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DETRUSOR PRESSURE IN CYSTOMETRY COMPARED TO PHYSIOLOGICAL FILLING IN PATIENTS WITH A REFLEX URINARY BLADDER AFTER SPINAL CORD INJURY

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ABSTRACT. The maximum detrusor pressure and the duration of detrusor contractions in 10–50 ml/min fill cystometry were compared to the corresponding measurements during 12 hours of physiological filling, in 18 patients with a reflex urinary bladder after spinal cord injury. In four consecutive cystometries with 10 min intervals the intraindividual variation of the maximum detrusor pressure and the duration of detrusor contractions were similar to the variation during physiological filling. The mean pressure values in cystometries of each patient correlated well with the mean values in registration during physiological filling. In cystometry, there was no significant difference between mean values in 50 ml/min filling compared to 10 ml/min filling nor between mean values in first and second cystometries compared to third and fourth cystometries. Thus, mean values from a series of 10 ml/min or 50 ml/min fill cystometries appear to be as useful as registrations during physiological filling to describe the mean maximum detrusor pressure and the mean duration of contractions in a patient with a spinal reflex bladder.

Key words: manometry, neurogenic bladder, pressure, spinal cord injuries—complications, urodynamics.

In patients with a reflex urinary bladder, after spinal cord injury, urodynamic evaluation is important for the rehabilitation programme. In many patients it can be necessary to recuce the amplitude and duration of the detrusor pressure during bladder contractions (10). The detrusor pressure varies intraindividually in contractions during physiological filling of the bladder, both with respect to maximum amplitude and duration of contraction. The mean pressure values from a series of contractions during one day can be reproduced during the following day and thus seem to be useful to describe the detrusor pressure of an individual patient (9). Since registration of a series of contractions during physiological filling is time consuming, the aim of this study was to evaluate whether pressure values registered at cystometries with 10 or 50 ml/min filling rate might correspond to values during physiological filling of the urinary bladder.

PATIENTS

Eighteen patients with a traumatic spinal cord lesion were studied. The inclusion criteria were: 1) More than six months since the lesion. 2) Reflex bladder, according to Lapides classification (7), with neither sensation of bladder filling nor voluntary control of the bladder on clinical examination and cystometry. 3) No previous urinary tract operations.

All patients were men with an age ranging from 20 to 50, and a median of 26. The time after lesion ranged from 7 months to 22 years with a median of 2 years. Six patients had tetraplegia and 12 had paraplegia. Eleven patients had clinically complete lesions, Frankel class A (3), and 7 patients had some sensation for touch but no sensation for pain nor any motor function below the level of the lesion, i.e. Frankel class B with anterior cord syndrome. The bulbocavernosus reflex, the anal stretch reflex and the achilles tendon reflex were positive in all patients.

Thirteen patients were on clean intermittent self-catheterization and five patients emptied their bladders by tapping. In addition, all patients had spontaneous reflex emptying and used urinary collecting devices. During the urodynamic study and during the preceding week no patient was on any medication which affects the function of the lower urinary tract (2). No intravesical calculus was observed on X-ray examinations three days before the urodynamic study. No patient had clinical symptoms of urinary tract infection when admitted one week before the study and those with asymptomatic bacteriuria were treated with appropriate antibiotics during the week before the study.

METHODS

Four cystometries with 37°C normal saline infusion were performed in each patient. During the first and the third cystometries the filling rate was 50 ml/min. During the second and the fourth cystometries the filling rate was 10 ml/min. Filling was stopped when leakage was observed, which happened in every contraction. The interval between the end of one cystometry and the start of the next one was about 10 min.

After the cystometries, detrusor pressure was monitored during 12 hours of physiological filling of the bladder. The

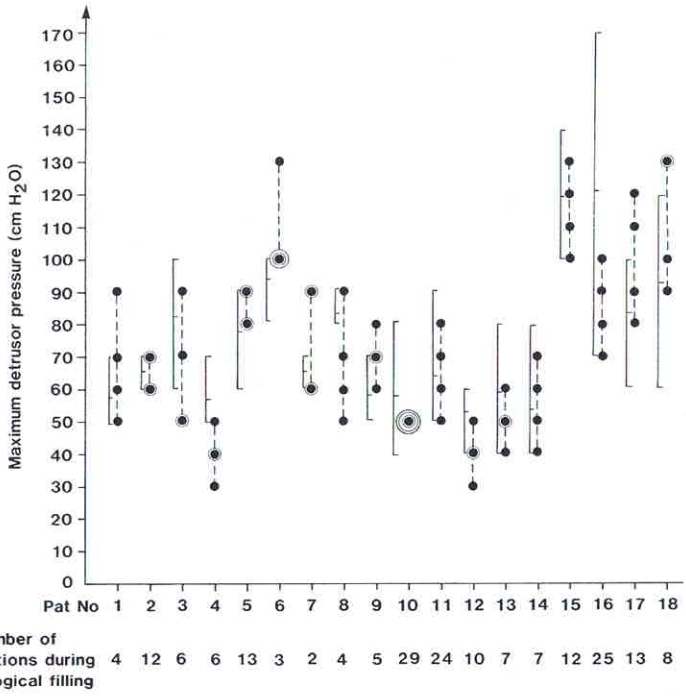

Fig. 1. Individual values of the maximum detrusor pressure in four cystometries (dots). A circle indicates identical values. Individual values during physiological filling are shown as lines, with indications of mean and range.

individual mean diuresis during this period ranged from 0.7 to 3.3 ml/min. In addition to self-catheterization or tapping, according to the usual individual routine, all patients had spontaneous reflex contractions and these were used for comparison with contractions induced by cystometry. The number of spontaneous reflex contractions during the 12 hours of physiological filling ranged from 2 to 29 with a median of 8.5.

The cystometries were done with the patients in about 30° sitting position, and during the physiological filling the patients were allowed to change between supine and about 80° sitting position.

Two intravesical and one prevesical teflon artery catheters, with an inner diameter of 1.0 mm and an outer diameter of 1.5 mm (Cuells 301), were introduced suprapubically with the Seldinger technique (9). One intravesical catheter and the prevesical catheter were connected to pressure transducers (Siemens Elema 746–5) via 100 cm long pressure monitoring tubes (Bentley). The transducers were placed at the same level as the upper edge of the symphysis pubis and connected to a pressure amplifier (Siemens Elema 863) and a multichannel recorder (Watanabe Linear Corder Mark VII). Paper velocity was 0.5 mm/s. The system was calibrated against a water column and against the air pressure before and after the registrations. The detrusor pressure was calculated as the difference between the intravesical and prevesical pressures by electronic subtraction (9). The second intravesical catheter was used for filling and emptying of residual urine in the four cystometries.

The maximum detrusor pressure in each contraction was measured and rounded to the nearest 10 cmH_2O units. The duration of a contraction (Dur_{20}) was defined as the time during which the detrusor pressure exceeded 20 cmH_2O, in a phasic contraction. The time during which the detrusor pressure exceeded 40 cmH_2O (Dur_{40}), in each contraction, was also measured. Methods, definitions and units conform to the standards proposed by the International Continence Society except where specifically noted (6).

To test differences, Wilcoxon's signed rank test was used. Correlations are described by Spearman's rank correlation coefficient (r_s).

RESULTS

In the group of patients the mean bladder capacity in cystometry was 367 ml with a range from 135 to 798 ml, and the detrusor pressure during the filling phase, defined as the linear pressure curve before the sharp rise due to a detrusor contraction, never exceeded 10 cmH_2O. Thus, we found no signs of low compliance within the registered bladder volumes.

Intraindividual variation of pressure

In four consecutive cystometries the maximum detrusor pressure, during the emptying phase, varied in most patients (Fig. 1) and the individual standard deviation ranged from 0 to 21 cmH_2O, with a median of 13 cmH_2O in the group of patients. During physiological filling there was also an intraindividual variation of the maximum detrusor pressure (Fig. 1) and the individual standard deviation ranged from 5 to 27 cmH_2O, with a median of 11 cmH_2O in the group of

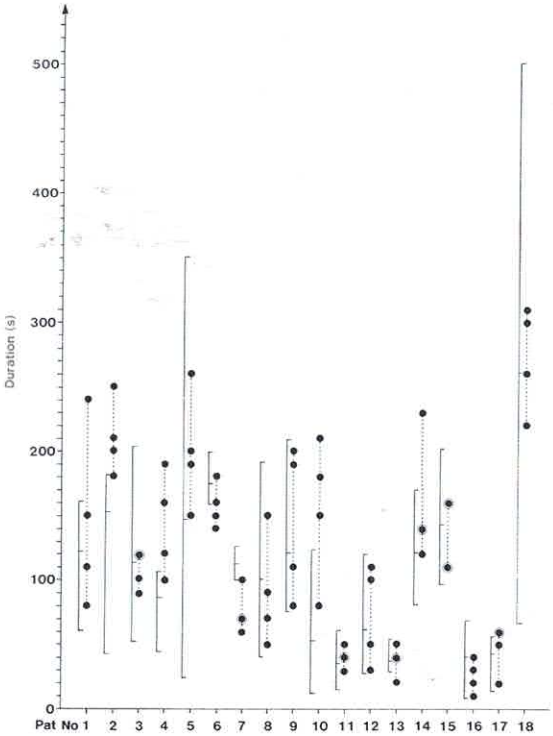

Fig. 2. Individual values of duration of detrusor contraction in four cystometries (dots). Values are rounded to the nearest 10 s and identical values are indicated by circles. Individual values during physiological filling are shown as lines, with indications of mean and range.

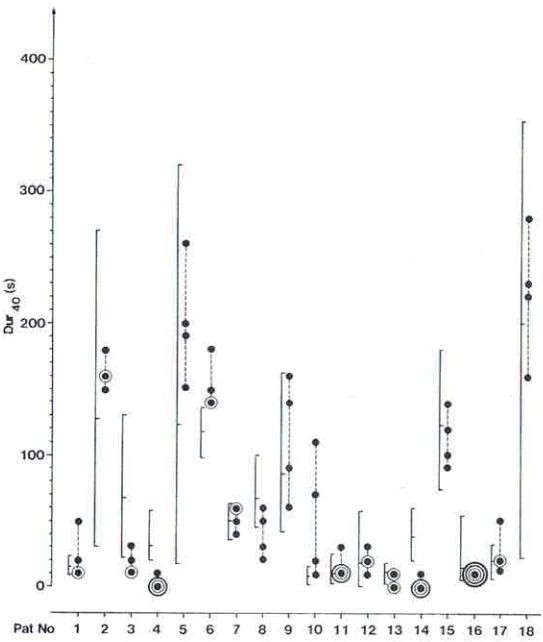

Fig. 3. Dur_{40}, i.e. the time during which the detrusor pressure exceeds 40 cmH_2O in each contraction, is shown by dots. Values are rounded to the nearest 10 s and identical values are indicated by circles. Values during physiological filling are shown by lines, with indications of mean and range.

patients. The difference of the standard deviations in cystometry compared to physiological filling was not statistically significant.

In cystometries there was also an intraindividual variation of the duration of detrusor contractions (Fig. 2) and the individual standard deviation ranged from 9 to 70 s, with a median of 30 s in the group. In physiological filling there was an intraindividual variation (Fig. 2) with an individual standard deviation ranging from 11 to 155 s, and a median of 29 s in the group. The difference of the standard deviations in cystometry compared to physiological filling was not statistically significant.

The individual standard deviation of the time during which the detrusor pressure exceeded 40 cmH_2O (Fig. 3), in each contraction, ranged from 2 to 49 s in cystometry and from 4 to 114 s during physiological filling, which was a statistically significant difference ($p<0.05$).

Cystometry correlated with physiological filling

When results from cystometry and physiological filling were compared (Table I), the individual mean maximum detrusor pressure, in the four cystometries, correlated with the individual mean maximum detrusor pressure in contractions during physiological filling (Fig. 4). The individual mean duration of detrusor contractions, in the four cystometries, also correlated with the individual mean duration of contractions during physiological filling (Table I). The mean time during which the pressure exceeded 40 cmH_2O, in cystometry, correlated with the corresponding measurement in contractions during physiological filling too (Table I).

When results from 10 ml/min fill cystometry were compared with results from 50 ml/min fill cystometry and when results from first and second cystometries were compared with results from third and fourth cystometries, we found no difference regarding maximum detrusor pressure (Figs. 5 and 6), duration of detrusor contraction or the time during which the detrusor pressure exceeded 40 cmH_2O in each contraction (Table I).

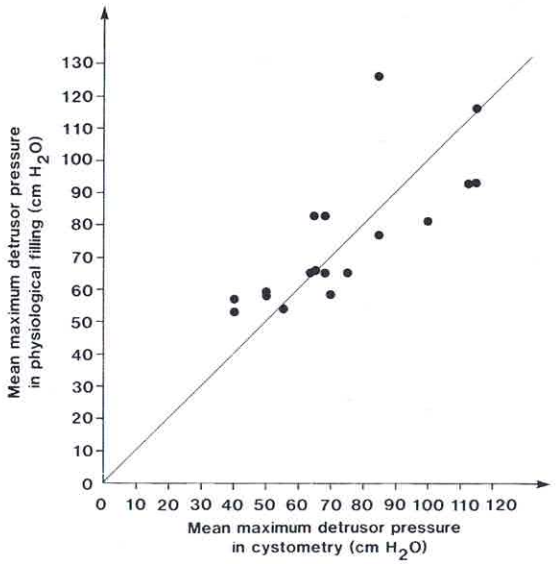

Fig. 4. The mean maximum detrusor pressure, of each patient, in four cystometries plotted against the mean maximum detrusor pressure in bladder contractions during physiological filling, $r_s=0.79$, ($p<0.001$).

We found no significant correlation between the intraindividual mean maximum detrusor pressure and the intraindividual mean duration of contraction.

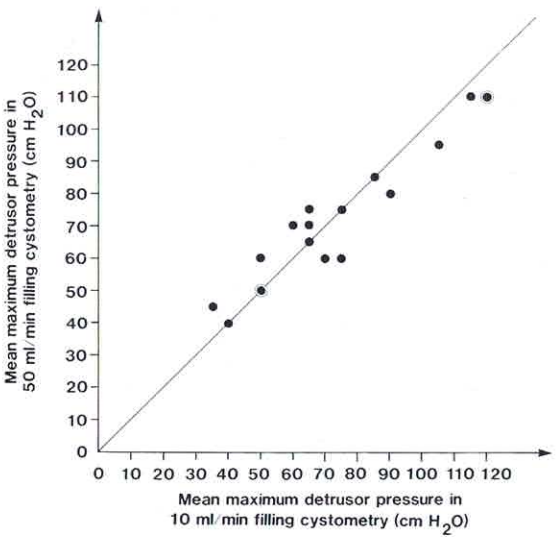

Fig. 5. The mean maximum detrusor pressure, of each patient, in two 10 ml/min fill cystometries plotted against the mean maximum detrusor pressure in two 50 ml/min fill cystometries. A circle indicates identical values. $r_s=0.91$ ($p<0.001$).

Table I. *Comparison of results, regarding mean maximum detrusor pressure (p_{max}), mean duration of contraction (Dur_{20}) and mean time during which the detrusor pressure exceeded 40 cmH_2O in each contraction (Dur_{40})*

The statistical p value is less than 0.001 for each correlation coefficient (r_s). There was no significant difference between the groups of the variables which were tested against each other

Tested groups	Variable	r_s
Physiological filling versus cystometry×4	p_{max}	0.79
	Dur_{20}	0.80
	Dur_{40}	0.74
Physiological filling versus 50 ml/min fill cystometry×2	p_{max}	0.88
	Dur_{20}	0.78
	Dur_{40}	0.74
Physiological filling versus 10 ml/min fill cystometry×2	p_{max}	0.74
	Dur_{20}	0.83
	Dur_{40}	0.80
50 ml/min cystometry×2 versus 10 ml/min fill cystometry×2	p_{max}	0.91
	Dur_{20}	0.88
	Dur_{40}	0.91
First and second cystometry versus third and fourth cystometry	p_{max}	0.79
	Dur_{20}	0.79
	Dur_{40}	0.92

DISCUSSION

In patients with a reflex urinary bladder (1), a high detrusor pressure seems to be a relevant contributing factor in the development of renal dysfunction. Important facts in prevention are the amplitude of detrusor pressure and the duration of high pressure that are acceptable and furthermore what kind of treatment that may be effective (10). It is not clear if a few daily episodes of a high detrusor pressure of short duration, with or without reflux, is an important risk factor or if the duration of the pressure elevations is a more important aspect.

To study these questions we need to know the validity and reliability of cystometry. In this study suprapubic intra- and prevesical water-filled catheters with external transducers were used in order to avoid influence on the function of the urethra and to get a well defined detrusor pressure (9). During physiological filling the maximum detrusor pressure and the duration of bladder contractions vary intraindividually in patients with a reflex bladder, but mean values from a series of contractions during one day correlate well with mean values during the following day. Furthermore, the standard deviation of the maximum detrusor pressure may be used to validate

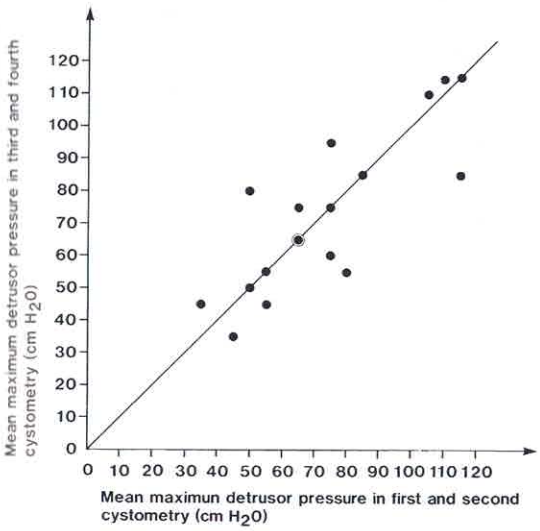

Fig. 6. The mean maximum detrusor pressure, of each patient, in the first and second cystometry plotted against the mean maximum detrusor pressure in the third and fourth cystometry. A circle indicates identical values. $r_s=0.79$ ($p<0.001$).

how representative the mean value, from a certain number of contractions, is of the mean value that would theoretically be observed in a large number of contractions, under similar conditions (9). In this study we examined whether 10 or 50 ml/min fill cystometry gives as representative measurements as measurements during physiological filling.

The intraindividual variation of the maximum detrusor pressure and the intraindividual variation of the duration of detrusor contractions in four consecutive cystometries corresponded well with results previously observed by us during 24 hours of physiological filling (9). A detailed comparison of similar studies is difficult because of differences in patients, methods and presentation of results. Regarding the maximum intravesical pressure, diagrams reported by Grynderup (5) in double cystometries performed in a group of patients with multiple sclerosis and detrusor hyperreflexia and by Petersen & Hedegaard (8) in three or four consecutive cystometries, in patients with varying neurological lesions and detrusor hyperreflexia, however, seem totally with our results. We did not find similar studies of the duration of the pressure.

In this study the mean maximum detrusor pressure and its duration in cystometry correlate with the corresponding parameters in physiological filling. Grynderup found no significant difference in maximum intravesical pressure in medium fill (10–100 ml/min) cystometry compared to rapid fill cystometry (5). We did not use rapid fill cystometry since this seems to cause high pressure during the filling phase (4) which we have not been able to reproduce during physiological filling in patients with a reflex bladder (9).

In sequential cystometries, one might expect differences due to adaptation to the procedure, but we found no significant difference between the mean maximum detrusor pressure in the first and second cystometries compared to the third and fourth cystometries. This tallies with the results of Petersen & Hedegaard (8).

This study focuses on the aspect that the filling rate in medium fill cystometry is different from the filling rate in physiological filling of the bladder. It seems, however, that mean values from a series of 10 ml/min or 50 ml/min fill cystometries give as representative information about mean maximum detrusor pressure and mean duration of each contraction as registrations during physiological filling, in a patient with a reflex urinary bladder after spinal cord injury.

For further discussion about the relation between cystometry and physiological conditions one may need to specify whether the term physiological refers to the function of the bladder of a person, with a reflex bladder, in his normal activity and environment or if it refers to examination of the bladder function, in standardized activity and environment, by introduction of catheters that may alter this function. When detrusor pressure is regarded as an important parameter it is difficult to avoid catheters (9). Unwanted effects of sensory stimulation from catheters, in a patient with uninhibited reflexes, might increase if examinations were done in a more active patient.

Another aspect is when filling should be stopped during cystometry. If it were to be continued during the detrusor contraction, a prolonged contraction might result. In this study, filling was stopped when leakage was observed, but a more physiological end point might be as soon as the detrusor contraction is observed, or at least when the pressure exceeds about 40 cmH_2O when there would physiologically be no filling (9).

CONCLUSION

In order to describe the maximum detrusor pressure and the duration of detrusor contractions, in a patient

with a spinal reflex bladder, mean values from a series of consecutive 10–50 ml/min fill cystometries seem to be useful. This method may be used in studies of the causal relation between a high detrusor pressure and renal complications and also for evaluation of any treatment which is assumed to change the detrusor pressure.

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