
Cystometrographic Patterns in Predicting Bladder Function after Spinal Cord Injury

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Summary

The cystometrographic patterns together with anal sphincter electromyograms of 62 patients with recent spinal cord injury were analysed. Four main patterns could be distinguished. The patients with well-developed detrusor reflex gained easy emptying of the bladder significantly more often than those with supranuclear injury but weak or unsustained detrusor contractions, or those with mixed spinal lesions. The patients with mixed lesions and low compliance bladders had the most severe incontinence problems. One fourth of the total series had various degrees of upper tract dilatation in their first urogram, and these changes occurred more often in patients with high detrusor activity. Urinary tract infections occurred in all patients but less often in those with areflexic bladders. This group of patients was also most suitable for intermittent self-catheterisation.

Key words: Cystometry; Electromyography; Spinal cord injury; Neuropathic bladder.

Introduction

Function of the neuropathic bladder after spinal cord injury is one of the most important factors contributing to the patient's well-being and later prognosis. Preservation of normal upper urinary tract is dependent on a balanced bladder function and control of urinary infection. To achieve this goal some degree of urinary incontinence has been generally accepted after transurethral sphincter ablative procedures.

In well equipped centres sophisticated urodynamic studies are pursued actively, and they have been shown to be of great benefit in planning therapy for various types of neuropathic bladder dysfunction (Thomas *et al.*, 1975; Rickwood *et al.*, 1982; Arnold *et al.*, 1984). It has also been stated that urodynamic studies have not influenced the therapeutic decisions (O'Flynn, 1978).

In most places, the therapeutic decisions have to be made on clinical basis, or with the help of simple urostatic measurements.

This study was started to find out whether simple routine urostatic measurements would be of help in predicting the future bladder function with regard to ease of emptying, degree of incontinence, state of the upper urinary tract, urinary tract infection and which patients would be suitable candidates for bladder outlet surgery to avoid total incontinence.

Patients and methods

All patients who had sustained a traumatic spinal injury not longer than 12 months earlier, and remitted for urological evaluation to our department during the 3-year period 1980–82, were included in the study. There were 68 patients. Five with high tetraplegia died during the first post-injury year and one was lost for follow-up, leaving 62 patients for the analysis.

Fifty-two out of the 62 patients (84%) were males and 10 (16%) were females. The mean age at the time of the injury was 33 years (range 14–60). Twenty-four were tetraplegics, 36 paraplegics and two patients had a cauda equina lesion. Forty-four out of 62 (71%) had a complete lesion below the level of the injury, and 18 (29%) were incomplete. Bladder sensation was absent in 45 (72%), lowered in 14 (23%) and normal or almost normal in 3 (5%) of the cases.

All patients had been primarily treated in a surgical or orthopaedic unit. The treatment of bladder paralysis during spinal shock had been indwelling catheter in 53 cases, suprapubic cystostomy in one, and intermittent catheterisation in eight. The patients arrived at a rehabilitation centre usually 2–3 months post-injury, and, where there was still an indwelling catheter, this was immediately removed and bladder rehabilitation with intermittent catheterisation and/or manual provocation started.

Urine samples were taken at the beginning at weekly intervals and during the follow-up at least every third month. All urinary infections were treated with antimicrobials according to the sensitivity assays. Growth of $\geq 10^5$ bacteria/ml was regarded significant.

Pharmacotherapy for spasticity (dantrolene sodium) and sympathetic dys-synergia (phenoxybenzamine) were used symptomatically.

Primary urological evaluation was carried out during the patients' stay in the rehabilitation centre, since 2–12 months had elapsed from the injury (mean 5·6). It consisted of urography and cystometry in all cases. Urethrocystography with or without voiding study was done on 50 patients and cystoscopy on 55.

A carbon dioxide cystometry (Disa type 21G01) was performed with rapid filling technique (200 ml/min). Recording of the anal sphincter activity was done simultaneously by a ring electrode mounted on an anal plug (Disa 13K78/79) and recorded on a polygraph. If there was any doubt that a cystometrogram showing detrusor areflexia was due to spinal shock, the investigation was repeated later and the latest cystometrogram chosen as the representative one.

The patterns of the cystometograms and their correlation with the following parameters were analysed:

1. Level of the spinal lesion
2. Detrusor sphincter dyssynergia
3. Easiness of bladder emptying

4. State of the upper urinary tracts
5. Urinary continence
6. Degree of urinary tract infection

Urinary continence was regarded normal if only occasional involuntary reflex emptying of the bladder or stress leakage with full bladder occurred. An incontinent patient had frequent spontaneous reflex bladder evacuations or continuous stress leakage of urine in the supine or erect position.

Urinary tract infection was divided into three degrees:

1. Completely free of infection during the last 6 months of follow-up
2. Intermittent bacteriuria but no febrile episodes
3. Chronic bacteriuria or febrile episodes

In the statistical calculations the X^2 -test was used. The follow-up from the primary urological evaluation ranges 9–44 months (mean 23).

Results

Four different main patterns of cystometograms (CMG) could be distinguished (Fig. 1):

Pattern A (37 patients): Forceful uninhibited detrusor contraction

Pattern B (5 patients): Weak or unsustained detrusor contraction

Pattern C (8 patients): Steadily rising pressure curve, low compliance bladder

Pattern D (12 patients): Flat cystometrogram.

All patients with tetraplegia had either a pattern A or B cystometrogram. Of the 11 paraplegics who had a spinal lesion above the 10th thoracic segment, nine had a cystometrogram of pattern A, one of pattern B and one of pattern D. The

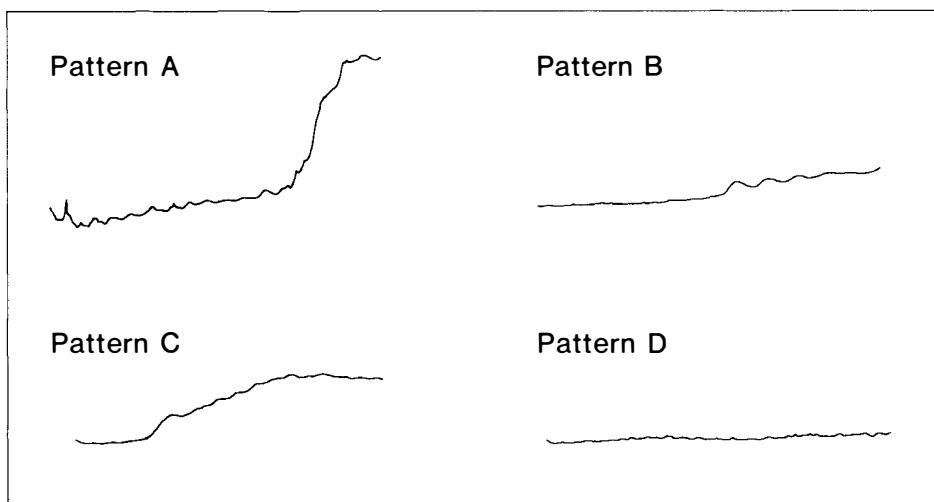


Figure 1. Four different cystometrographic patterns.

last mentioned patient also had absent sphincter tone and anal reflexes, consistent with a possible cord infarction below the injured 6th thoracic segment.

Of the 27 patients with thoracolumbar lesions at or below the 10th thoracic segment, eight patients had a pattern A, eight had a pattern C and 11 had a pattern D cystometrogram.

Detrusor sphincter dyssynergia

The anal sphincter activity increased abruptly simultaneously with the uninhibited detrusor contraction (Fig. 2) in 20 out of 34 patients with a pattern A cystometrogram. The EMG recording was not performed on three females. In the other 14 patients the activity either decreased (Fig. 3) or did not change.

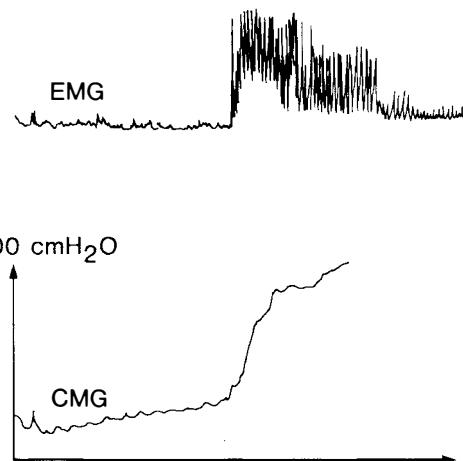


Figure 2. Pattern A cystometrogram of a 38-year-old male tetraplegic with severe voiding difficulties 1 year after injury; marked detrusor-sphincter dyssynergia.

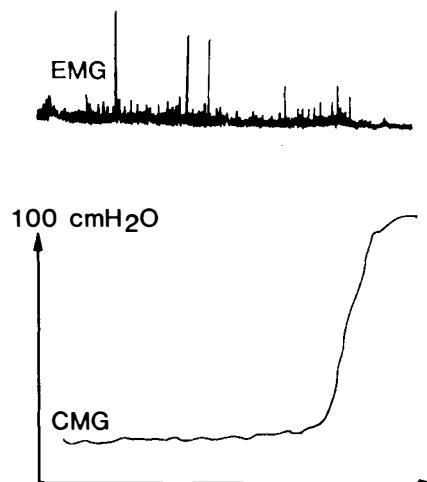


Figure 3. Pattern A cystometrogram of a 41-year-old male paraplegic with easy reflex voiding 5 months after injury; decreased EMG activity with detrusor contraction.

All five patients with a pattern B cystometrogram had a clearly increased anal sphincter activity with bladder filling.

Only two patients with patterns C and D, one in each group, respectively, had such an increased anal sphincter activity. Both had an incomplete neurological lesion.

Emptying of the bladder

The majority, 27 out of 37 patients with pattern A cystometrogram gained spontaneously easy reflex emptying of the bladder during the first post-injury year. Ten patients had difficulties. Seven of these had measurable sphincter dyssynergia. In one extreme case an extraperitoneal bladder rupture took place in an orthopaedic hospital. This patient as well as another underwent external sphincterotomy with good result, and a third patient is waiting for such an operation. One patient without dyssynergia underwent bladder neck incision with good result.

The emptying difficulties of the other six patients have so far been temporary in character and seem to correlate with general spasticity.

All five patients with pattern B cystometrogram had considerable difficulties in voiding. All had sphincter dyssynergia. Two of them underwent external sphincterotomy with good result. Two patients refused the operation. One has an indwelling catheter and the other needs daily nursing help to evacuate the bladder. The emptying difficulties have gradually declined in one patient.

Six out of the eight patients with a pattern C cystometrogram experienced difficulties in emptying the bladder. The only patient with demonstrable detrusor sphincter dyssynergia underwent external sphincterotomy with resulting mild stress incontinence with full bladder. Another patient had a TUR of the bladder neck with total incontinence as the result. Two patients are satisfied with intermittent self-catheterisation and are continent. In two patients, the emptying difficulties have been intermittent in character and not necessitated operative interventions.

Six out of the 12 patients with pattern D cystometrogram had emptying difficulties. Two of them now manage with Crede voiding, three with intermittent self-catheterisation, and one elderly female has an indwelling catheter.

The state of bladder emptying in the different groups is summarized in Table 1. There is a statistically significant difference between groups A and B ($p < 0.01$) and groups A and C ($p < 0.02$) but not between A and D.

Table 1 Bladder emptying

Pattern of CMG	Easy	Difficult	Total
A	27 (73%)	10 (27%)	37
B	—	5 (100%)	5
C	2 (33%)	6 (67%)	8
D	6 (50%)	6 (50%)	12
Total	35 (56%)	27 (44%)	62

Urinary continence (Table 2)

According to the described criteria six out of 32 males and four out of five females

Table 2 Continence

Pattern of CMG	Continent	Incontinent	Total
A	27 (73%)	10 (27%)	37
B	5 (100%)	—	5
C	3 (38%)	5 (62%)	8
D	10 (83%)	2 (17%)	12
Total	46 (74%)	16 (26%)	62

Table 3 State of the upper urinary tracts

Pattern of CMG	Normal	Dilatation	Total
A	28 (76%)	9 (24%)	37
B	5 (100%)	—	5
C	3 (38%)	5 (62%)	8
D	10 (83%)	2 (17%)	12
Total	46 (74%)	16 (26%)	62

with a pattern A cystometrogram had reflex incontinence. The mean cystometric bladder capacity of these patients was 90 ml, compared with 220 ml of the continent patients with type A cystometrogram.

All patients with a pattern B cystometrogram were continent.

Incontinence was a major problem for the patients with pattern C cystometrogram. Thus, five out of eight patients experienced continuous leakage of urine, one of these after bladder neck TUR.

Among patients with pattern D cystometrogram, two females had continuous leakage of urine.

The difference in the occurrence of incontinence between patients in groups C and D is statistically almost significant ($p < 0.05$).

Altogether four patients (6%) in the whole series have an indwelling catheter, two because of difficulties in bladder emptying and two because of incontinence. Five patients (2 in group C and 3 in group D), all continent, catheterise themselves intermittently because of emptying difficulties.

State of the upper urinary tracts

Altogether 16 patients out of 62 (26%) had upper urinary tract changes in their first urogram. Two patients had true hydronephrosis which had developed as early as 3 and 5 months post-injury. One of these patients had a pattern A cystometrogram, and the other one a pattern C. The other 14 patients with upper tract changes had various degrees of ureteric dilatation, 11 being bilateral and three unilateral. Two patients with urographic changes and one patient with a normal urogram had vesico-ureteric reflux.

There were more patients with upper tract dilatation in the cystometric groups with high detrusor activity (A and C) compared with those with low detrusor activity (B and D), but the difference was not statistically significant (Table 3).

In the follow-up, 10 out of the 16 pathological urograms became normal without surgical intervention. Both patients with true hydronephrosis had bladder neck TUR to relieve the obstruction, and the postoperative urograms

were normal. Two patients are waiting for transurethral surgery, and in case of two females temporary indwelling catheterisation led to normalization of the upper tracts.

During the follow-up infectious changes (clubbing of the upper calyx group unilaterally) have developed in one patient with a pattern B cystometrogram, despite sphincterotomy.

Urinary tract infection

All patients were primarily infected. In the follow-up 17 out of 62 patients (27%) became free of infection, 26 (42%) had intermittent bacteriuria and 19 (31%) had chronic bacteriuria with or without febrile reactions. There were no statistical differences between the groups.

Discussion

The advantages of gas cystometry are well recognized; it is simple and rapid to perform and can thus easily be used as a screening method and repeated when necessary. In some patients with neuropathic bladder dysfunction the character of the voiding disturbance cannot be solved by such simple methods, and then synchronous pressure-flow-radiological studies are of great value (Madersbacher and Dietl, 1984).

In the majority of the present cases the type of the cystometrogram was consistent with the neurological level of the injury, but there were some exceptions. Therefore difficulties were faced in trying to group the patients with different bladder disturbances according either to neuro-anatomical classifications (Bors, 1957; Hald, 1969) or the purely functional classification proposed by the International Continence Society (1981). A combination of neuro-anatomical and functional classification is urgently needed.

Anal sphincter activity registration, as an indirect measurement of urethral sphincteric function, has been used widely but it has been shown that in some cases there exists a difference (Perkash, 1980, Koyanagi *et al.*, 1982). In this work anal sphincter activity was helpful in planning the mode of surgical treatment for outlet obstruction. Those patients with marked decrease in the sphincteric activity (concomitantly with detrusor contraction), usually gained easy reflex voiding rapidly. On the other hand, some patients with dyssynergia also did so, and these patients could well represent cases where the two sphincteric functions were dissociated. In some patients an inco-ordinated EMG can also change to a co-ordinated one with passage of time (Perlow and Diokno, 1980).

The future bladder function seemed to correlate with the pattern of the cystometrogram. In patients with pattern A good reflex micturition could be anticipated. The problems in this group were related either to detrusor sphincter dyssynergia, or to hyperactive detrusor and small bladder capacity. There is probably some degree of sphincter dyssynergia in all patients with true supranuclear injury but only in part does this situation lead to a high pressure voiding system necessitating sphincterotomy (Thomas, *et al.*, 1975).

Nonobstructive severe detrusor hyperreflexia leading to diminished bladder capacity can react favourably to anticholinergic drugs (McGuire and Savastano,

1983), but in resistant cases conversion to an infranuclear paresis by neurosurgical procedures has to be considered.

All patients with poor detrusor contraction despite of high spinal injury (pattern B) had difficulties in emptying the bladder. All had also sphincter dyssynergia. The poor detrusor response could not be explained by prolonged bladder overdistension because all had been adequately intermittently catheterised. Also all had normal upper urinary tracts. This finding is consistent with some other reports (Nanninga *et al.*, 1977; McGuire and Brady, 1979) and supports the view that, if bladder emptying is adequately maintained, low detrusor activity in patients with spinal cord injury may protect the upper tracts from deterioration. These patients could be maintained indefinitely on intermittent self-catheterisation but, if the manual skills do not allow such a procedure, external sphincterotomy should be done. If this fails, a bladder neck resection may solve the problem by reducing the outlet resistance to minimum (Rossier and Ott, 1974).

The problems associated with pattern C cystometrogram were multiple. The unfavourable combination of small capacity, low compliance and lower somatomotor paresis led not only to severe incontinence but also to emptying difficulties if some innervation of the perineal musculature was left. Early upper tract changes were also seen. This complicated patient group probably would benefit most by synchronous video-urodynamic studies. Conversion to an infranuclear paresis, and thereafter intermittent self-catheterisation together with artificial sphincter, seem an attractive alternative for these patients (Barrett and Furlow, 1984).

Bladder reconstruction with enterocystoplasty, sphincterotomy and replacement with artificial sphincter also seems to open new possibilities (Stephenson and Mundy, 1984).

The patients with pattern D had both emptying and continence problems but these were relatively benign in character. Neither was upper tract deterioration a problem in this group. This again is consistent with the previously mentioned findings of low detrusor pressure and preservation of the upper tracts. If Crede voiding is not successful intermittent self-catheterisation is the choice of procedure and all of our patients were pleased with the method. Outlet surgery is to be avoided because of the risk of complete incontinence.

There was no significant difference in the occurrence of urinary tract infection between the patients with different cystometric patterns. In an earlier series with long follow-up we found a clearcut correlation between bacteriuria and upper tract changes, which were mostly obstructive in character (Ruutu *et al.*, 1984). According to the patients of the present series more follow-up time is needed to see whether disappearance or reactivation of urinary tract infection is related to change in bladder function.

It is concluded that simple cystometry is helpful in predicting future bladder function after spinal cord injury. Anal sphincter activity registration is of help in diagnosing detrusor sphincter dyssynergia although not as accurate as urethral sphincter activity.

In selected cases pressure-flow video studies give valuable additional information.

Patients with mixed spinal lesion are the most likely to develop severe in-

continence, and, in these patients as well as those with areflexic bladders and flaccid sphincters, outlet surgery should be avoided if bladder emptying can be maintained by intermittent self-catheterisation. Tetraplegics with weak detrusor contractions need sphincter ablative surgery to lower outflow tract resistance.

Résumé

On a analysé en même temps les graphiques de la cystométrie et les électromyogrammes du sphincter anal de 62 patients dont la moelle épinière avait été récemment endommagée. On a pu dégager de cette analyse quatre points principaux. Les patients possédant un réflexe expulsif bien développé obtenaient un vidage aisément de la vessie significativement plus souvent que ceux qui avaient une blessure supranucléaire mais des contractions expulsives plus faibles ou insoutenues, ou que ceux qui avaient différentes lésions spinales.

Les patients affligés de différentes lésions et de vessie à faible dilatation étaient ceux qui avaient les plus graves problèmes d'incontinence. Un quart des patients du groupe total présentaient différents degrés de dilatation du conduit supérieur sur leur premier urogramme, et ces changements se produisaient plus souvent chez les patients à haute activité expulsive. On a constaté des infections du conduit urinaire chez tous les patients mais plus rarement chez ceux dotés d'une vessie areflexique, ce dernier groupe étant également le plus désigné pour une auto-cathéterisation intermittente.

Zusammenfassung

Die Kystometrographischen Kurven mit Elektromyogrammen der Anussphinkter von 62 Patienten mit Querschnittgelähmungen waren analysiert. Vier Hauptkurven konnten getrennt werden. Die Patienten, die einen gut entwickelten Detrusorreflex hatten, konnten die Blase signifikant öfter leicht entleeren als die Patienten, die eine supranukleare Lesion aber eine schwache oder instabile Detrusorkontraktion oder Patienten, die eine gemischte spinale Lesion hatten.

Die Patienten mit gemischten Lesionen und niedrigen Blasenkomplianz hatten die schwierigsten Problemen mit der Kontinenz. In der ersten Urographie hatte 26% von den allen Serien eine verschiedene Größe Dilatation des oberen Harntraktes. Dieses Befund fand man öfter bei den Patienten mit hohen Detrusoraktivität. Alle Patienten hatten Infektionen der Harntrakt, am seltesten die Patienten mit den reflekslosen Blase. Die intermittierende Selbstkatherisierung eignete am besten dieser Gruppe der Patienten.

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