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Uroflowmetry in the management of lower urinary tract symptoms of children and adolescents with cerebral palsy

J.A. Fernandes Silva*, F. Borges Carrerette, R. Damião

Division of Urology, Pedro Ernesto Memorial Hospital, State University of Rio de Janeiro, Boulevard Vinte e Oito de Setembro, 77 — Vila Isabel, Rio de Janeiro 55-20551-030, Brazil

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Abstract *Objective:* To evaluate uroflow measurements in the initial management of lower urinary tract dysfunction in children and adolescents with cerebral palsy.
Materials and methods: A total of 54 patients was enrolled in this study. All patients reported their urinary symptoms and underwent a physical examination, renal and urinary tract ultrasonography, and uroflow assessment.
Results: Twenty-three patients were female. Mean age was 9 years and 6 months (SD: 2 years and 10 months), with a range of 5–18 years. Twenty-eight of the patients (51.8%) were symptomatic. Urgency (42.6%), urge incontinence (40.7%), and enuresis (16.7%) were the most frequently observed symptoms. No association was found between gender, ambulatory status, or distribution of the paralysis and uroflow parameters. Symptomatic patients presented a statistically lower maximum flow (Q_{max}) than asymptomatic patients (17.2 $\pm$ 7.8 ml/s vs 22.6 $\pm$ 7.5 ml/s, $p = 0.013$, respectively). Normal bell-shaped curves were observed more frequently in asymptomatic patients, while abnormal curves were observed more frequently in symptomatic patients ($p = 0.022$).
Conclusions: Gender, ambulatory status, and the distribution of the paralysis do not affect Q_{max} rate or flow pattern. Symptomatic patients present lower Q_{max} and may also have an abnormal uroflow curve. Uroflowmetry may be useful in the initial urological evaluation.

* Corresponding author. Tel.: +55 21 81053270; fax: +55 21 35437234.
E-mail address: urocentre@hotmail.com (J.A. Fernandes Silva).

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Introduction

Cerebral palsy (CP) is a permanent disorder affecting the development of movement and posture. It causes limitations in activity and is attributed to disturbances that occur in the developing fetal or infant brain [1].

The lower urinary tract (LUT) is innervated by three sets of peripheral nerves, involving the parasympathetic, sympathetic, and somatic nervous systems. In children, urinary continence develops with the maturation of the cortical pathways that regulate the micturition center in the brainstem [2].

LUT symptoms, such as incontinence, increased frequency, and urinary tract infections, are common among the CP patient population [3,4]. Several factors may contribute to a predisposition to incontinence, including the impairment of cognitive and communication skills, and the reduction of mobility. In general, patients with lesions localized anatomically above the brainstem develop neurogenic phasic detrusor overactivity and coordinated sphincters [5].

The initial assessment of LUT dysfunction in patients with CP should be based upon their voiding history and urinary symptoms. Uroflowmetry is a noninvasive method, well tolerated, and may be included as part of the initial urological evaluation in these patients. The aim of this present study is to evaluate uroflow measurements in the initial management of LUT dysfunction in children with CP.

Materials and methods

This study included all consecutive children and adolescents who visited the hospital for physical rehabilitation between January and December 2008, and who had sufficient bladder control to do uroflow test. They reported their LUT symptoms and underwent physical examination and a urologic work-up, including a renal function test (creatinine), urine tests, renal and urinary tract ultrasonography, and uroflow assessment. The cases were classified based on the distribution of the paralysis (hemiplegic, diplegic, or tetraplegic) and on their performance over distances: ambulator (independently or with aid) or nonambulator (wheelchair).

A noninvasive uroflow study (Duet System, v. 8.20; Medtronic, Minneapolis, MN, USA) was conducted, and the post-void residual was measured by ultrasonography immediately after the uroflow assessment. The test was performed in the office, in a sitting or standing position, based on patient choice, only when the patient had the desire to void. Two curves were obtained in the different clinic visits, and the selection criteria for the analysis were based on a normal flow curve and the highest voided volume. The parameters observed included maximum flow (Q_{max}), flow curve shape, voided volume, and post-void residual. The flow curve shapes were evaluated and classified as normal (bell-shaped) or abnormal (tower, plateau, staccato, or interrupted). The expected age-related bladder capacity (EBC) was calculated and compared with the observed voided volume, and then the percentage of voided volume (VV)/EBC (%VV/EBC) was calculated. EBC was calculated in ml using the formula [(age in years $\times$ 30) + 30] [6,7]. The formula is useful in patients up to the age of 12 years, after which the EBC remained constant at 390 ml. The criterion used for an increase in post-void residual was a volume > 20 ml [8] in patients up to the age of 12 years, and for patients older than 12 years the limit was considered to be 10% of the bladder capacity.

All methods and definitions were based on the standardization of the International Children's Continence Society [8]. The study was approved by the local ethics committee.

Data and results are expressed as the means and SDs. Data were analyzed using the Student *t*-test, a chi-square test and an ANOVA. A p-value <0.05 was considered to be statistically significant.

Results

Fifty-four children and adolescents were investigated (23 females and 31 males). The mean age was 9 years and 6 months (SD: 2 years and 10 months), with a range of 5–18 years. Twenty-eight of the patients (51.8%) were symptomatic. The mean age of achieving daytime and night-time bladder control was 3 years and 7 months, and 4 years and 6 months, respectively.

Urgency (42.6%), urge incontinence (40.7%), and enuresis (16.7%) were the most frequently observed symptoms. Among these symptoms, 13% of the symptomatic patients presented all of them, 39% had two symptoms, and 24% presented only one symptom.

According to the topography and motor impairment, 16 patients (29.6%) were hemiplegic, 17 (31.5%) were diplegic, and 21 (38.9%) were tetraplegic. Based on the ambulatory status, 33 patients (61.1%) were ambulators and 21 (38.9%) were nonambulators.

Serum creatinine levels were normal in all patients. A urinary tract infection was reported in 11 patients (20.4%), and asymptomatic bacteriuria was found in three patients (5.5%). There were no apparent renal abnormalities identified in the ultrasonography.

Uroflow measurements

The mean Q_{max} was 19.6 ml/s. This value was higher in girls and ambulators than in boys and nonambulators, but this difference was not statistically significant. Children older than 12 years of age (five girls and seven boys) had a statistically significantly higher Q_{max} (28.0 ml/s vs 18.6 ml/s, $p = 0.004$, respectively). The results related to Q_{max} are shown in Table 1.

Based on the LUT symptoms, symptomatic patients presented with a statistically lower Q_{max} than asymptomatic patients (17.2 $\pm$ 7.8 ml/s vs 22.6 $\pm$ 7.5 ml/s, $p = 0.013$, respectively). There was also a statistically significant association between the type of uroflowmetry curves (bell-shaped or abnormal) and urinary symptoms ($p = 0.022$, Fig. 1). The distribution of the uroflowmetric patterns were normal bell-shaped in 33 patients (61.1%), staccato in 14 (25.9%), plateau in five (9.3%), tower in one (1.9%), and interrupted in one (1.9%).

The mean of %VV/EBC was 46.8%. No association was found between gender, ambulatory status, or the

Table 1 Maximum flow (ml) data stratified by gender, age, ambulatory status, and topography.

Patients shared by group	n	Mean (SD)	p
Female	23	23.0 (10.2)	0.158
Male	31	19.0 (9.9)	
≤12 y	42	18.6 (7.9)	0.004*
>12 y	12	28.0 (13.8)	
Ambulator	38	22.2 (11.1)	0.095
Nonambulator	16	17.2 (6.2)	
Diplegia	17	22.3 (12.4)	0.728
Hemiplegia	16	20.3 (8.7)	
Tetraplegia	21	19.7 (9.3)	
Total	54	20.7 (10.1)	

*Statistically significant.

distribution of the paralysis and voided volume or %VV/EBC (Table 2). Eleven patients (20.4%) had significant post-void residual, and the mean was 21.2 ml/s.

Discussion

The evaluation of children with LUT symptoms should be made based on their urinary symptoms and the clinical findings. Monitoring their voiding and bladder-related symptoms is crucial for this purpose. It is generally accepted that uroflowmetry is also an important diagnostic tool for children presenting with LUT symptoms. Uroflow test is uncomplicated, reproducible, and reliable, and it can contribute to the plan of treatment if patients can void voluntarily or spontaneously. It is worth noting that at least two uroflow tests should be obtained before any conclusion is made [8,9].

Bladder control develops first in the daytime and later at night [10]. In our study, children gained night-time bladder control almost 1 year after their daytime bladder control. Children with CP achieve control of their voiding at an older age than healthy children [11]. This delayed control probably happens because the development of continence is related to cognitive function, which was not evaluated in this study. Urgency, urge incontinence, and enuresis were the most frequently observed urinary symptoms. However, these symptoms are not particularly characteristic of CP and have been seen in many children at this age [12–14].

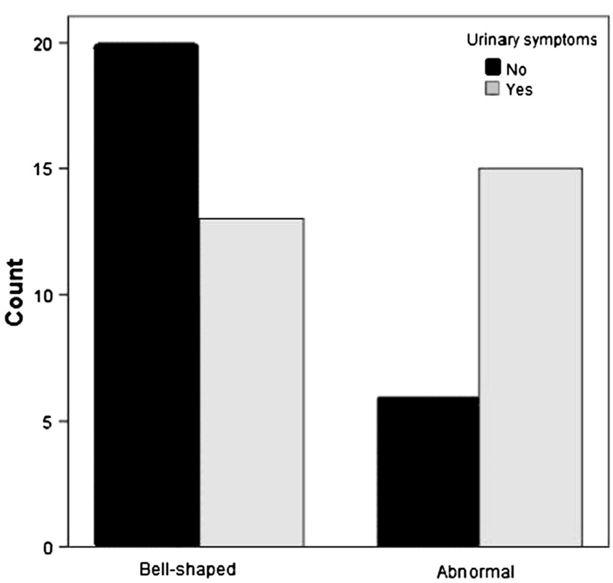

Figure 1 Association between the type of uroflowmetry curve (bell-shaped or abnormal) and urinary symptoms. Curve (bell-shaped or abnormal) and urinary symptoms.

The mean Q_{max} was higher in girls and ambulators than in boys and nonambulators, respectively, but the difference was not statistically significant. Children older than 12 years had a statistically higher Q_{max}, which is most likely the result of growth-related anatomical changes, such as an increase in the diameter of the urethra, considering the fact that this group of patients was composed of five girls and seven boys. However some studies have shown that spasticity and motor disability, especially the degree of mobility, can be the cause of LUT symptoms [15,16]. In this study, the distribution of the paralysis did not affect the Q_{max} rate. There was no association of the level of disability and the ability to empty the bladder.

The flow pattern in children is far more informative than the flow rate owing to the ability of the detrusor in children to exert a strong contraction and to overcome any outflow resistance. The shape of the curve can be indicative of detrusor function, degree of bladder outlet resistance, and external urethral sphincter activity during voiding [8,17]. According to our findings, both the Q_{max} and the shape of the flow curves demonstrated a statistically significant relationship with the urinary symptoms. Symptomatic patients presented a significantly lower Q_{max} and abnormal curves. These findings constitute an important indicator for the existence of a specific condition, such as overactive bladder, dysfunctional voiding, underactive bladder, and bladder outlet resistance. Therefore urological investigation should be recommended only for symptomatic children.

Previously published studies have shown reduced bladder capacity in children with CP [18,19]; our findings were similar. The mean of VV/EBC was 46.8%, indicating a reduced bladder capacity.

The mean post-void residual was 21.2 ml/s. To define which values of post-void residual are considered high is not easy in the pediatric population. The lowest acceptable limit of 10% of the bladder capacity, often stated for adults, is not relevant for infants and children. Studies in healthy infants and toddlers have shown that they do not empty their bladders completely every time, but do so at least once during a 4-h observation period [20]. Older children should, however, be expected to habitually empty their bladders completely [8]. In this study, there was no significant association between urinary symptoms and post-void residual. On behalf of its variability, the post-void residual should not be evaluated alone and is also less important than the Q_{max} and the flow shape curve in the evaluation of LUT dysfunction.

Although these patients experienced LUT symptoms and recurrent urinary tract infections, there were no apparent renal abnormalities identified in the ultrasonography. Bladder wall thickness was not evaluated, as our experience has shown that ultrasound assessment of bladder wall

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Table 2 Voided volume (VV), expected bladder capacity (EBC) and %VV/EBC stratified by gender, ambulatory status, and topography.

	n	VV (ml)	p[a]	EBC (ml)	p[a]	%VV/EBC	p[a]
		Mean (SD)		Mean (SD)		Mean (SD)	
Female	23	154.5 (96.7)	0.551	298.7(75.4)	*0.330*	50.8 (30.1)	0.345
Male	31	140.3 (77.7)		316.1(54.8)		43.8 (24.7)	
Ambulator	33	152.2 (89.2)	0.533	306.1(62.7)	*0.716*	49.0 (28.8)	0.460
Nonambulator	21	137.1 (81.2)		312.9(68.1)		43.3 (24.5)	
Diplegia	17	168.3 (99.1)	0.360	304.7(63.9)	*0.848*	54.2 (32.7)	0.301
Hemiplegia	16	147.1 (80.2)		316.9(60.9)		47.3 (29.6)	
Tetraplegia	21	127.9 (75.6)		305.7(69.5)		40.4 (18.5)	
Total	54	146.3 (85.7)		308.7(64.3)		46.8 (27.1)	

[a] *t*-tEst or ANOVA (topography).

thickness is not relevant for diagnosis of LUT dysfunction in children with CP [4].

The same approach suggested for the evaluation of children with LUT symptoms may also be recommended for the evaluation of the CP population. Although these patients experience bladder dysfunction, it generally does not progress to upper tract changes, probably because detrusor sphincter dyssynergia is not frequent. The recommended initial evaluation of LUT symptoms should be based on bladder diary and uroflowmetry. The combination of these tools should also be used as a measure to monitor the outcomes when therapy is indicated. Despite conservative treatment, patients with persistently abnormal urination patterns and those with abnormal flow curve should be submitted to a complete urodynamic study.

Limitations of this study include the relatively small sample, considering the heterogeneity of CP and that there was also no control group. Features such as movement and posture, along with disturbances in perception, cognition, and communication may play a role in the development of urinary patterns. Electromyography was not used in conjunction with uroflow. Another issue is that uroflowmetry can only be made in patients able to void spontaneously, which limits the method for all patients.

Based on symptoms of urgency and urge incontinence, we recommend antimuscarinic agents and adequate fluid intake for these patients as an initial treatment approach. These agents should be given with caution in cases showing abnormal flow curve, which may be indicative of voiding dysfunction, underactive bladder, or bladder outlet resistance.

Conclusion

In conclusion, LUT symptoms are common in patients with CP. Gender, ambulatory status, and the distribution of the paralysis do not affect Q_{max} rate or flow pattern. Symptomatic patients present lower Q_{max} and may also have an abnormal uroflow curve. Uroflowmetry may be useful in the initial urological evaluation of LUT dysfunction in the CP patient population.

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Conflict of interest

None.

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