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Evaluation of lower urinary system symptoms and neurogenic bladder in children with cerebral palsy: relationships with the severity of cerebral palsy and mental status

Aim: This study aimed to evaluate lower urinary system symptoms, to determine bladder type in children with cerebral palsy (CP), and to determine the relationship between bladder type, and the severity of CP and mental status of the children.

Materials and Methods: The study included 41 children with CP. Subjects were first asked to provide information concerning lower urinary system symptoms. Urodynamic examination was performed in 41 children with CP. The severity of CP was determined according to the Gross Motor Functional Classification System (GMFCS). The Stanford-Binet Intelligence Scale was used to determine intelligence quotients (IQ). After urodynamic examination, subjects were divided into 2 groups based on bladder type: neurogenic detrusor overactivity (NDO) and normal bladder (NB) groups.

Results: One or more lower urinary system symptoms were observed in 78% of the subjects. NDO was observed in 30 subjects (73.2%), while NB was observed in 11 (26.8%), based on urodynamic study. While there was an almost statistically significant difference in terms of IQ scores ($P = 0.053$) between the NDO and NB groups, there was not a statistical difference in terms of GMFCS distribution.

Conclusion: The incidences of urinary system symptoms and neurogenic bladder are high in the CP population. Multiple factors, such as the effects on IQ, bladder functions, and mobility caused by cerebral lesions, may cause urinary dysfunction.

Key words: Cerebral palsy, lower urinary system symptoms, neurogenic bladder, mental status, disability

Serebral palsili çocuklarda alt üriner sistem semptomlarının ve nörojenik mesanenin değerlendirilmesi: serebral palsinin şiddeti ve çocuğun mental durumu ile ilişkisi

Amaç: Çalışmanın amacı serebral palsili (SP) çocuklarda alt üriner sistem semptomlarını değerlendirmek, mesane tipini belirlemek ve mesane tipinin SP'nin şiddeti ve SP'li çocuğun mental durumu ile ilişkisini ortaya koymaktır.

Hastalar ve Yöntemler: 41 SP'li çocuk çalışmaya alındı. Olgular öncelikle alt üriner sistem semptomları yönünden sorgulandı. 41 olguya ürodinamik inceleme yapıldı. SP'nin şiddeti Kaba Motor Fonksiyonel Sınıflama Sistemi (KMFKS) ile değerlendirildi. Olguların zeka bölümünü değerlendirmede Stanford-Binet Zeka Skalası kullanıldı. Ürodinamik incelemeden sonra olgular mesane tipine göre aşırı aktif nörojenik detrusör (AAND) ve normal mesane (NM) olarak iki gruba ayrıldı.

Bulgular: Olguların % 78'inde bir ya da daha fazla alt üriner sistem semptomu saptandı. 30 (% 73,2) olguda AAND ve 11 (% 26,8) olguda NM saptandı. AAND ve NM grupları arasında zeka bölümü açısından istatistiksel olarak anlamlı olabilecek fark saptanırken KMFKS dağılımları açısından fark saptanmadı.

Sonuç: SP populasyonunda alt üriner sistem semptomları ve nörojenik mesane insidansı yüksektir. Serebral lezyona bağlı olarak zeka bölümü, mesane fonksiyonları ve mobilite gibi çeşitli faktörler üriner disfonksiyona neden olabilir.

Anahtar sözcükler: Serebral palsi, alt üriner sistem semptomları, nörojenik mesane, mental durum, disabilite

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Introduction

Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances in sensation, perception, cognition, communication, and behavior, and by epilepsy and secondary musculoskeletal problems (1). Neurological damage in CP may cause delayed or incomplete development of bladder control, and can also cause impairment in communication, cognition, upper arm function, and mobility. Both neurological damage and impairment may result in urinary incontinence (2). Urinary incontinence, or enuresis, is common among adults and children with CP (2-4); however, the actual incidence of incontinence in CP is not precisely known. Early studies demonstrated that at least one-third of children with CP have 2 or more types of lower urinary system symptoms (4). Bladder capacity increases over time in normal children and plays an important role in the development of urinary continence (5). Studies conducted in this area report that bladder capacity decreases with detrusor hyperreflexia in CP (3,6). It is thought that the uninhibited contractions from detrusor hyperreflexia make urinary continence difficult to obtain (7). The ability to void or inhibit voiding voluntarily at any degree of bladder filling commonly develops during the second and third years of life, and most children acquire an adult pattern of urinary control by the age of 4 years (8). Furthermore, the age at which bladder control is achieved in children with CP is higher than that in their healthy peers (2,9). Although lower urinary tract symptoms and related urodynamic findings in this group of patients have been documented in several studies (2-4,6,7), the relationships between neurogenic bladder, mental functions, and the severity of CP have not been evaluated adequately.

Most researchers agree that the bladder pathology associated with neurological damage can be observed when an urodynamic study is performed on subjects with lower urinary system symptoms (10). Introduction of appropriate treatment protocols after determining the causes of urinary system symptoms will be an important step in the rehabilitation of CP patients.

The aim of the present study was to investigate lower urinary system symptoms in children with CP, to determine their bladder type, and to determine the relationship between bladder type, and the severity of CP and mental status of the children.

Methods

Subjects

The study included 60 children with CP. The subjects' relatives were informed about the examination, and their written informed consent for the study were obtained. The study protocol was approved by the local ethics committee. The subjects were first examined with respect to lower urinary system symptoms, and thereafter further planning was made for urodynamic examination of all the subjects.

It was possible to perform a urodynamic examination in only 41 subjects that were able to fully cooperate; therefore, 19 subjects were excluded. All the subjects with CP were diagnosed by a pediatric neurologist. A detailed systematic physical and neuromuscular system examination was performed for each subject included in the study in order to determine CP type according to the clinical classification (11,12). The subjects were investigated as to whether they were able to express their urination need or not, and the age they were able to state their needs was recorded as the expression age in months. Common lower urinary system symptoms, such as day-time incontinence, night-time incontinence, day- and night-time incontinence, stress incontinence, urgency, frequency, difficulty initiating voiding, and recurrent urinary system infections were investigated in detail (3,7). A minimum of one instance of incontinence a night was recorded as night-time incontinence, while a minimum of one instance of incontinence during a day was accepted as day-time incontinence. Stress incontinence was defined as involuntary leakage on effort or exertion, or when sneezing or coughing. Urgency was defined as a sudden compelling desire to pass urine that is difficult to defer (13).

Instruments

Kidney functions were evaluated by examining serum urea, creatinine, sodium, potassium, phosphorus, and uric acid levels. Urinary tract

infections were investigated through urinalysis, urine culture, blood leucocyte count, erythrocyte sedimentation, and C-reactive protein tests. Pathological changes in the kidneys, the ureters, and the bladder were assessed using urinary system ultrasonography. Urodynamic examination was performed in 41 children with CP that had normal kidney function test results, did not have clinical or laboratory urinary tract infections, did not have any pathology of the urinary system based on ultrasonography, and were able to cooperate.

Subjects were not sedated before urodynamic examination because of the possible effects of sedation on detrusor function. Urodynamic examination, consisting of cystometry and sphincter electromyography (EMG), was performed using a Libra (MMS, Enschede, The Netherlands) urodynamic measuring system and a 6F double-lumen transurethral urodynamic catheter. A rectal ball catheter was placed in the rectum in order to measure abdominal pressure. A surface electrode was placed around the anal region to record sphincter EMG. Sodium chloride solution (0.9%) at room temperature was used to fill the bladder at a rate of 20 mL min⁻¹ after discharging all the urine in the bladder. Filling was discontinued when the subject indicated bladder fullness or when significant leakage occurred. During the filling procedure, subjects were kept in the supine position. The level at which significant urination or leakage occurred, or at which intravesical pressure exceeded 40 cm H₂O was defined as cystometric capacity. Upon completion of the urodynamic study, bladder types were determined on the basis of bladder capacity and bladder pressure. Detrusor-sphincter dyssynergia was investigated by voiding cystometry performed together with sphincter EMG.

Expected normal bladder capacity for each subject was calculated according to a formula developed for normal children: bladder capacity = [(age/2) + 6] × 28 (mL) (14). All methods and definitions were based on the International Continence Society (13). The term neurogenic detrusor overactivity (NDO) was used instead of detrusor hyperreflexia. The subjects were then divided into 2 groups: those with NDO and those with a normal bladder (NB) on the basis of urodynamic examination results.

The severity of CP was determined according to the Gross Motor Functional Classification System (GMFCS) (15). GMFCS is a standardized measure that classifies gross motor functions in children with CP. It is a 5-level system defined by separating 4 age groups. In particular, it emphasizes sitting and walking functions of children, focusing on self-initiation of the action. Children in level I are very independent in motor functions, while those in level V are the least independent. Level I: walks without restrictions; II: walks without assistive devices, limitations in walking outdoors; III: walks with assistive devices; IV: self-mobility with limitations, children are transported or use powered mobility; V: self-mobility is severely limited (15,16). Patients with GMFCS level 1-2 were classified as mild, those with level 3 were classified as moderate, and those with level 4-5 were classified as severe CP (GMFCS groups).

In order to determine the intelligence quotients (IQ) of the subjects, an evaluation was performed by a psychologist using the Stanford-Binet Intelligence Scale, devised by Terman and Merrill (17). This scale was previously adapted for use with Turkish children by Ugurel-Semin (18). According to the test, those with scores of 160-140 are classified as genius, 139-120 as superior, 119-110 as medium high, 109-90 as normal, 89-80 as low middle, 79-70 at the boundary of retardation, and ≤ 69 as mentally retarded (17).

Statistics

Statistical analysis of the collected data was performed using SPSS v.11.0. Descriptive statistics were used to express results. Subjects were divided into 2 groups (NDO and NB) after urodynamic examination. Distribution of lower urinary system symptoms and GMFCS levels in these groups were compared using the chi-square test. Independent samples t-test was used to determine whether there were any differences between the NDO and NB groups with respect to measured and expected bladder capacities, and IQ scores. Logistic regression analysis was performed in order to predict the neurogenic bladder state based on IQ scores, the age when they were able to express their urination need, and the severity of CP.

Results

The study included 41 subjects (16 girls (39%) and 25 boys (61%)), with mean age of 8.09 ± 2.96 years. In all, 21 children (51.2%) had spastic diplegic CP, 11 (26.8%) had spastic quadriplegic CP, 7 (17.1%) had mixed types, and 2 (4.9%) had right hemiplegic CP. In terms of the severity of CP, 28 (68.3%) subjects had moderate (GMFCS level 3) and 13 (31.7%) had severe (GMFCS level 4-5) CP. Percentages of lower urinary system symptoms in all subjects are shown in Table 1.

NDO was observed in 30 subjects (73.2%), while NB was observed in 11 (26.8%) based on urodynamic examination. Neither reflex detrusor nor detrusor-sphincter dyssynergia was detected in any of the subjects. The 30 subjects with NDO included 11 girls and 19 boys with mean age of 7.60 ± 2.40 years, whereas the 11 subjects with NB included 5 girls and 6 boys with mean age of 9.45 ± 3.95 years. A statistically significant difference in terms of gender ($X^2 = 0.220$, $P = 0.881$) and mean age ($t = -1.826$, $P = 0.076$) between the NDO and NB groups was not observed. Of the subjects with NDO, 19 (63.3%) had spastic diplegic CP, 7 (23.3%) had spastic quadriplegic CP, and 4 (13.3%) had mixed-type CP. Of the subjects with NB, 4 (36.4%) had spastic quadriplegic CP, 3 (27.3%) had mixed-type CP, 2 had (18.2%) spastic diplegic CP, and 2 (18.2%) had right hemiplegic CP. Due to an insufficient number of subjects in each group, the relationship between CP type and bladder type was not investigated.

Thirty-one (75.6%) of the 41 subjects had at least 1 lower urinary system symptom, while 10 (24.4%) had no lower urinary symptoms (2 in the NDO group and 8 in the NB group). The distribution of lower urinary system symptoms according to bladder type is given in Table 1. A significant difference was observed between the groups with respect to stress incontinence and frequency complaints (respectively $X^2 = 7.942$, $P = 0.005$; $X^2 = 4.072$, $P = 0.044$). While 73.3% of the NDO group had stress incontinence and 50% had frequency complaints, only 18.2% of the NB group had stress incontinence and 9.1% had frequency complaints.

A significant difference was not observed between the groups in terms of expressing the need to urinate ($t = 0.673$, $P = 0.505$). Mean age at which the need to urinate was verbalized was 45.80 ± 22.58 months in the NDO group and 40.90 ± 13.36 months in the NB group.

Mean bladder capacity in the NDO group (148.73 ± 58.69 mL) was significantly lower ($t = 4.215$, $P = 0.000$) than that in the NB group (231.36 ± 45.52 mL). The difference ($P = 0.067$) between the NDO (271.86 ± 30.89) and NB groups (297.36 ± 54.56) with respect to mean value of expected bladder capacity was not statistically significant.

In all, 21 patients (51.2%) in the NDO group had moderate CP and 9 patients (22%) had severe CP. In the NB group 7 patients (17.1%) had moderate CP and 4 patients (9.8%) had severe CP. There was no

Table 1. Observed frequencies of lower urinary system symptoms in all subjects with CP and the distribution of lower urinary system symptoms according to the bladder type.

Urological Symptoms	All Subjects (n = 41)	NDO (%) (n = 30)	NB (%) (n = 11)	P
Day-time incontinence	14.6	20	0	0.268
Night-time incontinence	19.5	26.7	0	0.143
Day- and night-time incontinence	22	30	0	0.103
Stress incontinence	58.5	73.3	18.2	0.005*
Urgency	29.3	30	27.3	1.000
Frequency	39	50	9.1	0.044*
Difficulty initiating voiding	14.6	0	0	-

*Significant.

NDO: Neurogenic detrusor overactivity.

NB: Normal bladder.

difference between the 2 groups in terms of GMFCS groups (moderate and severe groups) ($X^2 = 0.000$, $P = 0.993$).

One of the 2 subjects (4.9%) with IQ scores between 90 and 109 had NDO and the other had an NB, as did the 2 subjects with IQ scores between 80 and 89, and with the same distribution. Five of the 8 subjects (19.5%) with IQ scores between 70 and 79 had NDO and 3 had an NB, while the same figures were, respectively, 23 (NDO) and 6 (NB) among the 29 subjects (70.7%) with IQ scores ≤ 69 . There was an almost statistically significant difference in IQ scores ($t = -1.998$, $P = 0.053$) between the NDO (61.61 ± 2.65) and NB (70.36 ± 11.62) groups.

Logistic regression analysis was used in order to determine if age at which the need to urinate was first expressed, IQ score, and the severity of CP (GMFCS group 1 and group 2) were significantly related to bladder type. IQ scores and the age at which the need to urinate was first expressed took place in this model. The classification scale of the model, based on the logistic regression analysis applied to the related scores, is given in Table 2. When the classification table was evaluated it was correctly predicted that 36.4% of the subjects were in the NB group and 93.3% of the subjects were in the NDO group. The rate of correct classification of the model according to this scale was 78%. The X^2 value of the model was 8.708 and this value was statistically significant ($P = 0.033$). According to the results of this analysis, the age at which the need to urinate was first expressed ($P = 0.044$) would make the classification of bladder type

easier; however, the results indicate that the severity of CP ($P = 0.773$) and IQ score ($P = 0.078$) were not significant in the prediction of bladder type.

Discussion

More than one-third of children with CP present with dysfunctional urinary symptoms (4). In the present study, 1 or more lower urinary system symptoms were observed in the 78% of the subjects and the most frequently observed symptoms (consistent with the literature) were stress incontinence, and frequency and urgency complaints (3,4,7). Karaman et al. showed that 66.6% of 36 children with CP had dysfunctional voiding symptoms (19). Decter et al. observed incontinence complaints in 86% of 57 subjects with CP that presented with urological symptoms (7). Early studies demonstrated that the most common symptoms in subjects with CP presenting with lower urinary system complaints were incontinence, frequency, urgency, stress incontinence, and difficulty in initiating voiding (3,4,20). The results of our study and the literature show that children with CP should be questioned carefully in terms of lower urinary system symptoms.

Ewalt and Bauer suggest that careful clinical and radiological evaluation is necessary in children with CP that present with voiding problems (21). Brodak et al. concluded that when there is the absence of a urinary tract infection and lower urinary tract symptoms, it is unnecessary to evaluate these patients

Table 2. Prediction of the neurogenic bladder state based on the age at which the need to urinate was first expressed, intelligence-quotient (IQ), and the severity of CP.

Observed Group		Predicted Group		Correctness of Estimate (%)
		Bladder Status		
		NB	NDO	
Bladder Status	NB	4	7	36.4
	NDO	2	28	93.3
Total (%)				78.0

NB: Normal bladder.

NDO: Neurogenic detrusor overactivity.

for neurogenic bladder dysfunction (10). As such, in a recent study by Bross et al. (22) it was concluded that urodynamic assessment should be performed in all children with infantile CP and that the decision should not be based on clinical symptoms, such as recurrent urinary tract infection or urinary incontinence. As a matter of fact, we performed urodynamic examinations in children with and without lower urinary system symptoms. Although we observed higher rates of NDO in subjects with lower urinary system symptoms, we also observed NDO in asymptomatic subjects.

In the present study NDO was observed in 30 of the 41 subjects and NB was observed in 11 subjects. Reflex detrusor or detrusor-sphincter dyssynergia was not observed in any of the subjects included in the study. Based on urodynamics, Decter et al. reported that the most common abnormality was NDO (70%) and that 7 patients (12%) had detrusor-sphincter dyssynergia (7). This leads us to conclude that NDO is common in children with CP. Uninhibited bladder contractions resulting from detrusor hyperreflexia cause urinary continence to be difficult (23). High level of stress incontinence in the children with NDO and the existence of frequency symptoms in the present study may have been due to overactive contraction of the hyperreflex detrusor muscle.

Bladder capacity increases over time in normal children and has an important role in the development of urinary continence (5). Studies have reported that bladder capacity decreases with detrusor hyperreflexia in CP (3,6). In the present study bladder capacity in the subjects with NDO, as measured by urodynamic examination, was significantly lower than that in the NB group, leading us to think that decreased bladder capacity, along with detrusor hyperreflexia, is another factor contributing to retardation of urinary continence in children with CP. Hyperreflexia and reduced bladder capacity can be considered as findings of the upper motor neuron lesions leading to CP. Although upper motor neuron damage is observed in most children with CP, there are also reported cases of lower motor neuron lesions and vesicoureteral reflux (1,24).

Autonomic nerve system maturation and the functions of frontal and parietal lobes, in addition to urinary system maturation, also affect the development of bladder control (2). Normal children

achieve day-time continence at the age of 2 or 3 years (11). Ninety-five percent of normal children by the age of 5 years achieve day-time continence, while 80%-85% achieve night-time continence (25). It is reported that children with CP achieve urinary continence later than their normal counterparts (2). Ozturk et al. compared continence rates of patients with CP (n = 45) to those of healthy children (n = 37). Mean age for nighttime bladder control was 47 months for children with CP and 27 months for healthy children, indicating that bladder control is delayed in patients with CP (8). In Turkey, Erkin et al. evaluated the functional disability of Turkish children with CP using the Functional Independence Measure of Children (WeeFIM) and reported that the sphincter control subset scores increased in children with CP as they aged, whereas in healthy controls such a change was not observed (26). In the present study we observed that most of the subjects were incontinent, even though they could express the need to urinate. It was also determined that the NDO group began to express the need to urinate later than those in the NB group. This finding indicates that the effect on bladder functions caused by cerebral lesion damage in CP is an important factor in delayed attainment of urinary continence.

It is also suggested that many factors affect bladder control attainment in children with CP. Borzyskowski argues that age, mobility, and cognitive functions may affect bladder control, and that the situation does not arise only from a relationship between the evaluated bladder function and the central nervous system (24). Roijen et al. divided subjects with CP into 2 groups of low and high intellectual capacity, according to their intellectual capacity on the basis of school types to which they attended (2). They reported that tetraplegic patients with low intellectual capacity achieved urinary continence at a later age than did diplegic and hemiplegic CP patients with higher intellectual capacity. Lower IQ levels, though almost statistically significant, of the subjects with NDO in our study suggest that both bladder dysfunction and cognitive functions may influence the achievement of urinary continence in children with CP. As a result, lesions in the central nervous system that cause CP in these subjects lead to neurogenic bladder and adversely affect cognitive functions. Urinary incontinence may be present in children with CP that

also have the cognitive ability for toilet training; however, there may be patients that cannot be toilet trained due to insufficient cognitive capacity, despite of the absence of a neurogenic bladder. Therefore, in clinical practice, when assessing incontinence in children with CP, sufficiency of cognitive capacity must also be considered during urodynamic bladder testing.

In the present study we did not observe any differences between the NDO and NB groups in terms of the severity of CP. We also did not observe any increase in lower urinary system symptoms as the severity of CP increased. Bross et al. evaluated urodynamic findings in patients with infantile CP and correlated the findings with impaired motor function (22). Symptomatic patients had higher GMFCS levels than asymptomatic patients. They concluded that urinary symptoms and pathological urodynamic findings increase as the degree of motor function impairment based GMFCS increases.

A limitation of the present study is that only CP patients with GMFCS levels 3-5 were evaluated, as children with severe CP usually apply to the pediatric rehabilitation unit of our hospital. As such, CP patients with GMFCS level 1 and 2 did not participate

in the study and we could not examine the relationship between the severity of CP and lower urinary system symptoms.

In conclusion, the present study shows that the incidences of urinary system symptoms and neurogenic bladder were high in the CP population. The most frequently observed symptoms were stress incontinence, and frequency and urgency complaints. We performed urodynamic examinations in children with and without lower urinary system symptoms. Although we observed higher rates of NDO in subjects with lower urinary system symptoms, we also observed NDO in asymptomatic subjects. We propose that the investigation of urinary system symptoms in all children with CP must be carefully performed and an urodynamic examination should be performed as early as possible in children with CP. Urodynamic examination provides an objectively planned treatment. We also observed that urinary system symptoms were not affected by the severity of CP. Lower IQ levels in the subjects with NDO, although almost statistically significant, suggest that both bladder dysfunction and cognitive functions may influence the achievement of urinary continence in children with CP.

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