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Research Article

A comparison of urodynamic findings between patients with complete and incomplete traumatic spinal cord injuries

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Objective: To compare urodynamic findings between patients with complete and incomplete traumatic spinal cord injuries (SCI) and to determine whether it is important to test with urodynamic study in patients with incomplete SCI.
Design: Retrospective study
Setting: Ankara Physical Medicine and Rehabilitation Training and Research Hospital, Ankara, Turkey
Participants: A total of 66 patients with 36 complete and 30 incomplete traumatic SCI were included in the study, from July 2012 to September 2014.
Interventions: Urodynamic study
Outcome Measures: Maximum cystometric capacity (MCC) , vesicle pressure at MCC, detrusor function (detrusor overactivity or not), bladder complience, bladder storage and emptying disorders, post-void residual volume (PVR) and bladder emptying method were recorded. It was also recorded whether the patients used anticholinergic drugs before urodynamic study.
Results: In urodynamic findings MCC, vesicle pressure at MCC, PVR, there was no statistically significant difference between complete and incomplete traumatic SCI patients. Also there was no statistically significant difference in low-compliance of detrusor frequency and bladder storage and emptying disorder frequency. Clean intermittent catheterization (CIC) was the most commonly recommended method after urodynamic studies in both groups of patients with SCI.
Conclusions: In urodynamic study findings, there was no statistical difference between complete and incomplete traumatic SCI patients. The present study demonstrate that even if patients with incomplete SCI appear to be functionally better than the patients with complete SCI, urodynamic studies should still be performed in patients with incomplete SCI to identify bladder characteristics and to identify appropriate treatment.

Keywords: Incomplete spinal cord injury, Urodynamics, Clean intermittent catheterization, Paraplegia, Low-compliance of detrusor

Introduction

Spinal cord injuries (SCI) not only result in motor and sensorial dysfunction but also play roles in mortality and morbidity by causing dysfunction in various organs. Among the potential urinary system disorders, neurogenic bladder is one of the major causes of morbidity and mortality in patients who present with SCI. When left untreated, a neurogenic bladder may result in the development of many different urinary system complications, such as urinary tract infections, vesicoureteral reflux, nephrolithiasis, incontinence, renal failure and bladder cancer.[1] While genitourinary infections have been the most common cause of death for the last 30 years, they are today far less frequent due to improvements in the management and treatment of neurogenic bladder.[2]

Sometimes, it can be thought that bladder function is better in patients with incomplete SCI than patients with

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complete SCI, particularly in ambulatory patients. However, there have been several studies in which evidence garnered through urodynamic studies points to varying degrees of lower urinary system dysfunction, and urinary system complications may still develop even if the patient appears to have normal functions. The maximum cystometric capacity (MCC) or maximal vesicle pressure values do not differ significantly between these two groups with detrusor overactivity.[3–8]

All patients with SCI should undergo urodynamic tests to identify potential complications in the lower urinary system, and the present study compares the urodynamic findings of patients with complete and incomplete SCI through an evaluation of detrusor function, storage-emptying disorders, MCC, post-void residual volume (PVR) and methods of bladder emptying (e.g. clean intermittent catheterization (CIC), indwelling catheterization, spontaneous). Different from previous studies, the present study compared PVR, low-compliance of detrusor frequency, recommended emptying method other than MCC and vesicle pressure at MSC. The use of anticholinergics that may affect the bladder character of patients is also considered in these evaluations. If the results do not indicate a significant difference in the urodynamic findings of patients with complete and incomplete SCI, the evaluation of the neurogenic bladder in patients with incomplete SCI should be treated with equal importance as the evaluation of patients with complete SCI.

Methods

A total 66 paraplegic patients with traumatic SCI who took part in a rehabilitation program in the Ankara Physical Therapy and Rehabilitation Training and Research Hospital between 2012 and 2014, were included in this study. Patients with unstable neurologic injuries and patients who were in spinal shock were excluded from this study. The patients were divided into two groups according to the presence of complete (AIS-A) or incomplete (AIS-″B-E″) SCI, based on the classification of the AIS (American Spinal Injury Association Impairment Scale).[7] This study was approved by the local ethics committee of our hospital.

Demographical data on the patients and their history of anticholinergic use before urodynamic studies were recorded, and the patients underwent urodynamic studies using a double-lumen 8 F sterile urethral catheter with the Libra+ (MMS, Enschede, The Netherlands) urodynamic measurement system. After the bladder was emptied of urine, the bladder was filled with a sterile serum physiological at room temperature at a rate of 30–50 ml/min to perform filling cystometry. Patients were asked to describe the bladder filling sensations (the initial bladder filling sensation, the sensation of the need to urinate and the severe sensation to urinate) if they felt during the filling cystometry. Based on data collected during the filling cystometry, parameters, including MCC, vesicle pressure at MCC, detrusor function (detrusor overactivity or not) and bladder compliance, were recorded, and bladder compliance was considered normal at values of $\geq$20 ml/cm H_2O, with low-compliance of detrusor was considered at values $<$20 ml/cm H_2O.[8]

The filling phase was terminated when the patients developed a severe need to urinate when intravesical pressure exceeded 40 cm H_2O, when apparent uncontrolled urination started and when systolic blood pressure exceeded 140 mmHg or increased by more than 20 mmHg during the filling. The pressure measured at the time of a sharp increase being seen in intravesical pressure, maximum intravesical pressure and MCC, defined as the volume measured at the time of a sharp increase in intravesical pressure, was recorded. The lower limit of the normal bladder capacity was considered to be 300 ml, and a storage disorder was defined as the presence of $<$300 ml bladder capacity.[9,10]

PVR was recorded after the emptying cystometry. PVR is defined as the urine that remains in the intravesical catheter and the bladder after urination. Emptying disorders were defined as $\geq$50 ml of residual urine after the urination phase.[9,10] The emptying method that was recommended based on urodynamic findings, and included spontaneous urination, clean intermittent catheter or indwelling urethral catheter, was recorded.

The data were evaluated using SPSS package software (Statistical Package for Social Sciences, version 22.0) and P-values $<$0.05 were considered statistically significant. A t-test was used for comparisons of descriptive statistics and measurable parameters, while categorical parameters were compared with a Chi-square test.

Results

A total of 36 patients, including 27 men and 9 women with complete injury and 30 patients, including 21 men and 9 women with incomplete injury, were included in this study. Demographic and clinical features of the patients are shown in Table 1. All patients underwent urodynamic studies, and overactive detrusor was detected in 28 (77.8%) and 22 (73.3%) patients with complete and incomplete SCI, respectively ($P > 0.05$). Bladder storage and emptying disorders were noted in 18 (50%) and 32 (88.9%) patients with complete SCI,

Table 1 Demographic and clinical features of the patients.

	Complete (*n* = 36)	Incomplete (*n* = 30)	Total (*n* = 66)
Age (years)	29.22 ± 11,26	35.4 ± 12,47	32.03 ± 11.92
Interval between SCI and urodynamics (months)	19.22 ± 21.07	26.60 ± 25.93	22.57 ± 23.51
Sex, *n* (%)			
Male	27 (75%)	21 (70%)	48 (72.7%)
Female	9 (25%)	9 (30%)	18 (27.3%)
Etiological Factor, *n* (%)			
Vehicle accidents	17 (47.2%)	10 (33.3%)	27 (40.9%)
Fall from height	13 (36.1%)	14 (46.7%)	27 (40.9%)
Others[a]	6 (16.7%)	6 (5%)	12 (19.2%)
Lesion Levels, *n*			
T2	1	0	1
T4	5	3	8
T5	5	0	5
T6	2	3	5
T7	3	0	3
T8	3	3	6
T9	1	1	2
T10	1	0	1
T11	6	1	7
T12	7	6	13
L1	1	8	9
L2	0	3	3
L3	1	1	2
AIS Classification, *n* (%)			
AIS-A	36	10 (33.3%)	36 (54.5%)
AIS-B		14 (46.7%)	10 (15.2%)
AIS-C		6 (20.0%)	14 (21.2%)
AIS-D			6 (9.1%)

[a]Exposure to high weight, gunshot wounds, stab wounds.

respectively, while these figures were 15 (50%) and 27 (% 90) in patients with incomplete SCI. Comparisons of detrusor function (overactive or not), and the presence of storage and emptying disorders did not reveal any significant differences between the patients with complete and incomplete SCI (P = 0.675, P = 1.000, P = 0.884, respectively; Table 2).

A statistically significant difference was not noted when the detrusor compliance of the two groups was compared, firstly, in those with overactive detrusor who did or did not have low-compliance of detrusor, and then, in the patient group with overactive detrusor without a history of anticholinergic use before the urodynamic studies (P = 0.164, P = 0.902, Table 2).

MCC was measured during the filling phase and vesicular pressure at MCC, and PVR measured at the end of emptying phase were compared between three groups that are defined as follows: all patients with complete or incomplete SCI; patients with complete or incomplete SCI who had detrusor overactivity; and patients with complete or incomplete SCI who had detrusor overactivity but no history of anticholinergic

Table 2 Comparison of detrusor function and presence of bladder storage and emptying disorders frequency in all patients and low-compliance detrusor frequency in overactive detrusor group and overactive detrusor + without history anticholinergic use group with complete and incomplete SCI.

	Complete *n* (%)	Incomplete *n* (%)	Total n (%)	X^2	*P*-value
All Patients	36	30	66		
Overactive Detrusor	28 (77.8%)	22 (73.3%)	50 (75.8%)	0.176	0.675
Bladder Storage Disorder	18 (50%)	15 (50%)	33 (50%)	0.000	1000
Bladder Emptying Disorder	32 (88.9%)	27 (90%)	59 (89.4%)	0.018	0.884
Patients with Overactive Detrusor	28	22	50		
Low-Compliance Detrusor	17 (60.7%)	9 (40.9%)	26 (52%)	1.936	0.164
Patients with Overactive detrusor and without history anticholinergic use	16	13	29		
Low-Compliance Detrusor	12 (75%)	6 (46.2%)	18 (62.1%)	0.015	0.902

Table 3 Comparison of maximum cystometric capacity (MCC), maximum vesicle pressure, post-void residual volume (PVR) in all patients; overactive detrusor group; overactive detrusor + without history anticholinergic use group.

	MCC (ml)			Maximum Vesicle Pressure (cm H_2O)			PVR (ml)		
	Complete	Incomplete	*P* value	Complete	Incomplete	*P* value	Complete	Incomplete	*P* value
All Patients(n = 66)	359 ± 215	352 ± 187	0.343	24.6 ± 10.3	22.6 ± 10.2	0.342	322 ± 209	302 ± 201	0.840
Overactive detrusor patients (n = 50)	285 ± 181	287 ± 148	0.634	24.8 ± 10.4	22,8 ± 10.1	0.426	255 ± 184	247 ± 162	0.672
Overactive detrusor + without history anticolinergic use (n = 29)	242 ± 183	267 ± 155	0.642	26.7 ± 10.4	23.9 ± 11.1	0.792	218 ± 183	210 ± 162	0.672

Table 4 Comparison of bladder emptying method after urodynamic studies.

	Bladder emptying method after urodynamic studies		
	CIC n(%)	***Indwelling Catheter n (%)***	***Spontaneus + CIC n (%)***
Complete	26 (72.2)	8 (22.2)	2 (5.6)
Incomplete	22 (73.3)	6 (20)	2 (6.7)
Total	48 (72.7)	14 (21.2)	4 (6.1)

use before the urodynamic studies. In all three groups, the patients with complete or incomplete SCI were not found to be significantly different regarding bladder capacity, vesicular pressure at MCC and PVR (P = 0.343, P = 0.342, P = 0.842; P = 0.634, P = 0.426, P = 0.672; P = 0.642, P = 0.792, P = 0.672, respectively; Table 3).

In our study, as a result of urodynamic study, spontaneous voiding was not recommended to any patient. Only, a few patients who could spontaneously void in a certain amount, were recommended firstly spontaneous voiding than bladder emptying with CIC. CIC was the most commonly recommended indwelling in both groups of patients with SCI (Table 4).

Discussion

In the present study, urodynamic studies performed on patients with complete and incomplete SCI did not reveal any significant difference between the two groups regarding detrusor function, bladder compliance, MCC, the vesicular pressure at MCC and PVR after urodynamic studies. As the bladder characteristics were similar in the patients with complete and incomplete SCI, the medical treatments and bladder emptying methods used for these patients were also found to be comparable.

Sometimes it can be thought that bladder functions are better in patients with incomplete SCI after neurologic damage than in patients with complete injuries, and urodynamic studies are often neglected in these patients. However, we should note that as demonstrated in previous studies, and supported by our findings, lower urinary system dysfunction may still develop in patients with neurologically stable SCI.[3–6] Patki *et al.* reported previously that neurogenic bladder may also develop in patients with incomplete SCI, and when left untreated, this can even result in substantial bladder dysfunction.[5] Rather than the localization of lesions, bladder functions are important in evaluations of neurogenic bladder in patients who suffer from neurologic injuries. Urodynamic studies, which reflect neurogenic bladder dysfunction, were shown that neurological level or the severity of neurological injury does not fully reflect bladder dysfunction. The bladder function must be decided upon based on data obtained through urodynamic studies.[11]

The patients' MCC and vesicular pressure at MCC recorded at the storage phase and PVR measured at the emptying phase were investigated in three different groups (all patients, patients with detrusor overactivity, patients with detrusor overactivity and without a history of anticholinergic use before urodynamic studies). Bladder volume, maximal vesicular pressure and PVR were not found to be significantly different between complete and incomplete SCI in the three groups. In a previous study performed by Moslavac *et al.*, MCC was not found to be significantly different between patients with complete and incomplete SCI with detrusor overactivity. In that study, the MCC in patients with complete and incomplete SCI was found

to be 239 ± 107 ml and 227 ± 125 ml, respectively.[3] In another study performed in Turkey by Akkoç *et al.*, patients with detrusor overactivity and complete or incomplete SCI were compared, and the MCC in patients with complete and incomplete SCI was found to be 269 ± 139 ml and 223 ± 135 ml, respectively – the difference being statistically insignificant.[6] Similarly, when we evaluated patients with detrusor overactivity in this study, we found out that the MCC in patients with complete and incomplete SCI was 285 ± 181 ml and 287 ± 148 ml, respectively, and the difference between two groups was not statistically significant. Regarding maximal vesicular pressure, Moslavac *et al.* reported figures of 79 ± 30 cm H_2O and 70 ± 29 cm H_2O in patients with detrusor overactivity when accompanied by complete and incomplete SCI, respectively.[3] In the present study, the maximal vesicular pressure in bladders with detrusor overactivity was found to be 24.8 ± 10.4 cm H_2O in patients with complete and 22.8 ± 10.1 cm H_2O in patients with incomplete SCI, and the difference between two groups was not significant. However, the vesicular pressure levels measured in this study were lower than those reported by Moslavac *et al.*, which may be because one of our criteria in terminating cystometric tests in this study was the development of a terminal detrusor contraction, defined as vesicular pressure reaching 40 cm H_2O. In the present study, we also investigated the potential differences between the two groups regarding storage and emptying disorders and presence of low-compliance of detrusor and could not find any significant difference in these parameters. While evaluating the urodynamic findings in this study, we also compared patients with complete and incomplete SCI, considering the detrusor function and considering the use of anticholinergics before urodynamic studies that may affect bladder characteristics. However, no significant difference was noted between the patients with complete and incomplete SCI. (In group with who had overactive detrusor and in group with who had overactive detrusor and without history of anticholinergic use). In contrast, without statistical comparison, it can be seen that in the overactive detrusor group, MCC and PVR volume decreased compared to all patients. The same situation can be seen when compared the group with "who had overactive detrusor and without history of anticholinergic use" and "who had overactive detrusor". This can suggests that detrusor function and anticholinergic use can affect bladder volume. Thus, they affect all urodynamic results (storage, emptying disorders and compliance).

When the methods of bladder emptying recommended to the patients after urodynamic studies were investigated, the rates were found to be similar between the two groups. In both groups, the frequency of CIC use was higher than indwelling catheterization. In the absence of any indication of indwelling catheterization, the preferred method of bladder emptying should be CIC, condom catheter or spontaneous urination in these patients.[11–13] However, there have been several studies that reported increased rates of urinary infection and urologic complications in patients who used indwelling catheters. In addition, the number of hospitalizations and the duration of hospital stay were found to be higher in these patients, and they experienced an increased rate of non-urological medical problems. Last but not least, the compliance of these patients to an indwelling catheter was found to be lower when compared to the other methods.[14,15] In a previous study performed in Turkey by Çetinel *et al.*, CIC use was reported in 64.3% of patients with SCI.[16] A large-scale study that was carried out in the United States showed that the rate of CIC use in patients who developed neurogenic bladder after SCI increased from 12.6 to 56.2% between 1972 and 1991, while the rate of indwelling catheter use decreased from 33.1 to 16.5% over the same period, although the rate of indwelling catheter use was found to increase in parallel to disease duration.[15] In a multicentral study performed in Turkey by Akkoç *et al.*, CIC was the preferred method of bladder emptying in 73.8% of patients with SCI.[17] In summary, the most commonly used method after SCI appears to be CIC, as demonstrated in several studies in the literature, and supported by the present findings.[1,18]

Conclusion

In conclusion, the results of the present study demonstrate that even if patients with incomplete SCI appear to be functionally better than the patients with complete SCI, urodynamic studies should still be performed in patients with incomplete SCI to identify bladder characteristics and to identify appropriate treatment.

Disclamer statement

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