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CONTROVERSIAL TOPIC

Lower Urinary Tract Dysfunction in Children With Cerebral Palsy

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Aims: The focus of this study was to evaluate urodynamic findings and possible renal damage in children with cerebral palsy and urinary symptoms. **Methods:** Children with cerebral palsy and lower urinary tract symptoms were studied. Patients were submitted to urodynamic evaluation, urine examination, measurement of serum creatinine, and renal and urinary tract ultrasonography. Voiding cystourethrography was performed on patients with urinary tract infections. **Results:** Thirty-seven children were investigated, including 21 females and 16 males. The mean age was 7 years and 8 months [SD of 4 years 6 months], with a range from 1 to 17-year-old. The symptoms that led to evaluation were urinary infections in 21 56.7% cases, incontinence in 15 (40.5%) cases, increased voiding frequency in six (16%) cases, enuresis in five (13.5%) cases, and hesitancy and urgency in two (5.4%) cases each. The urodynamic findings involved reduced bladder capacity in 20 (54%) cases, with mean cystometric capacity of 168.0 ± 122.2 ml. Detrusor overactivity was observed in 13 (35.1%) cases, with mean of 67.9 ± 34.6 cmH_2O. The range of the residual volume was 17.5 ± 33.5 ml, which was increased in five (13.5%) cases. Low bladder compliance was seen in four (10.8%) patients, mean bladder compliance of 22.2 ± 12.2 ml/cmH_2O. No hydronephrosis or reflux was observed. **Conclusion:** Almost one-third of the patients with cerebral palsy and urinary symptoms presented with normal urodynamic findings. The most frequent findings were reduced bladder capacity, detrusor overactivity, and increased post-void residual. No urinary tract complications were observed. *Neurourol. Urodynam. 28:959–963, 2009.* © 2009 Wiley-Liss, Inc.

Key words: cerebral palsy; children; lower urinary tract dysfunction; urodynamics

INTRODUCTION

The term cerebral palsy describes a group of permanent disorders of the development of movement and posture that cause limitations in activity and are attribute to nonprogressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances in sensation, perception, cognition, communication, and behavior, as well as epilepsy and secondary musculoskeletal problems.[1]

The prevalence of cerebral palsy ranges from 1.0 to 2.4 per 1,000 live births, and its etiology remains unexplained in many cases.[2,3] Because the diagnosis of cerebral palsy does not specify a particular etiology or pathology, epidemiologic studies have traditionally grouped children with cerebral palsy into phenotypic subtypes based on the distribution of limb weakness and the type of tone abnormality.[4] The design of a classification system, for instance, whether it is organized into nominal or ordinal categories, will vary depending on the concept being classified and the intended purpose for which classification is made.[5]

Control of micturition, the phases of bladder filling and emptying, is performed by the autonomic nervous system (sympathetic and parasympathetic) and by the somatic nervous system, including cortical pathways. In children, urinary continence develops with maturation of the cortical pathways that regulate the micturition centre located in the brainstem. During bladder filling, afferent impulses are transmitted through the spinal cord by sympathetic and parasympathetic pathways that converge in the pontine micturition centre, where the micturition reflex is constantly inhibited by cortical impulses until the appropriate time for voiding.[6] Cerebral lesions resulting in the loss of this inhibition may cause detrusor overactivity and voiding dysfunction.[6] The development of bladder control may be influenced by neurological impairment in children with cerebral palsy.

Although the prevalence of voiding dysfunction has been observed in an estimated one-third of patients with cerebral palsy,[7] few studies have documented urodynamic findings and urinary tract complications in children with cerebral palsy. It is important to think about the possibility of bladder dysfunction in any child with cerebral palsy who presents lower urinary tract symptoms.

Conflicts of interest: none.
Christopher Chapple led the review process.
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Thus, the objective of the present study was to evaluate urodynamic findings and possible renal damage in children with cerebral palsy and lower urinary tract symptoms.

METHODS

The children and adolescents included in the study were seen at the SARAH Network of Rehabilitation Hospitals in Rio de Janeiro, Brazil between January 2003 and June 2005. The children visited the hospital for physical rehabilitation and were first evaluated by the pediatric rehabilitation team. Children presenting with lower urinary tract symptoms were referred for assessment and a urologic work-up.

A retrospective study was conducted, including data obtained from the records of 37 children and adolescents with a diagnosis of cerebral palsy and lower urinary tract symptoms. All patients were submitted to a physical examination and urologic investigation involving laboratory tests of renal function (creatinine), urine tests, renal and urinary tract ultrasonography, and urodynamic evaluation. In cases with a history of urinary infection, the assessment was complemented by voiding cystourethrography.

Multichannel urodynamics studies (Medtronic Duet system, version 8.20, Minneapolis) consisted of cystometry, a pressure flow study, and external urethral sphincter electromyography using surface electrodes. The test was performed with the patient in a supine position using two 4-French catheters inserted transurethrally into the bladder. Intra-abdominal pressure was simultaneously measured with a rectal balloon catheter. Filling water cystometry was performed by infusion of a room temperature saline solution at a rate of up to 10% of predicted bladder capacity, expressed as ml/min (Koff formula).[8] The residual urine volume was assessed using a urethral catheter, immediately after the pressure flow study. The criterion used for an increased in post-void residual urine was a volume higher than 20 ml.[9] A bladder compliance of <10 ml/cmH_2O was considered low.

Were considered constipation a fewer than three bowel movements per week.[10]

All patients were given three doses of Nitrofurantoin (at 1.5 mg/kg) with the first dose being taken 1 hr prior to the procedure and the others at every 6 hr following.

Statistical analysis was performed using Fisher's exact or Yates' chi-square test. Two-sided probabilities (*P*-value) were computed and compared with a 0.05 alpha level.All methods and definitions were based on standardization of the International Children's Continence Society.[9] The study was performed in accordance with the Ethics Committee of the institution.

RESULTS

Thirty-seven children and adolescents were investigated, including 21 females and 16 males. The mean age was 7 years 8 months [SD of 4 years 6 months], with a range from 1 to 17-year-old. Patients' characteristics are presented in Tables I and II. Urinary tract infections were the main reason for the urologic investigation, and they were observed in 21 (56.7%) cases. The other main urinary symptoms were: incontinence in 15 (40.5%) cases, increased urinary frequency in six (16.0%) cases, and enuresis in five (13.5%) cases.

Serum creatinine was normal in all patients. Urine cultures showed asymptomatic bacteriuria in only two (5.4%) children, including *Proteus* and *Enterococcus* in one patient and *Streptococcus* in the other.

TABLE I. Patient Characteristics by Performance

	Wheelchair	Walking	Total
No. of groups			
Patients	21	16	37
Male	8	8	16
Female	13	8	21
Mean age, in years (SD)	6.2 (4.4)	10.3 (3.3)	7.8 (4.6)
No. of variables (% patients)			
Incontinence*	19	13	32 (86.4)
UTI**	17	4	21 (56.7)
Frequency	1	5	6 (16)
Enuresis	1	4	5 (13.5)
Hesitancy	1	1	2 (5.4)
Urgency	0	2	2 (5.4)
Straining	0	1	1 (2.7)
Weak stream	0	1	1 (2.7)
History of vesicoureteral reflux	1	0	1 (2.7)
Feeling of incomplete emptying	0	1	1 (2.7)
No. of bowel habits			
Constipation	7	1	8 (21.8)

*Present in 32 patients (86.4%). However, only 15 (40.5%) of the patients had this issue as the direct cause of the urologic investigation.
**UTI, urinary tract infection.

The results of renal and urinary tract ultrasonography were altered in only two (5.4%) patients. One had asymmetry in renal size, and the other had unilateral renal microlithiasis.

Voiding cystourethrography was performed on 13 patients with a history of urinary tract infection, and none of them presented vesicoureteral reflux. The previous report of vesicoureteral reflux in one patient was not confirmed.

The urodynamic tests were normal in 11 (29.7%) patients. Reduced bladder capacity was the most frequent urodynamic finding, observed in 20 (54%) patients. Mean $\pm$ standard deviation cystometric capacity was 168.0 $\pm$ 122.2 ml. Thirteen (35.1%) patients presented cystometric detrusor overactivity, with mean maximum amplitude of 67.9 $\pm$ 34.6 cmH_2O (Fig. 1). There were no cases of detrusor-sphincter dyssynergia. The other urodynamic findings and parameters are shown in Tables III and IV, respectively.

In this cohort, the occurrence of incontinence was statistically similar between wheelchair and walking patients ($P = 0.630$).

Constipation was observed in eight (21.6%) children. An association between the occurrence of urinary tract infections and constipation was not statistically significant ($P = 0.104$).

Anticholinergic agents was prescribed, specifically oxybutynin (at 0.2 mg/kg) for patients with cystometric detrusor overactivity. There were enough data to evaluate patients' response to the treatment indicated.

DISCUSSION

Although lower urinary tract dysfunction has been seen in children with cerebral palsy since the studies of Cass and Geist[11] in 1972, Waldbaum and Muecke[12] in 1972, and McNeal et al.[7] in 1983, few reports involving this patient group are available. Additionally, there has been no long-term follow-up to evaluate the risks of bladder dysfunction on renal function. Thus, urodynamic parameters that may cause damage to the upper urinary tract in these patients have not been established. Lower urinary tract dysfunction in patients with cerebral palsy differs from that observed in patients with spinal cord injuries and myelodysplasias. The risk for upper urinary tract deterioration is lower in the former group. Since

TABLE II. Patient Characteristics by Topography

	Choreoathetosis	Spastic diplegia	Spastic hemiplegia	Spastic tetraplegia	Total
No. of groups					
Patients	3	12	1	21	37
Male	3	3	1	9	16
Female	0	9	0	12	21
Mean age, in years (SD)	8 (6.1)	8.7 (4.2)	8 (0)	7 (4.6)	7.7 (4.5)
No. of variables (% patients)					
Incontinence	3	10	0	19	32 (86.4)
UTI	2	5	0	14	21 (56.7)
Frequency	0	2	1	3	6 (16)
Enuresis	1	3	0	1	5 (13.5)
Hesitancy	1	1	0	0	2 (5.4)
Urgency	0	0	1	1	2 (5.4)
Straining	1	0	0	0	1 (2.7)
Weak stream	0	0	1	0	1 (2.7)
History of vesicoureteral reflux	1	0	0	0	1 (2.7)
Feeling of incomplete emptying	0	1	0	0	1 (2.7)
No. of bowel habits					
Constipation	0	0	1	7	8 (21.6)
No. of walking disabilities					
Wheelchair	1	2	0	18	21
Walking	2	10	1	3	16

lesions in cerebral palsy involve suprapontine structures, the presence of detrusor-sphincter dyssynergia is uncommon. In a Mayo[13] study, 33 children with a diagnosis of cerebral palsy and with urinary symptoms were submitted to urodynamic evaluation, and detrusor-sphincter dyssynergia was observed in only one case. In the current study, there were no cases of detrusor-sphincter dyssynergia. In contrast, Decter et al.[14] studied 57 children with cerebral palsy and found detrusor-sphincter dyssynergia in seven cases. The most frequent urodynamic finding was detrusor overactivity, which was seen in 70% of cases.

In the present study, the most common urinary signs or symptoms that led to the urologic investigation were urinary infections (56.7%) and incontinence (40.5%). Although incontinence was present in 32 (86.4%) patients, only 15 (40.5%) of these patients had this symptom as the direct cause for the urologic investigation. The most common urodynamic findings were reduced cystometric capacity (54%) and detrusor overactivity (35.1%), with mean maximum amplitude of 67.9 ± 34.6 cmH_2O. Similar findings have been reported in the recent study of Karaman et al.,[15] who investigated 36 children with cerebral palsy and lower urinary tract dysfunction. Their urodynamic assessments showed a reduced cystometric capacity with detrusor overactivity in 17 (47%) patients and detrusor-sphincter dyssynergia with high voiding detrusor pressures and increased post-void residual in four (11%) patients.

Although a feeling of incomplete emptying was reported by only one (2.7%) patient, an increased in post-void residual urine was observed in five (13.5%) cases. In these patients, the voiding detrusor pressure ranged from 22 to 57 cmH_2O, and detrusor contraction was shortened in all patients. Thus, we believe that incomplete bladder emptying was a result of the fact that the duration of detrusor contraction was insufficient to allow for complete bladder voiding. It is also important to note that studies in healthy infants and toddlers have shown that children of this age do not always empty their bladders completely. Older children should, however, be expected to habitually empty their bladders completely.[16]

In a study involving 90 patients, Brodak et al.[17] observed structural anomalies of the urinary tract (mild hydronephrosis and bladder wall thickening) in only 2% of patients with cerebral palsy. They concluded that, in a general population

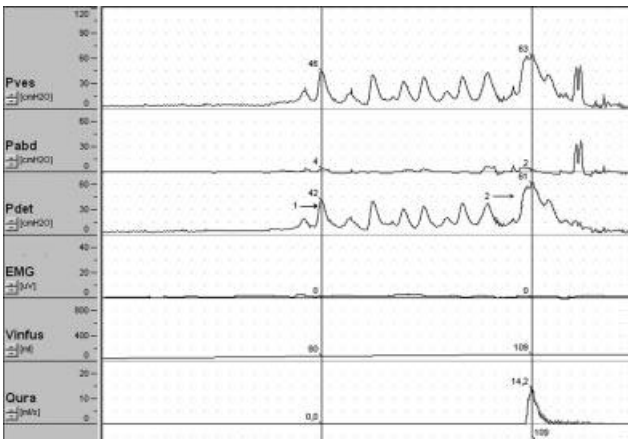

Fig. 1. Urodynamic evaluation of a 12-year-old female with cerebral palsy showing detrusor overactivity (arrow 1) with a pressure of 42 cmH_2O and a high voiding pressure (arrow 2). P_{ves}: vesical pressure; P_{abd}: abdominal pressure; P_{det}: detrusor pressure; EMG: electromyography; V_{infus}: infusion volume; Q_{ura}: urinary flow.

TABLE III. Urodynamic Findings

	(n = 37), n (%)
Reduced bladder capacity	20 (54.0)
Detrusor overactivity	13 (35.1)
Normal test	11 (29.7)
High voiding detrusor pressure (detrusor pressure > 40 cmH_2O)	10 (27.0)
Increased post-void residual (>20 ml)	5 (13.5)
Low bladder compliance (<10 ml/cmH_2O)	4 (10.8)
Detrusor areflexia	1 (2.7)

TABLE IV. Urodynamic Parameters

Cystometric capacity, ml (SD)	168.0 ± 122.2
Expected bladder capacity, ml (SD)	246.7 ± 144.1
Detrusor overactivity, cmH_2O (SD)	67.9 ± 34.6
Bladder compliance, ml/cmH_2O (SD)	22.2 ± 12.2
Residual urine, ml (SD)	17.5 ± 33.5

with cerebral palsy, the incidence of structural abnormalities is low. While these patients may experience bladder dysfunction, it does not appear to result in progression to upper tract changes in a significant percentage of patients. Thus, these authors advocated that routine evaluation of patients with cerebral palsy may be unwarranted, unless they have a history of urinary tract infection or the cognitive ability to convey symptoms. In agreement with these investigators, we also found a low rate of renal anomalies. Only two patients had abnormalities. One had asymmetry in renal size, and the other presented with microlithiasis. Although urinary tract infections were a frequent finding (56.7% of the patients), 13 patients were submitted to voiding cystourethrography, and none of them had a vesicoureteral reflux. In addition, no hydronephrosis or structural anomalies were detected upon ultrasonography. We have not been involved with any cases of detrusor-sphincter dyssynergia, which seems to be unusual in this group of patients. It is possible that in those cases, no upper urinary tract complications were observed.

Urinary incontinence is common among patients with cerebral palsy,[15,18] and it seems to be more frequent in patients with severe motor and cognitive impairments. Van Laecke et al.[18] performed a prospective study on voiding and continence patterns in 38 children who had severe mental and motor disabilities. They concluded that the development of incontinence is determined by a motor disability, especially the degree of mobility, rather than by mental development. In the current study, incontinence was observed in 86.4% of the patients.

Low bladder compliance was observed in only four (10.8%) cases. Bladder compliance is a complicated issue in pediatric practices, for several reasons. Compliance normally changes according to bladder volume. It also varies with age and can be affected by the rate of bladder filling. There are no reliable reference values available in infancy and childhood.[9]

It is important to emphasize that, although patients with urinary symptoms were investigated, urodynamic tests were normal in approximately one-third of the patients. This finding might be explained by the inclusion of children with bacteriuria that are not truly from the bladder and just a contaminant, but were reported to have urinary infections by their parents. Another possibility is that asymptomatic bacteriuria may not require treatment, which makes it different from a bacterial urinary tract infection. Only in two (5.4%) children, did the urine culture have asymptomatic bacteriuria and those patients were not given antibiotics. The significance of asymptomatic bacteriuria has been studied in various high risk groups, including children and adults with neurogenic bladders. The evidence from these studies suggests that no antibiotic treatment is necessary unless there are co-existent risk factors, such as a vesicoureteral reflux.[19,20]

Constipation was observed in eight children. An association between the occurrence of urinary tract infections and constipation was not statistically significant, although studies have supported the concept that children with a urinary tract infection have a higher rate of constipation.[21]

Although the use of prophylactic antibiotics was not the aim of this study, zero patients had a urinary infection after the urodynamic assessment. In fact, there are several studies on the effective use of prophylactic antibiotics to reduce a urinary tract infection in patients with urodynamics, but the results are conflicting. In particular, it must be noted that none of these studies included data from children.

There are some limitations in this study. It is a retrospective study, analyzing a small patient population of 37 cases and there were no long-term data. Additionally, cerebral palsy encompasses a heterogeneous group of patients. It has always been a challenge to define and classify, as documented by the number of attempts that have been made over the years. It seems that features of cerebral palsy, such as issues with movement and/or posture, along with disturbances in perception, cognition, and communication, may influence the acquisition of urinary continence. These factors have not been evaluated in this group of patients. Another important point is that most parents, and some physicians, have not given enough attention to the actual urinary problem and only focus on rehabilitation. This practice hinders an understanding of the incidence of affected children with urinary tract problems.

This study was conducted between January 2003 and June 2005. During this period, there were 1,817 children diagnosed with cerebral palsy in our institution. However, it was not possible to know the incidence of affected children with lower urinary tract problems because we believe the number of affected children was probably higher than that reported, for the same reasons as described above. Another reason for this issue is that some children with urinary symptoms may have been treated by the pediatric rehabilitation team and were not referred for urodynamic evaluation. We are currently monitoring a group of children with cerebral palsy, who are both symptomatic and asymptomatic for urinary tract problems. To gather data on these patients, we are using a questionnaire focusing on urinary and bowel habits, a bladder diary, urinary tract ultrasonography, and urofluxometry. We hope that soon we will be able to discuss our data and perhaps add more information to the scientific community.

In view of the urodynamic findings in this study, treatment consisted of anticholinergic agents or alpha-blockers to patients with cystometric detrusor overactivity or with an increased post-void residual volume, respectively. Clean intermittent catheterization was only suggested for the one patient who presented with detrusor areflexia.

CONCLUSION

In this study, no upper urinary tract complications were observed in the children with cerebral palsy. Although bladder dysfunction is common in the symptomatic population, the risk for upper urinary tract damage seems low. The most frequent urodynamic findings were reduced bladder capacity, detrusor overactivity, and an increased post-void residual. The urodynamic findings were normal in approximately one-third of the children with cerebral palsy and lower urinary tract symptoms, indicating that urodynamic evaluation might have been avoided in many cases, even in the presence of urinary symptoms.

REFERENCES

1. Rosenbaum P, Paneth N, Leviton A, et al. A report: The definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl 2007; 109:8–14.
2. Nelson KB. The epidemiology of cerebral palsy in term infants. Ment Retard Dev Disabil Res Rev 2002;8:146–50.

3. Winter S, Autry A, Boyle C, et al. Trends in the prevalence of cerebral palsy in a population-based study. Pediatrics 2002;110:1220–5.
4. Stanley FJ, Blair E, Alberman E. Cerebral palsies: Epidemiology and causal pathways. London, United Kingdom: Mac Keith Press; 2000.
5. Morris C. Definition and classification of cerebral palsy: A historical perspective. Dev Med Child Neurol Suppl 2007;109:3–7.
6. Boone TB. The bladder and genitourinary tract in the cerebral palsies. In: Miller G, Clark GD, editors. The cerebral palsies. Woburn, MA: Butterworth-Heinemann; 1998. Ch. 11.
7. McNeal DM, Hawtrey CE, Wolraich ML, et al. Symptomatic neurogenic bladder in a cerebral-palsied population. Dev Med Child Neurol 1983;25:612–6.
8. Koff SA. Estimating bladder capacity in children. Urology 1983;21:248.
9. Neveus T, von GA, Hoebeke P, et al. The standardization of terminology of lower urinary tract function in children and adolescents: Report from the Standardisation Committee of the International Children's Continence Society. J Urol 2006;176:314–24.
10. Thompson WG, Longstreth GF, Drossman DA, et al. Functional bowel disorders and functional abdominal pain. Gut 1999;45:1143–7.
11. Cass A, Geist R. Results of conservative and surgical management of the neurogenic bladder in 160 children. J Urol 1972;107:865–8.
12. Waldbaum R, Muecke E. Management of the congenital neurogenic bladder in children. J Urol 1972;108:165–6.
13. Mayo ME. Lower urinary tract dysfunction in cerebral palsy. J Urol 1992;147:419–20.
14. Decter RM, Bauer SB, Khoshbin S, et al. Urodynamic assessment of children with cerebral palsy. J Urol 1987;138:1110–2.
15. Karaman MI, Kaya C, Caskurlu T, et al. Urodynamic findings in children with cerebral palsy. Int J Urol 2005;12:717–20.
16. Jansson UB, Hanson M, Hanson E, et al. Voiding pattern in healthy children 0 to 3 years old: A longitudinal study. J Urol 2000;164:2050–4.
17. Brodak PP, Scherz HC, Packer MG, et al. Is urinary tract screening necessary for patients with cerebral palsy? J Urol 1994;152:1586–7.
18. Van Laecke E, Golinveaux L, Goossens L, et al. Voiding disorders in severely mentally and motor disabled children. J Urol 2001;166:2404–6.
19. Jayawardena V, Midha M. Significance of bacteriuria in neurogenic bladder. J Spinal Cord Med 2004;27:102–5.
20. Ottolini MC, Shaer CM, Rushton HG, et al. Relationship of asymptomatic bacteriuria and renal scarring in children with neuropathic bladders who are practicing clean intermittent catheterization. J Pediatr 1995;127:368–72.
21. Giramonti KM, Kogan BA, Agboola OO, et al. The association of constipation with childhood urinary tract infections. J Pediatr Urol 2005;1:273–8.