis, classified in 50 ml increments of micturated bladder Volume.

Conclusions

This study demonstrates that during normal male micturition there is an optimum range of bladder volumes, where bladder contractility occurs at minimum values of WF. Above and below this volume significantly higher detrusor work is required for bladder emptying. These observations are suggestive of the "Frank-Starlings" type of relationship where, in analogy to the heart, developed tension increases to a maximum and then declines as the volume increases.