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Urodynamic findings in stroke patients with overactive bladder symptoms

Aşırı aktif mesane belirtileri olan inme hastalarında ürodinamik bulgular

Koray Aydemir, Emre Adıgüzel, Bilge Yılmaz

Gulhane Military Medical Academy, Department of Physical Medicine and Rehabilitation, Turkish Armed Forces Rehabilitation Center, Ankara, Turkey

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ABSTRACT

Objectives: This study aims to determine the effect of the localization of the brain lesion on bladder functions in patients with stroke.

Patients and methods: We retrospectively reviewed the medical records and urodynamic charts of a total of 51 ischemic and hemorrhagic stroke patients (34 males, 17 females; mean age 65.8±16.2 years; range 13 to 88 years) with overactive bladder. Stroke localization was classified according to the Oxfordshire Community Stroke Project stroke subtypes. Urodynamic parameters included the first sensation of bladder filling, maximum vesical volume, maximum detrusor pressure, detrusor compliance, residual volume, mean flow rate, voided volume, voiding time, desire to void and strong desire to void. The patients were also classified according to sex and compared in terms of brain lesion laterality.

Results: Thirty six patients had ischemic and 15 had hemorrhagic stroke. The mean time from stroke to the urodynamic studies was 396.9±713.8 days. Maximum detrusor pressure was associated with sex, resulting in a significantly higher rates in males (p=0.028). Residual volume was significantly higher in the right hemiplegic group than the left hemiplegic group (p=0.007). The voided volume was significantly lower in the right hemiplegic group than the left hemiplegic group (p=0.007). In the right hemiplegic male group, the first sensation of bladder filling was delayed, residual volume was higher and the voided volume was lower (p=0.045, p=0.01, and p=0.043, respectively). In the right hemiplegic female group, the voided volume was lower than the left hemiplegic female group (p=0.024).

Conclusion: Our study results show that there are significant differences in urodynamic variables between the right and left hemispheric cerebral infarctions. These findings suggest that urodynamic findings can be characterized by the laterality of the unilateral hemispheric stroke. However, further large-scale studies are required to confirm these findings.

Keywords: Stroke; urinary incontinence; urodynamic study.

ÖZ

Amaç: Bu çalışmada inme hastalarında beyindeki lezyon yerinin mesane fonksiyonları üzerine olan etkisi belirlendi.

Hastalar ve yöntemler: Bu çalışmada aşırı aktif mesanesi olan, iskemik ve hemorajik inmeli toplam 51 hastanın (34 erkek, 17 kadın; ort. yaş 65.8±16.2 yıl; dağılım: 13-88 yıl) tıbbi kayıtları ve ürodinamik verileri retrospektif olarak incelendi. İnme yerleri, Oxfordshire Topluluğu İnme Projesi inme alt tiplerine göre sınıflandırıldı. Ürodinamik parametreler arasında ilk mesane doluluk hissi, maksimum mesane hacmi, maksimum detrüsör basıncı, detrüsör kompliyansı, rezidüel hacim, ortalama akış hızı, işeme hacmi, işeme zamanı, normal sıkışma ve çok sıkışma hacimleri yer almaktaydı. Hastalar cinsiyete göre de sınıflandırıldı ve beyin lezyon lateralitesi açısından karşılaştırıldı.

Bulgular: Otuz altı hasta iskemik, 15 hasta hemorajik inme geçirmişti. İnmeden ürodinamik çalışmalara kadar geçen ortalama süre, 396.9±713.8 gündü. Maksimum detrüsör basıncı, erkeklerde anlamlı düzeyde yüksek oranlar ile cinsiyet ile ilişkilendirildi (p=0.028). Rezidüel hacim, sol hemiplejik gruba kıyasla, sağ hemiplejik grupta anlamlı düzeyde daha yüksekti (p=0.007). İşeme hacmi, sol hemiplejik gruba kıyasla, sağ hemiplejik grupta anlamlı düzeyde daha düşüktü (p=0.007). Sağ hemiplejik erkek grubunda, ilk mesane doluluk hissinde gecikme vardı, rezidüel hacim daha yüksekti ve işeme hacmi daha düşüktü (sırasıyla p=0.045, p=0.01 ve p=0.043). Sağ hemiplejik kadın grubunda, işeme hacmi, sol hemiplejik kadın grubuna kıyasla, daha düşüktü (p=0.024).

Sonuç: Çalışma bulgularımız, sağ ve sol serebral hemisferik infarktı arasında ürodinamik parametreleri açısından anlamlı farklılıklar olduğunu göstermektedir. Bu bulgular, tek taraflı hemisferik inmeli hastalarda ürodinamik bulguların lezyon lateralitesine göre karakterize olduğuna işaret etmektedir. Ancak, bu bulguları doğrulamak için geniş ölçekli başka çalışmalara ihtiyaç vardır.

Anahtar sözcükler: İnme; üriner inkontinans; ürodinamik çalışma.

Corresponding author / *İletişim adresi*: Emre Adıgüzel, MD. Gülhane Askeri Tıp Akademisi, Fiziksel Tıp ve Rehabilitasyon Kliniği, Türk Silahlı Kuvvetleri Rehabilitasyon Merkezi, 06800 Bilkent, Ankara, Türkiye.

e-mail / *e-posta*: dremreadiguzel@gmail.com

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Voiding disorders, which are common complications of stroke, have been documented that urinary incontinence in these patients may persist, resolve or develop later in the normal course of the disease.[1] Stroke is one of the established causes of urinary incontinence.[1] Previous studies have reported that 28 to 79% of stroke patients experience urinary incontinence. Detrusor overactivity is predominant and detrusor underactivity is less prevalent.[2-4]

Incontinent patients are at risk for several urological complications including vesicoureteral reflux, hydronephrosis, urinary tract infections, calculus disease, bladder cancer, sexual dysfunction, and the destroyed bladder, and urethra.[5] Although urinary incontinence in stroke patients can cause such complications, many aspects of the neurophysiological mechanism of incontinence have not been revealed yet. In addition, there is limited data on the relationship between post-stroke detrusor contractility and voiding efficiency.[6]

In this study, we aimed to determine the effect of the localization of the brain lesions on the bladder functions in patients with stroke.

PATIENTS AND METHODS

This study was approved by the Local Ethics Committee of Gülhane Military Medical Academy Hospital (No: 2933/Date: 05.12.2012). A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

In this retrospective, cross-sectional study, we evaluated the medical records and urodynamic charts of ischemic or hemorrhagic stroke patients with overactive bladder (OAB) symptoms between January 2005 and December 2012 at the brain injury rehabilitation unit of a tertiary rehabilitation center. The inclusion criteria were ischemic or hemorrhagic stroke. The diagnosis of stroke was confirmed by computed tomography (CT) or magnetic resonance imaging (MRI). Exclusion criteria included a previous history of stroke, severe cognitive deficits, diffuse traumatic brain injury, spinal cord injury, premorbid history of obstructive urinary complaints, diabetes mellitus, cystopathy, previous pelvic surgery, and other neurological etiologies. A total of 51 patients (34 males, 17 females; mean age 65.8±16.2 years; range 13 to 88 years) who met the inclusion criteria were included.

The demographic and clinical characteristics such as age, sex, brain lesion laterality (left or right), type of stroke (ischemic or hemorrhagic), interval between stroke, and urodynamic assessment (days), and vesical ultrasonographic investigations were evaluated. Clinical stroke syndromes were classified according to the Oxfordshire Community Stroke Project[7] stroke subtypes: *(i)* large anterior circulation infarctions with both cortical and subcortical involvement (total anterior circulation infarctions; TACI); *(ii)* more restricted and predominantly cortical infarctions (partial anterior circulation infarctions; PACI); *(iii)* infarctions clearly associated with the vertebrobasillar arterial territory (posterior circulation infarctions; POCI); *(iv)* infarctions confined to the territory of the deep perforating arteries (lacunar infarctions; LACI).

The urodynamic tests were performed using the multi-channel urodynamic equipment (MMS International, The Netherlands, 1999) capable of recording data on urinary flow, intravesical and abdominal pressure, and urethral pressure profile. All tests were performed in the supine position. The bladder was filled with sterile room temperature saline at a filling rate of 30 mL/min. The filling stopped, when the patient had voiding sensation, at which the infused volume was measured as the maximum vesical volume (MVV), and the bladder pressure at the same point was recorded as maximum detrusor pressure (MDP). After the filling phase, the voided volume (VV), mean flow rate, and post-void residual volume (PVR) were measured. Also, the first sensation of bladder filling (FSBF), detrusor compliance, and voiding time were recorded.

Statistical analysis

Statistical analysis was performed using the IBM SPSS for Windows version 22.0 (IBM Corporation, Armonk, NY, USA) software. Demographic and clinical characteristics of the patients such as sex, age, lesion location, and laterality were variables in predicting the patterns of incontinence. We set each urodynamic finding as an independent variable. All continuous variables were presented as mean and standard deviation. Categorical data were presented using the number and percent. The chi-square test was used to compare sex in terms of hemiplegic group. The Kolmogorov-Smirnov test was used to assess normal distribution of the data. The Student t-test was used to analyze normally distributed data, while the Mann-Whitney U test was used to analyze abnormally distributed data. To define differences between the groups according to urodynamic variables by the location of brain lesion (LACI, TACI, PACI, or POCI),

Table 1. Demographic and clinical characteristics of patients

Characteristics	n	%	Mean±SD
Age (years)			65.8±16.2
Sex			
Male	34	66.7	
Female	17	33.3	
Marital status			
Married	34	66.7	
Single-Widow	17	33.3	
Level of education			
Ungraduated	3	5.9	
Primary-High school	31	60.8	
University	17	33.3	
Interval between stroke and urodynamic assessment (days)			396.9±713.8
Type of lesion			
Hemorrhagic	15	29.4	
Ischemic	36	70.6	
Laterality			
Right	18	35.3	
Left	30	58.8	
Bilateral	3	5.9	
Comorbidities			
Hypertension	30	58.8	
Diabetes	14	27.5	
Smoking	19	37.3	
Neglect	6	11.8	
Aphasia	21	42.2	
Dominant hemisphere			
Left	50	98.0	
Right	1	2.0	
Vesical ultrasonography			
Normal in male	14	41.2	
Normal in female	14	82.4	

SD: Standard deviation.

one way analysis of variance (ANOVA) test was used to analyze normally distributed data. As the detrusor compliance (DC) and residual volume (RV) were non-normally distributed, the Kruskal-Wallis test was used to compare these variables. The Levene test was used to check the homogeneity of variances assumption. Analysis of covariance (ANCOVA) was used to analyze the confounding effects of variables (i.e., age and disease interval) on urodynamic data. A p value of <0.05 was considered statistically significant.

RESULTS

The mean time from the onset of stroke to urodynamic studies was 396.9±713.8 days. Minimum and maximum disease intervals were 15 and 3,553 days, respectively. The demographic and clinical characteristics of the patients are shown in Table 1 and the characteristics of the patients which are classified by the localization of brain lesion are shown in Table 2.

We did not find any statistical significant differences among the variables in the urodynamic study between the location types of brain lesions (Table 3).

Maximum detrusor pressure was associated with sex. Maximum detrusor pressure was significantly (p=0.028) high in male group. Mean MDP was 73.8±47.1 cmH_2O in male, with respect to 43.1±42.5 cmH_2O in female group. After adjustment for age and disease duration using one-way ANCOVA test, statistically significant differences for MDP still remained between the two sexes. After adjustment, MDP value for the male group was 74.1 mL and MDP value for the female group was 42.4 mL (p=0.027). The results of urodynamic variables of patients by sex are shown in Table 4.

When the patients with bilateral lesions (n=3) were excluded, RV and VV were associated with laterality. The RV was significantly (p=0.007) higher in the

Table 2. Patients' characteristics classified by the localization of the brain lesions

Patient characteristics	LACI		TACI		PACI		POCI	
	n	Mean±SD	n	Mean±SD	n	Mean±SD	n	Mean±SD
Number	14		12		19		6	
Age (years)		66.8±16.9		69.1±12.9		66.3±15.0		55.6±23.7
Sex								
Male	10		9		11		4	
Female	4		3		8		2	
Interval between stroke and urodynamic assessment (days)		314.3±379.2		641.8±1229.9		198.0±174.2		730.0±915.1
Type of lesion								
Hemorrhagic	4		2		5		4	
Ischemic	10		10		14		2	
Laterality								
Left	11		6		10		3	
Right	3		5		8		2	
Bilateral	0		1		1		1	

SD: Standard deviation; LACI: Lacunar infarction; TACI: Total anterior circulation infarction; PACI: Partial anterior circulation infarction; POCI: Posterior circulation infarction.

Table 3. Urodynamic variables by the localization of the brain lesions

Characteristics	LACI (n=14)	TACI (n=12)	PACI (n=19)	POCI (n=6)	
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	*p*
First sensation of bladder filling (mL)	129.9±99.1	163.1±116.9	163.0±84.5	209.0±118.7	NS*
Maximum vesical volume (mL)	73.3±57.7	267.8±132.2	298.0±150.8	305.8±246.0	NS*
Maximum detrusor pressure (cmH_2O)	73.2±57.7	72.6±51.5	49.4±40.5	67.2±30.1	NS*
Detrusor compliance (mL/cmH_2O)	35.7±31.4	35.2±34.3	134.9±353.2	27.4±19.0	NS**
Residual volume (mL)	134.0±193.7	159.4±227.6	170.6±169.7	58.2±93.4	NS**
Mean flow rate (mL/sec)	5.1±4.0	7.4±10.2	6.4±4.5	12.0±10.5	NS*
Voided volume (mL)	263.5±254.2	297.0±346.2	270.0±172.4	451.0±239.5	NS*
Voiding time (sec)	173.3±173±6	86.8±64.9	85.2±103.5	69.5±28.6	NS*
Desire to void (mL)	219.0±171.5	213.2±123.9	203.2±98.6	314.7±140.4	NS*
Strong desire to void (mL)	279.6±195.1	269.5±151.3	259.1±126.7	349.5±169.3	NS*

SD: Standard deviation; LACI: Lacunar infarction; TACI: Total anterior circulation infarction; PACI: Partial anterior circulation infarction; POCI: Posterior circulation infarction; * One way ANOVA test; ** Kruskal-Wallis test; NS: Not significant.

right hemiplegic group (267.3±187.4 mL) than the left hemiplegic group (103.1±143.3 mL). The VV was significantly (p=0.007) lower in the right hemiplegic group (167.6±153.7 mL) than left hemiplegic group (402.9±274.3 mL) (Table 5). After adjustment for age and disease duration using one-way ANCOVA test, statistically significant differences for VV still remained between the right and left hemiplegic groups. After adjustment, VV value for the right hemiplegic group was 166.6 mL and VV value for the left hemiplegic group was 403.5 mL (p=0.007). In the right hemiplegic group, 10 (55.6%) of patients were due to ischemic lesions, while 24 (80.0%) patients were due to ischemic lesions in the left hemiplegic group. Considering the involvement side of hemiplegia, there was no statistically significant difference between the groups according to ischemia or hemorrhage (p>0.05, Pearson chi-square test). However, there was statistically significant differences in sex between the right and left hemiplegic group (p=0.035, Pearson chi-square test).

The patients are also classified according to sex and compared in terms of laterality. In the right hemiplegic male group, FSBF was delayed (179.3±103.8 mL, p=0.045), RV was high (207.8±160.2 mL, p=0.01) and the VV was low (200.2±157.3 mL, p=0.043) (Data not shown). In the right hemiplegic female group, the VV was lower (48.0±51.1 mL, p=0.024) than the left hemiplegic group (data not shown).

DISCUSSION

Various neuropathological and animal studies have addressed to the medulla oblongata, pons, limbic system, superior frontal lobe, and premotor cortical regions, as implicated in the micturition control.[8,9] Micturition control is associated with a vast network of cortical and subcortical regions.[8,9] Specific cerebral lesions have been shown to play the key role for the brain-related control of micturition.[9]

Although the micturition reflex is one of the autonomic reflexes, the release of urine is regulated by voluntary neural mechanisms which involve centers in the brain and spinal cord.[10,11] There are various excitatory and inhibitory areas co-existing

Table 4. Urodynamic variables by sex

Characteristics	Male (n=34)	Female (n=17)	
	Mean±SD	Mean±SD	*p*
First sensation of bladder filling (mL)	147.7±105.5	184.1±87.2	NS*
Maximum vesical volume (mL)	264.1±175.1	357.1±116.7	NS*
Maximum detrusor pressure (cmH_2O)	73.8±47.1	43.1±42.5	0.028*
Detrusor compliance (mL/cmH_2O)	94.3±265.0	25.4±24.3	NS**
Residual volume (mL)	132.5±144.7	245.0±214.6	NS**
Mean flow rate (mL/sec)	6.7±7.5	8.1±4.8	NS*
Voided volume (mL)	317.7±279.9	268.0±200.6	NS*
Voiding time (sec)	117.2±118.9	83.8±110.1	NS*
Desire to void (mL)	202.5±137.6	256.6±117.7	NS*
Strong desire to void (mL)	250.3±163.8	319.9±124.5	NS*

SD: Standard deviation; * Student-t test; ** Mann-Whitney U test; NS: Not significant.

Table 5. Urodynamic variables by laterality

Characteristics	Right (n=18)	Left (n=30)	
	Mean±SD	Mean±SD	*p*
First sensation of bladder filling (mL)	187.1±98.4	137.6±94.2	NS*
Maximum vesical volume (mL)	313.4±146.9	273.9±167.2	NS*
Maximum detrusor pressure (cmH_2O)	62.0±49.1	64.3±48.9	NS*
Detrusor compliance (mL/cmH_2O)	138.0±352.1	33.1±32.4	NS**
Residual volume (mL)	267.3±187.4	103.1±143.3	0.007**
Mean flow rate (mL/sec)	5.6±3.1	8.9±8.4	NS*
Voided volume (mL)	167.6±153.7	402.9±274.3	0.007*
Voiding time (sec)	70.4±40.2	123.7±147.4	NS**
Desire to void (mL)	249.1±132.5	196.1±129.2	NS**
Strong desire to void (mL)	295.9±141.9	252.9±158.3	NS**

SD: Standard deviation; * Student-t test; ** Mann-Whitney U test; NS: Not significant; Patients with bilateral lesions (n=3) were excluded.

in the brain; however, the brain has an overall inhibitory effect on the micturition, thereby, maintaining continence. Many animal studies have shown that the bladder volume decreases and urinary frequency is induced in suprapontin lesions of cerebrum.[10,11] For micturition, the cerebrum must abate its inhibitory influence on the pontin micturition center which evokes micturition. In patients with cerebrovascular disease, urinary frequency and urgency are common.[3] Therefore, it is believed that the overall effect of the brain is to inhibit the micturition reflex.[3,10,11]

Gelber et al.[12] suggested three major mechanisms responsible for post-stroke urinary incontinence: *(i)* disruption of the neuromicturition pathways, resulting in bladder hyperreflexia and urgency incontinence; *(ii)* incontinence due to stroke-related cognitive and language deficits with normal bladder function; and *(iii)* concurrent neuropathy or medication use, resulting in bladder hyporeflexia and overflow incontinence.

Although it is well-known that cerebral infarction can cause urinary incontinence,[9] it is still controversial which region of the brain which is injured is likely to cause the specific patterns of urinary incontinence and which of the hemispheres has more important role in the micturition in stroke patients. In many circumstances, a lesion which occupies both the primary motor and sensory cortex has either a high possibility of micturitional dysfunction. Since many studies on urinary incontinence excluded patients with severe cognitive impairment, the effect of the localization of the lesion and cognitive impairment in stroke patients on urinary incontinence were unable to be thoroughly analyzed.

Furthermore, we found an association between the left-hemisphere lesions and the high RV and low VV variables of urodynamic study. Previous studies also demonstrated a correlation between the laterality of the brain lesion and the genitourinary system.[9] However, many other studies reported that laterality, particularly right-hemisphere, affected the detrusor dysfunction. In their functional imaging study, Blok et al.[13] reported that the micturition-control areas were found predominantly in the right side of the brain (frontal and cingulate cortex) and pontine areas. Kuroiwa et al.[14] and Maurice-Williams[15] also showed that the urgency of micturition was more common in patients with right-hemisphere lesions than those with left-hemisphere lesions. These study results were not consistent with our study findings.

On the other hand, Ersoz et al.[16] showed higher RV in ischemic brain lesions compared to hemorrhagic lesions. Similarly, in our study, RV was higher in the right hemiplegic group and 55.6% of patients were due to ischemic lesions. In the left hemiplegic group, the percentage of ischemic lesions was higher (80.0%); however, RV was not higher than the right hemiplegic group, which might result in sex differences between ischemic and hemorrhagic patients in our study. Of note, in the study of Ersoz et al.,[16] there was no sex differences between ischemic and hemorrhagic groups.

Moreover, Marinkovic and Badlani[4] and Badlani et al.[17] reported that the site and size of the stroke clearly had an influence on urological findings. However, there seems to be no significant differences in bladder dysfunction produced by stroke in the dominant and the non-dominant hemispheres. Also, Kim et al.,[18] in their retrospective study, were unable to identify an effect of dominant hemispheric ischemic stroke on the bladder function. In our study, we were unable to

assess the effect of dominancy, as almost all patients showed left-sided dominancy.

In addition, Wyndaele[19] attempted to define normal urodynamic variables in healthy adults and revealed that micturition bladder pressure was higher in men than in women. He also showed that detrusor pressure was not significantly different between the two sexes. Inconsistent with these findings, the MDP was higher in males in our study. This can be explained by higher intravesical abnormalities assessed by ultrasonography in men compared to women.

On the other hand, the present study has certain limitations. First, three patients had bilateral lesions; therefore, we were unable to evaluate laterality. We were also unable to classify the neurogenic bladder types. The disease duration was also long and the sample size was relatively small in the subgroups. Second, there was heterogeneity in some of the variables, which might result in bias. Third, we were unable to perform ANCOVA test for all abnormally distributed data. Based on the results from the present study, we can conclude that the primary factors which affect the micturition are the lesion laterality and sex.

In conclusion, we identified an effect of sex and lesion laterality of stroke on the bladder function in this retrospective study. It suggests that urodynamic findings can be characterized by the laterality of the unilateral hemispheric stroke, not by the site of the cerebrovascular injury sustained. Currently, there are no large-scale longitudinal studies investigating the possible link between urodynamic findings and localization or the degree of infarction. Thus, further prospective functional studies are needed to establish a conclusion.

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