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BLOOD PRESSURE RESPONSE TO DETRUSOR PRESSURE ELEVATION IN PATIENTS WITH A REFLEX URINARY BLADDER AFTER A CERVICAL OR HIGH THORACIC SPINAL CORD INJURY

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ABSTRACT. In 12 patients with a reflex urinary bladder after a cervical or high thoracic spinal cord injury, blood pressure was measured every 30 s during cystometry. Four consecutive cystometries were performed by means of suprapubical catheters and 50 ml/min filling rate. The aim was to improve the methodological basis for cystometrical studies of paroxysmal hypertension and its treatment. In each cystometry there was an elevation of the systolic (20–60 mmHg) and the diastolic (15–55 mmHg) blood pressure. The maximum blood pressure always occurred during the emptying phase and always in close relation to the peak of the detrusor pressure. The amplitude of the blood pressure response varied intraindividually, but did not change in any particular direction during the series of cystometries. Thus, a cystometrical method which stimulates the detrusor in a physiological way is sufficient to give the typical uninhibited blood pressure reaction in most patients with a reflex bladder and a spinal reflex vasomotor function after a high level spinal cord injury. The blood pressure reaction obtained with this method is probably representative for the daily reaction during physiological reflex emptying of the bladder. To describe the maximum blood pressure reaction, it has to be measured during a well defined emptying phase and close to the occurrence of the maximum detrusor pressure. Since repetition of cystometry did not change the blood pressure response, this cystometrical method is useful for evaluation of pharmacological intervention.

Key words: blood pressure; neurogenic bladder; spinal cord injuries, complications; sympathetic nervous system, physiopathology; urodynamics.

In patients with a spinal cord injury above the fifth thoracic segment, the lack of supraspinal vasomotor control may lead to considerable clinical problems (4, 15). When the spinal reflex vasomotor activity is low, there is orthostatism and a low maximal work capacity (5). When the spinal reflex vasomotor activity is stimulated, e.g. during distension of the urinary bladder, dyssynergic reflex micturition, ejaculation and delivery, paroxysmal hypertension appears and may lead to slight inconvenience as headache and sometimes to severe cerebrovascular complications (6). Autonomic dysreflexia, or similar terms, are used to describe the signs and symptoms of this uninhibited spinal reflex function, but there is no general agreement about what level of blood pressure reaction that should be observed in order to use this term (7, 9, 10, 13).

Distension of the urinary bladder is regarded as the most common cause of the paroxysmal hypertension (7). Cystometry has been used to determine if a patient has this type of blood pressure reaction, to quantify the blood pressure elevation and to assess pharmacological prevention or treatment (11).

Cystometry has been performed with varying techniques (4, 7, 11), from which it is not always possible to specify the maximum amplitude and duration of the detrusor contraction and the time of blood pressure elevation in relation to the different phases of bladder function. Furthermore, it is not obligate that all cystometrical methods will give a reflex bladder reaction that is similar to the reaction during physiological filling (14).

In addition, it is not clear if a repetition of cystometry, within short intervals, will cause any systematical change of the blood pressure response. These questions are important for the choice of a proper technique in order to determine if a patient has this type of blood pressure reaction, to be able to quantify it and to study the effect of treatment.

In previous studies of patients with a reflex bladder we have found that the detrusor pressure of the filling and emptying phase during a series of 50 ml/min fill cystometries was comparable to measurements of the detrusor pressure during 12 hours of physiological filling (16, 17). A urodynamical method was used that gave a well defined detrusor pressure during both the filling and the emptying phase.

Table I. *Neurological functional level and classification according to Frankel*

Patient	1	2	3	4	5	6	7	8	9	10	11	12
Level	C5	C4	C8	C7	C6	C5	C6	C7	C5	C7	C6	T3
Frankel	B	A	B	A	A	A	C	A	A	B	A	B

The aim of this study was to improve the methodological basis for cystometrical studies of paroxysmal hypertension and its treatment.

PATIENTS

As a part of the regular urodynamic assessment programme, 12 patients entered the study (Table I). The following inclusion criteria were used: there should be a spinal cord lesion above the 5th thoracic segment; at least 6 months should have elapsed after the lesion; the patients should have a reflex bladder, according to Lapides' classification (8), with neither sensation nor voluntary control of the bladder on clinical examination and cystometry.

All patients were men with an age ranging from 16 to 53, and a median of 24. The post lesion time ranged from 0.5 to 16 years, with a median of 4 years.

Cause of lesion

Five patients had a traumatic injury from a swimming accident, 4 from a traffic accident, 1 industrial and 1 gymnastics accident. One patient had a vascular spinal cord injury.

Neurological data

The level of the lesion and Frankel classification (3) of each patient is shown in Table I. Those classed as Frankel B had an anterior cord syndrome and the patient classed as Frankel C had a central cord syndrome with some motor and sensory function regarding his feet, but only spinal reflex function regarding the urinary bladder. The abdominal-, cremaster-, quadriceps-, achilles-, bulbocavernosus- and anal stretch reflexes were positive in all patients.

History of autonomic dysreflexia

All patients had experienced at least some mild symptoms of autonomic reflexes (6) in association with emptying of the urinary bladder, ejaculation or emptying of the bowel and also urinary tract infection. Eight patients had experienced one or a few attacks of headache. In 6 of these patients at least one short episode of paroxysmal hypertension was documented and in 3 facial vasodilatation had also been observed. In 1 patient severe attacks of autonomic dysreflexia with cerebrovascular complications were documented (6). Six patients had experienced profuse sweating. In 1 patient piloerection had been observed and in 2 patients mydriasis was observed when reflex ejaculation was induced. No patient reported any symptoms of autonomic dysreflexia during the week before the study.

General medical data

None of the patients had any known additional disease. No intravesical calculus was observed on ultrasound examinations and no patient had pressure sores. The bowel was emptied in the morning, 2–3 hours before the study. There were no symptoms of urinary tract infection but patients with bacteriuria were treated with appropriate antibiotics during the week before the study. Patient 3 was on medication with a daily dose of 150 mg baclofen. There was no other medication with known or suspected effect on bladder function or blood pressure in the group.

METHODS

Cystometry

Four consecutive cystometries were performed with 37°C normal saline and a filling rate of 50 ml/min. Filling was stopped as soon as the detrusor pressure exceeded 20 cmH_2O. The interval between the end of one cystometry and the start of the next one was about 10 min. The patients were in a bed with the upper part of the body elevated 30°.

The *filling phase* was defined from the time the filling started until the detrusor pressure exceeded 20 cmH_2O. The end of the following *emptying phase* was defined as the time when the detrusor pressure returned below 20 cmH_2O. The *post emptying phase* was the 3 min after the emptying phase. At the end of the post emptying phase residual urine was removed through the intravesical catheters.

Two intravesical and one prevesical teflon catheter, with an outer diameter of 1.5 mm and an inner diameter of 1.0 mm (Cuells 301), were introduced suprapubically after skin anaesthesia with lidocaine (16). One intravesical and the prevesical catheter were connected to pressure transducers (Abbot Transpac II). 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 the air pressure. The detrusor pressure was calculated as the difference between the intravesical and prevesical pressures by electronic subtraction (16). The urinary bladder was filled through the second intravesical catheter.

The maximum detrusor pressure in each contraction was measured. The duration of a detrusor contraction was defined as the time during which the detrusor pressure exceeded 20 cmH_2O. The time during which the detrusor pressure exceeded 40 cmH_2O was also measured.

Blood pressure

The systolic and diastolic blood pressure was measured in the left arm by indirect sphygmomanometry with a mercury column and auscultation of the Korotkoff sounds. The systolic pressure was defined as the pressure at which the first sound was heard. The diastolic pressure was defined as the pressure at which the last sound was heard. The measurements were

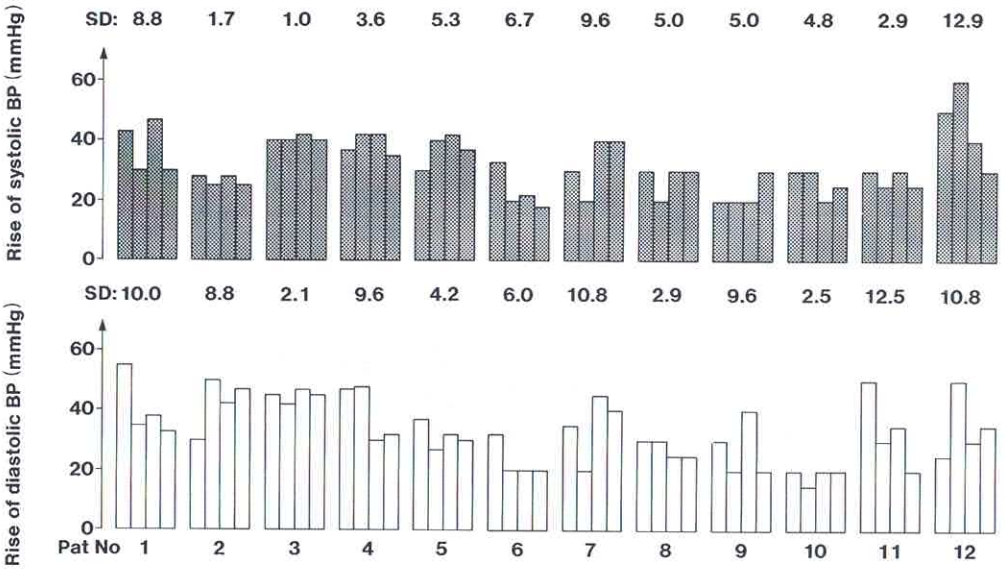

Fig. 1. The maximum rise of systolic and diastolic blood pressure in each of the 4 cystometries in each patient. The illustrated intraindividual variation is also described by the standard deviation (SD).

rounded to the nearest 5 mmHg units. At each cystometry there were 3 consecutive measurements at rest, before the filling started (Fig. 2). The mean systolic and mean diastolic pressure values from these 3 registrations were used as reference values when the maximum elevation of systolic and diastolic blood pressure during the same cystometry was calculated. During the different phases of cystometry the blood pressure was recorded every 30 s. The detrusor pressure curve was not visible for the person who measured the blood pressure.

In one patient from the study group and one additional patient we performed intra-arterial registration of the blood pressure along with the urodynamical assessments, in order to get more detailed information about the time pattern of the blood pressure elevation. The additional patient had a traumatic complete spinal cord injury with functional level C4/C5, since 5 months, with signs of return of spinal reflex function including a reflex bladder.

In 6 patients the heart rate was continuously monitored during cystometry, by an electrocardiogram (ECG). At each registration of the blood pressure, 5 consecutive heart beats were used to calculate the heart rate.

Statistics

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

RESULTS

Blood pressure reaction

In each cystometry there was an elevation of the systolic as well as the diastolic blood pressure (Fig. 1). In the 48 cystometries the rise of the systolic pressure varied between 20 and 60 mmHg and the rise of the diastolic pressure varied between 15 and 55 mmHg.

When the 4 cystometries of each patient were compared, the maximum elevation of the blood pressure varied intraindividually (Fig. 1). In the 12 patients the individual standard deviation of the maximum elevation ranged from 1 to 13 mmHg regarding the systolic pressure and from 2 to 13 mmHg regarding the diastolic pressure. The individual standard deviations are given in Fig. 1.

The maximum blood pressure was always observed during the emptying phase, i.e. during the contraction of the detrusor, and the blood pressure tended to vary in a pattern that was similar to the detrusor pressure, i.e. the highest blood pressure recordings occurred in close relation to the peaks of the detrusor pressure (Fig. 2).

The continuous intra-arterial blood pressure recordings tallied nicely with the intermittent sphygmomanometrical observations, i.e. confirmed that the elevation of the blood pressure occurred in close relation to the elevation of the detrusor pressure (Fig. 3). A detailed analysis showed that there was never more than a few seconds delay of the blood pressure response after the start of a detrusor contraction. (In this analysis the start of the contraction was defined at the moment when there was a change of the slope of the detrusor pressure curve.)

In all six patients in which the heart rate was moni-

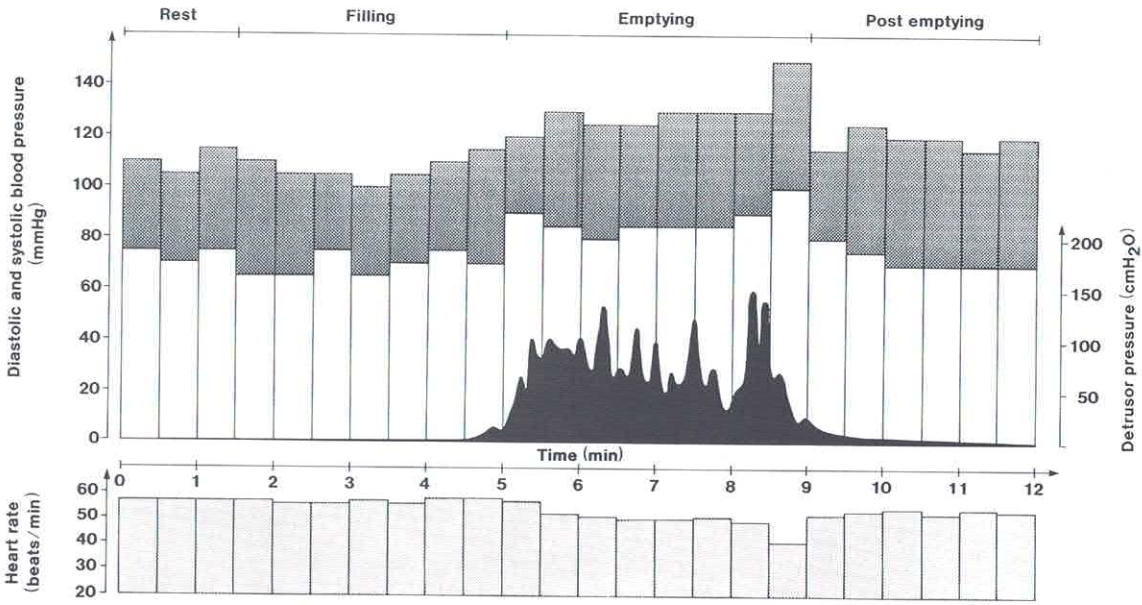

Fig. 2. Systolic and diastolic blood pressure and the detrusor pressure (black), during one cystometry. The figure shows the blood pressure recordings that were made at rest before the filling was started, and the following recordings that were made every 30 s throughout the different phases of the cystometry. This particular cystometry was chosen for illustration because of the short duration of the detrusor contraction but the pattern was typical of all cystometries, i.e. the maximum blood pressure occurred during the emptying phase, in close relation to the increase in detrusor pressure. The heart rate, as shown below, reached a minimum level at maximum blood pressure.

tored with ECG, the minimum heart rate was always observed simultaneously with the maximum blood pressure as illustrated in Fig. 2.

Blood pressure response did not change by repetition of cystometry

When the individual maximum elevation of systolic and diastolic blood pressures in the first cystometry were compared to the fourth cystometry and when individual mean values of the maximum elevation in the first and second cystometries were compared to individual mean values in the third and fourth cystometries, there were no significant differences.

A corresponding calculation regarding the individual mean systolic and mean diastolic blood pressures that were registered before each filling of the bladder disclosed no significant differences that could be attributed to the repetition of cystometry (Fig. 4).

Urodynamical parameters

The individual bladder capacity (mean of 4 cystometries) ranged from 110 to 619 ml, with a median of 265 ml. During the filling phase the detrusor pressure did not exceed 10 cm H_2O before the phasic reflex contraction occurred. The individual maximum detrusor pressure (mean of 4 cystometries) ranged from 55 to 145 cmH_2O, with a median of 86 cmH_2O. The individual duration of a detrusor contraction ranged from 45 s to 564 s, with a median of 240 s. The individual time during which the detrusor pressure exceeded 40 cmH_2O, in each contraction, ranged from 9 to 358 s, with a median of 141 s.

Blood pressure compared to urodynamical parameters

In the group of patients, the individual mean maximum elevation of systolic and diastolic blood pressure were compared to the individual mean values of the mentioned urodynamical parameters. There were significant correlations between both the elevation of systolic ($r_s=0.8$ and $p=0.005$) and diastolic ($r_s=0.6$ and $p=0.026$) blood pressure and the length of time during which the detrusor pressure exceeded 40 cmH_2O, as well as 20 cmH_2O ($r_s=0.7$ and $p=0.006$; $r_s=0.6$ and $p=0.042$). We found no significant correlation between the elevation of blood pressure and maximum detrusor pressure nor between the elevation of blood pressure and the capacity of the bladder.

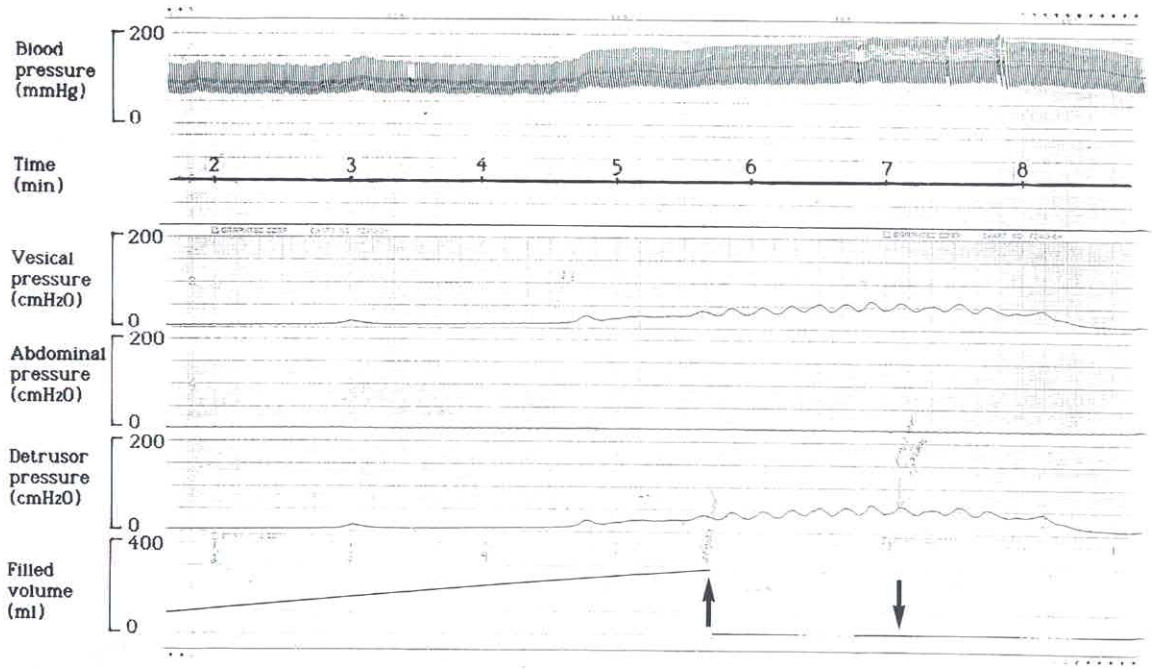

Fig. 3. Part of one cystometry with simultaneous intra-arterial registration of the blood pressure. The illustrated close relation between the detrusor pressure and the blood pressure is representative of 8 cystometries that were performed with intra-arterial catheters in 2 patients. The time axis indicates the time from the start of filling of the bladder. The left arrow indicates when filling was stopped and the first observation of micturated urine is indicated by the right arrow. The urine flow was slow and intermittent as a sign of detrusor-sphincter dyssynergia. Regarding both the blood pressure and the abdominal pressure there are small regular variations with the same frequency as the respiration (about 14/min). These variations are also observed intravesically but they are electronically subtracted from the detrusor pressure curve, which represents the difference between the intravesical and the abdominal pressure. At 3 min there is a small rise of the detrusor pressure that is accompanied by a small rise of the blood pressure. At the more consistent elevation of the detrusor pressure there is a more substantial elevation of the blood pressure.

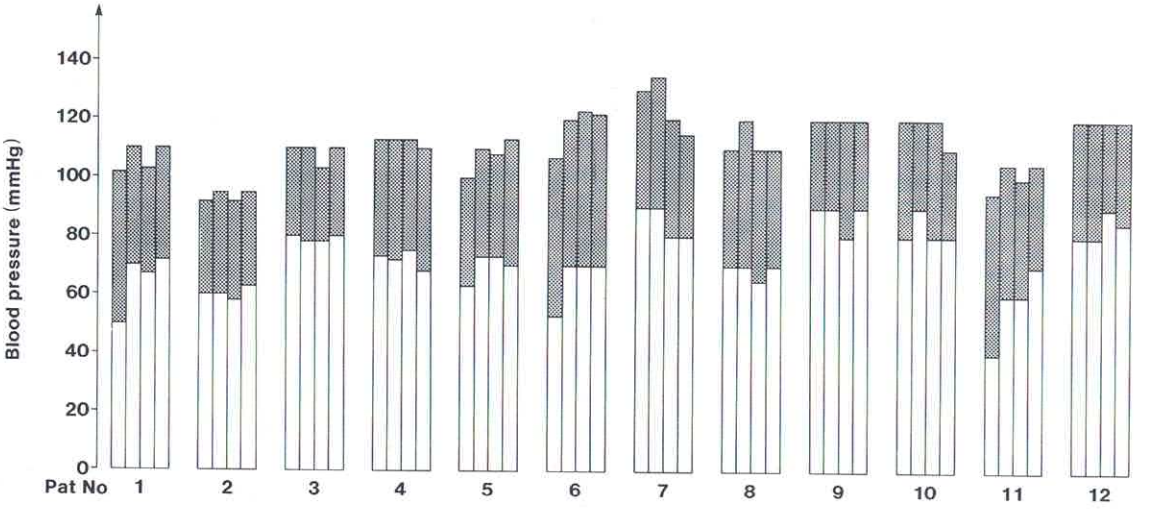

Fig. 4. Intraindividual variation of the systolic and diastolic blood pressure at rest, before the filling of the bladder in each cystometry. In each patient the 4 staples illustrate the blood pressure before each of 4 cystometries. Each staple represents the mean systolic and the mean diastolic blood pressure in 3 consecutive registrations that were done before each cystometry, in order to get a reference pressure to compare with the maximum pressure of each cystometry.

DISCUSSION

In this study autonomic dysreflexia is defined as the type of spinal cord injury in which most of the spinal reflexes distal to the fifth thoracic segment are preserved but deprived of supraspinal control. According to that definition our group of patients would be expected to have, at least potentially, reflex hypertension. They would, however, not necessarily show any signs at the time of the study.

Sometimes, however, the term autonomic dysreflexia may refer to a specific observation at which a patient suffers from paroxysmal reflex hypertension, with or without associated symptoms. In the latter case one may also have to clarify whether the observations are made during normal daily activities or during some, more or less unphysiological, procedure that is performed in order to demonstrate this type of uninhibited spinal reflex autonomic function.

One component of the spinal reflex function is the reflex vasomotor function. In a particular patient, the observed frequency and quantity of reflex hypertension will depend on: whether there is a complete interruption of descending vasomotor spinal pathways; whether the involved spinal reflexes are preserved; the interplay of different stimuli and the method of measurement. Some of these factors may be difficult to identify, but in explanations regarding causal relations e.g. between cystometry and reflex hypertension or between different pharmacological treatments and their effects, as many relevant factors as possible should be specified.

In our group of patients, an elevation of the blood pressure was observed at each cystometry, as a sign of autonomic dysreflexia. We always observed a rise of both the systolic and diastolic pressure and, in the 6 patients in which there were ECG recordings, the heart-rate always decreased in close relation to the maximum blood pressure, which tallies with the original observations by Guttman & Whitteridge (4). There are different opinions about the frequency of autonomic dysreflexia in this type of patient (6). This is probably due to the fact that different authors have not used the same magnitude of blood pressure reaction as a criterium for autonomic dysreflexia. Another reason is that the time or stimulus, at which the blood pressure was observed, has not always been well defined.

The neurological data of our patients were consistent with the discussed type of spinal cord injury. All patients included had a well defined reflex urinary bladder, but it should be emphasized that in some patients with a high level injury, and a substantial return of other spinal reflexes below the level of the lesion, a well defined reflex bladder does not develop (12). When a reflex bladder does not develop, the form of the cystometric detrusor pressure curve may be similar to the curve of those patients with a lower motor neuron lesion and an autonomic bladder who have a low compliance, i.e. the detrusor pressure gradually rises during the filling but no distinct phasic contraction occurs. Furthermore, little or no emptying of urine is observed, within moderate bladder volumes. In spite of the absence of a reflex bladder signs of autonomic dysreflexia may occur.

Our aim was to use a stimulus, that would be as physiological and standardized as possible (1, 16, 17). The method used to fill the bladder and to measure the detrusor pressure gives a well defined detrusor pressure and makes it possible to define the different phases of cystometry in a way that is similar to conditions with a physiological filling rate. The median duration of the bladder contractions, in our cystometries, also tallied with physiological filling cystometries performed by others (14). If the bladder is filled too fast or with an unphysiological medium, or if the urethra is obstructed by a catheter, the reaction would not necessarily be representative for normal conditions. In addition, a cystometry that is performed in an unphysiological way may have to be interrupted if a strong blood pressure response is observed (11), in order to avoid complications caused by the investigation.

Quantitative urodynamical data, regarding filled volume and intravesical pressure at certain intervals were reported in 4 of the 13 patients with high lesions that were studied by Guttman & Whitteridge (4). They reported that the blood pressure was elevated as long as the intravesical pressure stayed high, and that in one or two patients the blood pressure occasionally fell parallel with the intravesical pressure in spite of slow filling of the bladder, which tallies with our observations (Fig. 3).

Corbett et al. found that bladder contraction caused by percussion was associated with increased blood pressure whether or not the bladder was full (2). In a pharmacological study using gas cystometry, the filling was terminated when the blood pressure rose to 140/90 or the intravesical pressure rose to voiding level (11). According to our study the interpretation of results may be difficult if it is not possible to study a representative emptying of the bladder.

Our study has demonstrated there are no signifi-

cant changes in blood pressure response at 4 cystometries performed consecutively. Thus, the method seems to be useful for pharmacological studies. If continuous intra-arterial blood pressure measurement or measurement with short intervals is used, the standardized cystometry is suitable for further studies of short time effect on the blood pressure response by agents given in close relation to a stimulus. This is the way that antihypertensive intervention seems to be clinically useful (11). Half hourly recording of blood pressure during 24 hours has also been proposed for pharmacological studies of prophylactic agents against this type of blood pressure elevation (9). However, if the blood pressure is not measured more often, an elevation of short duration may be difficult to detect. Furthermore, a long time antihypertensive effect will probably not be the optimal treatment in most patients with a high level spinal cord injury, because of increased orthostatism (11) and further decrease of physical work capacity (5).

Within the group of patients with a high spinal cord injury, those with a long duration of elevated detrusor pressure tended to have a more pronounced blood pressure elevation. An extended detrusor contraction, during the reflex emptying of the bladder, is found in patients with severe detrusor-sphincter dyssynergia (6, 14, 16). In addition, those patients who have a high spinal cord injury, but do not develop a well defined reflex bladder (12) may have an elevated detrusor pressure of long duration during the filling phase. In these patients the risk of renal dysfunction and the risk of paroxysmal blood pressure elevation should mainly be considered. The risk levels, however, have not yet been identified (14, 16).

CONCLUSION

In order to describe the maximum elevation of blood pressure in cystometry, in a patient with a reflex bladder after a high spinal cord injury, registration of the blood pressure has to be performed during the emptying phase and has to be continuous or repeated with short intervals. With this method of blood pressure registration, repeated 50 ml/min fill cystometry with suprapubical catheters is a useful method in studies of paroxysmal elevation of the blood pressure and its treatment.

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