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ORIGINAL ARTICLE

The effects of repeated filling cystometries on cystometric variables in spinal cord-injured patients with overactive detrusor, who utilize different type of urine drainage methods

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Study design: Cross-sectional study.
Objectives: Our aim was to compare the effects of repeated cystometric measurements in spinal cord injury (SCI) patients with neurogenic detrusor overactivity (NDO) who use indwelling catheters (IDC) or intermittent catheterization (IC).
Setting: Turkey.
Methods: A total of 20 SCI patients with NDO, 9 patients on IC and 11 on IDC for at least two consecutive months were included. After emptying the bladder, first involuntary detrusor contraction volume (1stIDCV), cystometric bladder capacity (CC), bladder compliance and maximum detrusor pressure (MP_{det}) were assessed by filling it with sterile physiological saline at room temperature at a continuous rate of 30 ml min^{-1}. The bladder was re-emptied after the process and a second filling cystometry was performed in the same way.
Results: When all study population were taken into account, 1stIDCV and CC measures were significantly increased in the second cystometry compared with the first cystometry ($P=0.001$ and $P=0.022$, respectively), whereas there was no statistically significant difference on bladder compliance and MP_{det} measures between the first and the repeated cystometry. There was no statistically significant difference on 1stIDCV, CC and bladder compliance measures between the first and the repeated cystometries for IC group, whereas there was statistically significant increase on these measures in the IDC group ($P=0.003$, $P=0.008$ and $P=0.022$, respectively). In addition there was no statistically significant difference on MP_{det} measures between the first and the repeated cystometries for both the urine drainage methods. When IC and IDC groups were compared according to mean values of differences in 1stIDCV, CC and bladder compliance measures between the two cystometries, the IDC group had a statistically significant increase in all parameters when compared with the IC group in the second cystometry performed ($P=0.001$, $P=0.003$ and $P=0.048$, respectively).
Conclusion: Repeated cystometric measurements in SCI patients with NDO lead to an increase in 1stIDCV and CC. However, when the type of urine drainage method is taken into account, although repeated filling cystometry leads to an increase in 1stIDCV, MCC and bladder compliance in patients with IDC, it does not cause a difference in patients on IC.
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INTRODUCTION

Spinal cord injury (SCI) is well known to cause neurogenic bladder dysfunctions. Spinal cord lesions are classified as either upper or lower motor neurons, with respect to the anatomic location of the lesion relative to the sacral cord reflex centers. Spinal upper motor neuron lesions occur above the conus medullaris and spare the sacral reflex arc. The descending pontine (central) modulation of detrusor and sphincter activity is therefore disrupted, leading to detrusor–external sphincter dyssynergia; detrusor–internal sphincter dyssynergia may also occur in lesions above T6.[1] As sacral reflexes are present, independent sacral reflex activity leads to neurogenic detrusor overactivity (NDO) and/or detrusor–sphincter dyssynergia, resulting in elevated bladder storage pressure and reflex voiding with increased detrusor leak point pressure. The major goal of any treatment of patients with a neurogenic lower urinary tract function is the preservation of renal function. Elevated bladder storage pressure and detrusor leak point pressure has been proven to be the most important risk factors for renal damage in these patients.[2] It is difficult to predict bladder and sphincter behavior on the basis of clinical somatic neurological deficits. For many years, conventional artificial filling cystometry has been the standard method of investigating lower urinary tract function.[2] However, the artificial nature of cystometry may impose constrains on the reliability of the data.[3,4] In studies carried out to investigate over certainty and reliability of filling cystometry of patients with overactive detrusor (OAD) during cystometric assessment, it was aimed to imitate physiological filling of the

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bladder and evaluate the cystometry with the least probable error rate. For similar purposes in the literature, there are several studies in which effects of cystometric filling rates,[5] temperature instillation,[6] continuous and intermittent filling cystometry,[7] furosemide-stimulated filling cystometry[3] and repeated cystometries[8–13] on cystometric measurements and clinical decisions are searched. However, in the literature it was reported that repeated cystometric assessments had no considerable effects on cystometric variables in patients with non-neurogenic OAD and NDO.[8–13]

In the literature, we could not find any study investigating effects of current bladder drainage method on parameters of cystometry in SCI patients with NDO. According to our opinion and our own clinical experience, another factor that could have had an impact on the results of cystometry can be the type of method for emptying bladder. In other words, response to repeated cystometric measurements could be dissimilar in SCI patients with NDO, who use indwelling catheters (IDCs) and intermittent catheterization (IC) as methods of badder management. The aim of this study was to compare the effects of repeated filling cystometries in SCI patients with NDO who use IDC and IC.

MATERIALS AND METHODS

This study was performed after the approval of the local ethic committee of the institute. All of the patients were informed about the details and the procedure of the study. Written inform consent was obtained from all participants. A total of 20 SCI patients (13 male and 7 female) with NDO, aged over 18 years, 9 patients on IC and 11 on IDC for at least two consecutive months, were included in this cross-sectional study. Detrusor overactivity was confirmed in these patients with involuntary detrusor contraction demonstrated during routine cystometry, which may be spontaneous or provoked before the study enrollment.[13] The patients with reduced bladder compliance without NDO, those with urinary tract infection (UTI) and those with any previous history of lower urinary tract surgery were excluded from the study.

Nine of the 20 patients were not using antimuscarinic drugs, while 11 of them were on antimuscarinic drug therapy before the study. All urotropic medications were discontinued at least 1 week before the cystometric examinations. Age, gender, etiology, level and severity of SCI, disease duration and current bladder drainage method and duration of its use were noted.

Table 1 Clinical and demographic characteristics of patients with OAD, who use IC and IDC

	IC group (n = 9)	*IDC group (n = 11)*	P-*values*
Age (years) mean ± s.d.	42.4 ± 14.7	44.0 ± 15.4	0.941
Gender (male/female)	8/1	5/6	0.058
Etiology			
Traffic accident	5	2	0.095
Fall	3	3	
Non-traumatic	1	6	
Disease duration (months), mean ± s.d.	30.2 ± 40.9	11.5 ± 13.2	0.031
Duration of using bladder drainage method (months), mean ± s.d.	13.4 ± 7.2	5.4 ± 3.1	0.007
Level of injury			
Cervical	3	2	0.536
Thoracal	4	6	
Lumbosacral	2	3	
Severity of injury (AIS)			
Komplet (AIS-A)	5	5	0.374
İnkomplet (AIS-B,C,D)	4	6	

Abbreviations: AIS, American Spinal Injury Association Impairment Scale; IC, intermittent catheterization; IDC, indwelling catheter; OAD, overactive detrusor.

Patients with symptomatic UTIs were treated before the study. The urodynamic evaluations complied with International Continence Society recommendations.[14] Cystometry was performed by one of the authors (YN). Cystometry was done by Libra (MMS, Enschede, The Netherlands) urodynamic measurement system, using a double lumen 8F sterile urethral catheters and a rectal balloon. External sphincter electromyography was recorded by surface external sphincter electromyography patches at the 3- and 9-O' clock positions to the anus. After the drainage of all urine, first, the bladder was filled continuously at a filling rate of 30 ml min^{-1} until leakage was observed or the bladder filled to 500 ml with sterile physiologic saline at room temperature with the patient in the supine position. After the filling cystometry, the bladder was emptied again and 5 min later a second filling cystometry was performed in the same way.

The first involuntary detrusor contraction volume (1stIDCV), cystometric bladder capacity (CC), bladder compliance and maximum detrusor pressure (MPdet) during first and second filling were determined. The detrusor pressure was calculated as the difference between the intravesical and abdominal pressure. The CC was determined as bladder volume at which involuntary detrusor contraction with definite voiding or leakage is observed or bladder storage pressure exceeds 30 cmH_2O or the volume 500 ml fluid can be filled in.

The MPdet was estimated by urethral leak pressure or detrusor pressure at 500 ml filling. Compliance was defined as increase in pressure per unit of volume and was calculated according to the International Continence Society definition from CC (or 500 ml) and MPdet or pressure at 500 ml filling. For this purpose, it is recommended to use two standard points on cystometry diagram. First, detrusor pressure at which bladder filling starts and corresponding bladder volume and, second, detrusor pressure at CC or pressure just before any detrusor contraction prompting urine leakage and corresponding bladder volume.[14]

Statistical analysis

All statistical analyses were performed using SPSS version 17.0 for Windows (Statistical Package for the Social Sciences, Inc., Chicago, IL, USA). Descriptive statistics were used to describe demographic characteristics. The Shapiro Wilks test was used to analyze normal distribution assumption of the data. As the distributions were not normal, nonparametric tests were used in statistical evaluation. For continuous variables, the significance of the differences between IC and IDC groups was analyzed using Mann–Whitney *U*-test, whereas categorical variables were analyzed with a χ^2-test. The Wilcoxon signed-rank test was used to determine whether there was a significant difference between the first and repeated cystometry results for intragroup comparisons. $P<0.05$ was considered statistically significant.

RESULTS

Thirteen men and seven women, with ages ranging from 22 to 65 years and a mean age of 43.2 years, were studied. The duration after lesion ranged from 4 months to 60 months. Five patients (2 patients with C5, 1 patient with C6 and 2 patient with C7) had cervical cord injury, 10 patients (2 patient with T2, 2 patients with T4, 3 patients with T6 and 3 patients with T10) had thoracic cord injury and 5 patients (3 patients with L1 and 2 patients with L2) lumbo-sacral cord injury.

Table 1 displays comparison of the clinical properties and demographic characteristics of SCI patients with OAD. In the IC group, the mean disease duration and duration of using bladder drainage method were 30.2 ± 40.9 and 13.4 ± 7.2 months, respectively. For the IDC group, the mean disease duration and duration of using bladder drainage method were 11.5 ± 13.2 and 5.4 ± 3.1 months, respectively. In the IC group, both the disease duration and duration of using bladder drainage method were significantly longer ($P=0.031$ and $P=0.007$, respectively) than those in the IDC group (Table 1).

When all study population were taken into account, 1stIDCV and CC measures were significantly increased in the second cystometry compared with the first cystometry ($P=0.001$ and $P=0.022$, respectively), whereas there was no statistically significant difference on bladder compliance and MPdet measures between the first and repeated cystometry (Table 2).

There was no statistically significant difference on 1stIDCV, CC and bladder compliance measures between the first and repeated cystometries for the IC group, whereas there was statistically significant increase on these measures in the IDC group ($P=0.003$, $P=0.008$ and $P=0.022$, respectively). In addition, there was no statistically significant difference on MPdet measures between the first and repeated cystometries for each urine drainage methods (Table 3).

When IC and IDC groups were compared according to mean values of differences on 1stIDCV, CC and bladder compliance measures between two cystometries, the IDC group had a statistically significant increase in all parameters when compared with the IC group, with the second cystometry performed ($P=0.001$, $P=0.003$ and $P=0.048$, respectively) (Table 3).

There were no side effects in any of cystometries.

DISCUSSION

In this preliminary study, we investigated effects of repeated cyctometry in SCI patients with NDO, who use different type of urine drainage methods. Our results demonstrated that repeated cystometric measurements in SCI patients with NDO lead to an increase in the 1stIDCV and CC. On the other hand, when IC and IDC groups were compared, repeated filling cystometry leads to an increase in 1stIDCV, CC and bladder compliance in patients with IDC; however, it does not cause a difference in patients on IC.

Untreated NDO may result in bladder and/or renal damage and subsequent renal failure. Especially suprasacral lesions lead to NDO during storage phase. An elevated storage pressure, either due to low bladder compliance or to detrusor overactivity, is the major risk factor for renal deterioration.[2] Accurate diagnosis is important not only to plan appropriate treatment such as choosing antimuscarinic agent type and deciding its dosing or bladder management method, but, more importantly, to minimize the use of inappropriate treatment. Bladder management decision based on information provided by standard fill water cystometry assume that the data reflect physiologic state of patients, but this is not always true. Variables that may markedly affect the results of standard urodynamic examinations include nonphysiologic fill rates, instillation temperature and unfamiliar surrounding.[15] Making the correct evaluation and the appropriate therapeutic decision is very important in a patient with OAD.

In the literature, there are several studies in which effects of cystometric filling rates,[5] temperature instillation,[6] continuous and intermittent filling cystometry,[7] furosemide-stimulated filling cystometry[3] and repeated cystometries[8–13] on cystometric measurements and clinical decisions are searched. The possible effect of repeated cystometry on 1stIDCV and CC, and on the recorded changes in urodynamic volume parameteres have been discussed previously.[13] Previous studies in which the effectiveness of electrical stimulation was evaluated have reported an increase in 1stIDCV together with an increase in CC when stimulation was applied during cystometry.[16–17] In a single case study, an increase in CC was reported in a SCI patient, but detrusor contractions were found to recur immediately after stimulation was stopped.[17] In another study of

Table 2 Comparison of measurement outcomes of repeated cystometries in spinal cord-injured patients with OADs

	All patients (IC+IDC) (n = *20*)
1stIDCV (ml), mean ± s.d.	
Cys1	150.2 ± 56.3
Cys2	162.3 ± 52.3
ΔCys	12.1 ± 11.2
p	0.001
CC (ml), mean ± s.d.	
Cys1	245.4 ± 167.3
Cys2	261.0 ± 165.1
ΔCys	14.9 ± 30.8
p	0.022
MPdet (cmH_2O), mean ± s.d.	
Cys1	30.6 ± 5.4
Cys2	29.9 ± 5.8
ΔCys	−0.1 ± 5.2
p	0.585
Bladder compliance (ml/cmH_2O) mean ± s.d.	
Cys1	14.2 ± 12.1
Cys2	14.5 ± 12.7
ΔCys	0.3 ± 3.3
p	0.519

Abbreviations: CC, cystometric bladder capacity; Cys1, outcome of the first cystometry; Cys2, outcome of the second cystometry; IC, intermittent catheterization; IDC, indwelling catheter; MPdet, maximum detrusor pressure; OAD, overactive detrusor; p, Wilcoxon signed-rank test; 1stIDVC, first involuntary detrusor contraction volume.

Table 3 Comparison of measurement outcomes of repeated cystometries spinal cord-injured patients with OAD, who use IC and IDC

	IC group (n = *9*)	*IDC group* (n = *11*)	p^2
1stIDCV (ml), mean ± s.d.			
Cys1	182.2 ± 56.9	124.0 ± 41.7	<0.05
Cys2	185.0 ± 56.4	143.6 ± 42.6	0.001
ΔCys	3.3 ± 1.6	19.6 ± 8.8	
p^1	0.057	0.003	
CC (ml), mean ± s.d.			
Cys1	284.0 ± 199.9	210.4 ± 144.3	<0.05
Cys2	288.1 ± 191.6	242.2 ± 137.7	0.003
ΔCys	5.6 ± 23.8	31.8 ± 25.6	
p^1	0.813	0.008	
MPdet (cmH_2O) mean ± s.d.			
Cys1	25.7 ± 2.9	34.5 ± 3.3	<0.05
Cys2	25.3 ± 3.8	33.7 ± 4.2	0.656
ΔCys	−0.7 ± 5.4	−0.8 ± 5.2	
p^1	0.674	0.645	
Bladder compliance (ml/cmH_2O) mean ± s.d.			
Cys1	14.4 ± 8.4	12.9 ± 14.7	<0.05
Cys2	15.8 ± 8.4	14.6 ± 15.8	0.048
ΔCys	1.3 ± 3.8	1.7 ± 2.0	
p^1	0.260	0.022	

Abbreviations: CC, cystometric bladder capacity; Cys1, outcome of the first cystometry; Cys2, outcome of the second cystometry; IC, Intermittent catheterization; IDC, indwelling catheter; MPdet, maximum detrusor pressure; OAD, overactive detrusor; p^1, Wilcoxon signed-rank test; p^2, Mann–Whitney *U*-test; 1stIDVC, first involuntary detrusor contraction volume.

37 patients with NDO, it was concluded that stimulation was associated with a significant increase in 1stIDCV of 50% together with an increase in CC.[16] However, it is not clear whether these results are caused by stimulation or by the repeated bladder fillings at nonphysiologic rates.

Some studies have shown that repeated cystometries in neurogenic patients result in an increase in both 1stIDCV and CC. For example, Jensen[18] conducted two cystometries in 14 neurogenic patients. With repeated filling, without a rest between the filling, the CC increased in 12 and remained unchanged in 2 patients. The mean increase was 138%. In nine patients, the filling was performed six times. The capacity increased from filling to filling in six patients and was unchanged in three patients. In a study by Kaya *et al.*,[7] significant increase in maximum CC had been demonstrated in SCI patients with NDO by intermittent filling cystometry when compared with continuous cystometry, with a filling rate of 50 ml min^{-1}. In another study by Ko *et al.*,[3] significant decrease in MPdet and increase in bladder compliance had been demonstrated in SCI patients with NDO by furosemide-stimulated filling cystometry, which is more similar to physiologic conditions when compared with continuous cystometry with a filling rate of 50 ml min^{-1}. In sequential cystometries, one might expect differences due to adaptation to the procedure, but Thyberg *et al.*[8] found no significant difference between the mean MPdet in the first and second cystometries compared with the third and fourth cystometries, which were performed with 10-min intervals in SCI patients with NDO. Similarly, Ockrim *et al.*[13] performed three sequential cystometries (with a filling rate of 50 ml min^{-1}) in men with SCI and reported that cystometric variables and detrusor overactivity remained consistent over sequential studies. As a result, the effect of repeated cystometry has been studied in several investigations, but the results are conflicting, showing no change in capacities[9,10,13] or increasing capacity.[11,12] In addition, in these studies in which patients with NDO were assessed either present urine drainage methods were never mentioned or ignored, and in this regard heterogeneous groups were studied.[3,7,8,13]

In our study, it was observed primarily that repeated cystometry causes an increase in 1stIDCV and CC, irrespective of the type of bladder drainage method. It had been mentioned earlier that the major factor in the changes of the volumetric parameters is considered to be the patient's adaptation to the investigational situation.[12] In addition, the effect of current bladder drainage method on parameters of cystometry in SCI patients with NDO, which had not been investigated before, was assessed in this study. Study evolved out of the hypothesis that responses to repeated cystometric measurements could be dissimilar in SCI patients with OAD, who use IDC and IC, and as a result, for patients using IDC, 1stIDCV, CC and bladder compliance, all significantly increased after repeated cystometry. This situation could be explained by the fact that compliance may have been altered under the effect of IDCs in SCI patients, so even adapting of the bladder during the second cystometry can lead to observe involuntary detrusor contraction much later, thereby increasing compliance and CC. On the other hand, the fact that these two groups differing in means of bladder drainage method are also dissimilar according to disease duration and duration of using bladder drainage methods should not be disregarded. In our opinion, significant difference in duration of using the method between two patient groups might be more important in interpreting study results. Our clinical impression earlier suggested that findings of the cystometric measures in IDC using patients changed when we were to perform repeated cystometries. After completion of the study, statistically significant change occured in volumetric parameters in the IDC group compared with the IC group, which supports this opinion. Even though both disease duration and duration of the utilization of the drainage method were shorter in the IDC group when compared with the IC group, significant changes demonstrated in the IDC group, with the second cystometry being interpreted in two ways; First, IDC usage in SCI patients with NDO deteriorates normal physiologic streching and compliance of the bladder; thus, even with shorter duration of disease (11.5 months, mean) the second filling cystometry performed on SCI patients with NDO, who used IDC for at least 2 months duration (mean 5.4), yields changes in volumetric parameters as the bladder streches. Second, long-term IC appliance in SCI patients with NDO helps bladder adapting physiologic volumes and maintain compliance. Hence, in this group of patients any change in cystometric parameters with the second filling cystometry was not observed.

A study concluded that in the same session, repeated urodynamic investigations of patients with neurogenic lower tract dysfunction detrusor overactivity demonstrates excellent repeatability, but all other urodynamic parameters show insufficient agreement. Thus, they strongly recommend that clinical decision-making not be based on a single urodynamic investigation, as repeated measurements may yield completely different results.[19] Supporting this opinion and taking it a step further, we concluded that it should not be ignored that there could be margin of errors, particularly in volume parameters in the first cystometry applied to the SCI patients with NDO on IDC. Because of this reason, for this patient population repeated cystometry should be considered as a simple test, as it may contribute to make more appropriate therapeutic decisions. We suggest that in urodynamic studies evaluating effects of any intervention such as medication or stimulation via repeated cystometry on SCI patients with NDO, taking current drainage methods into consideration and patient groups being homogeneous in this respect would be much appropriate and will enhance the quality of the studies.

Limitations

Potential limitations of this study are the relatively small sample size, lack of assessment including voiding parameters, although some of the filling parameters were assessed, drainage methods other than IC and IDC were not considered and finally unassessment of relation of the cystometric findings with clinical results.

CONCLUSION

Repeated cystometric measurements in SCI patients with NDO lead to an increase in the 1stIDCV and CC. However, when type of urine drainage method is taken into account, while repeated filling cystometry leads to an increase in 1stIDCV, CC and bladder compliance in patients with IDC, it does not cause a difference in patients on IC. For this reason, when evaluating SCI patients with NDO, in particular patients who have been using IDCs for a long period of time, the cystometry that will be performed first could have error margins and the results should be interpreted with this fact; thus, repeated cystometry being a simple test should be considered for this group of patients.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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