Radionuclide voiding pattern in children with unstable bladder

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Abstract

BACKGROUND: The purpose of this study was to investigate bladder function parameters by means of quantitative radionuclide cystography (QRC) in anxious, irritable children with unstable bladder.

METHODS: Quantitative radionuclide cystography was performed in 18 children aged between 8 and 12 years, without evidence of neurologic and nephrourologic disorders. Findings were compared with those obtained in 10 healthy children aged between 7 and 10 years. The dynamics of the bladder emptying were studied after intravenous injection of 37 MBq/10 kg b.w. 99mTc-diethylenetriaminepentaacetic acid (DTPA) in the posterior views. Images of 90 frames every 2 sec. were stored in the 64x64 computer matrix during voiding. The patients voided into a container and the volumes were measured.

RESULTS: The parameters evaluated were: functional bladder capacity (ml) — FBC, expected bladder capacity (ml) — EBC, percentage of EBC (%), voided urine volume (ml) — VV, residual urine (ml) — RU, voiding time (sec) — VT, average flow rate (ml/sec) — AFR and peak flow rate (ml/sec) — PFR. There was a statistically significant difference between controls and children with unstable bladder in the following parameters: FBC 288 ± 33 *vs*. 244 ± 27 ml ($p < 0.001$), % of EBC 99 ± 6 *vs*. 82 ± 6% ($p < 0.0001$), VV 265 ± 37 *vs*. 202 ± 35 ml ($p < 0.0001$), RU 22 ± 11 *vs*. 48 ± 19 ml ($p < 0.007$), AFR 13 ± 5 ml/sec *vs*. 9 ± 4 ml/sec. ($p < 0.01$) and PFR 19 ± 2 *vs*. 13 ± 3 ml/s ($p < 0.0001$), respectively. The VT obtained from the control group of 23 ± 9 s did not differ significantly from the value of children with unstable bladder of 28 ± 14 s.

CONCLUSION: The results show that quantitative radionuclide cystography is a simple, noninvasive method, which allows a good separation of patients with unstable bladder from the children with normal voiding pattern.

Key words: children, enuresis, unstable bladder, voiding, radionuclide cystography, urinary flow rate, bladder emptying

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Introduction

The basic function of the lower urinary tract (LUT) is urine storage and micturition. The ability to provide an adequate low-pressure reservoir for urine storage, and when socially appropriate, the ability to empty the reservoir completely requires a complex interaction of anatomic, physiologic, psychological and biochemical events.

It is a remarkable fact that nocturnal enuresis is beside allergic disorders the most common chronic ailment in childhood, and has been a serious problem for both afflicted children and their families for thousands of years (1).

The World Health Organization defines enuresis as a lack of bladder control in children above the age of five without neurological or urological reasons. Voiding dysfunction in neurologically intact children (nonneurogenic neurogenic bladder) means abnormal voiding patterns in children who share many clinical, radiological, urodynamic and psychological characteristics (2,3). The symptom complex associated with dysfunctional voiding includes daytime incontinence, enuresis, encopresis and constipation, frequencies, urge and sometimes urinary tract infection (4).

Until recently, any type of voiding during sleep, including children who also had daytime incontinence, was called enuresis. Investigations in patients with monosymptomatic bedwetting have, however, revealed that they are clearly different from children who have daytime symptoms (5). Based on pathophysiological findings bedwetters can be divided into those who have truly monosymptomatic bedwetting and those who have nighttime incontinence together with daytime symptoms, the so-called unstable bladder (6).

Clinically, the events occurring during the storage and voiding phases of LUT function can be evaluated by urodynamic testing. The International Continence Society has standardized these techniques and the terminology used to report these findings (7).

Bladder instability manifesting as uninhibited contractions on urodynamic studies are often found in enuretic children and the incidence ranges from 16–84% (8). A higher incidence of uninhibited contraction was urodynamically found in enuretic children with daytime incontinence than in those with monosymptomatic nocturnal enuresis (9).

The purpose of this study was to investigate bladder function parameters by means of quantitative radionuclide cystography (QRC) in anxious, irritable children with unstable bladder.

Material and Methods

Study group

Eighteen schoolchildren, aged between 7 and 11 years, 11 males and 7 females, were enrolled in the study. All of the investigated children were under psychological observation and treatment due to anxiousness, irritability and maladaptation. Beside the psychological problems, children suffered from LUT symptoms including urge, frequencies, daytime incontinence and bedwetting.

Physical examination including echosonography, urine and blood analyses were within normal limits in all studied children. Normal findings were found in 9 children who underwent intravenous urography. Urodynamic investigation was done in seven children. Six children were found to have idiopathic detrusor motor instability and in one detrusor — sphincter disinergia was diagnosed.

Control group (CG) consisted of 10 children, 6 males and 4 females aged between 7 and 10 years, having low probability of nephrourological disorders.

Methods

Siemens gamma camera equipped with low energy parallel hole collimator connected to a Sciniview computer system was used.

Patients were asked to void at the start of the investigation and forced urine output was then achieved by 400-ml oral water load.

The dynamics of the bladder emptying were started after intravenous injection of 37 MBq/10 kg body weight ^{99m}Tc-DTPA, when spontaneous urge to void expressed and could no longer be resisted. The patients voided into a container and the volumes voided (VV) were measured. Images of 90 frames every 2 sec. were stored in 64x64-computer matrix. A region of interest (ROI) was defined for the bladder and background subtraction was accomplished with a second ROI drawn on the gluteal region in order to generate background subtracted time activity curve.

Voiding time (VT) was defined as the time in seconds between the last point of maximal counts and the first point of minimal counts.

Average flow rate (AFR) determined the volume voided divided by the voiding time (ml/s).

Peak flow rate (PFR) is proportional to AFR multiplying with peak bladder emptying rate (maximum slope value of the derivative curve: cps/s) divided by mean bladder emptying rate (mean value of all slopes of the derivative curve: cps/s).

To obtain expected bladder capacity (EBC) Berger's formula was used (10) and estimated as follows: (age + 2) x 28.3 ml .

Functional bladder capacity (FBC) equals volume voided plus residual urine (ml) and also, was expressed as percentage of age adjusted bladder capacity — (%) EBC. Residual urine was calculated from 30 s static images done, before and after voiding, using the equation:

$$\text{Residual urine (ml)} = \frac{\text{VV [ml]} \times \text{minimum counts (cps)}}{\text{Maximum counts (CPAs)} - \text{minimum counts (CPAs)}}$$

The value of residual urine volume (RU) was presented as percentage of FBC (%).

Statistical analysis

Values are represented by the mean ± standard deviation and statistical differences between means were calculated using Student's t test for unpaired data. Differences were considered as significant when $p < 0.05$.

Results

The fact that the age is a strong predictor of bladder capacity and that girls tend to have larger capacity even after adjusting for age was the reason for evaluation of age and sex differences between and inside study groups (Table 1). Mean age value of 8.3 ± 1.05 years or the CG did not differ significantly from the value of 8.5 ± 1.29 years obtained for the group with unstable bladder. Also, the two sample Kolmogorov-Smirnov z test revealed no significant sex differentiation inside each group.

The mean values of functional and expected bladder capacity are displayed in Table 2. Values of EBC did not differ significantly between two groups (Control: 292 ± 30 ml *vs*. UB: 299 ± 37 ml). Conversely, the value of FBC (Control: 288 ± 33 ml *vs*. UB: 244 ± 27 ml) as well as a percentage of age-adjusted normal capacity (Control: 99 ± 6% *vs*. UB: 82 ± 6) were significantly lower in subjects with unstable bladder in comparison to the control group (FBC: $p < 0.001$, % EBC: $p < 0.0001$).

The results of voided and residual urine volumes are presented in Table 3. Mean value of voided urine volume in the group with unstable bladder of 202 ± 35 ml was markedly decreased compared to normal value of 265 ± 37 ml ($p < 0.0001$). Voiding time of 28 ± 14 s obtained for enuretics, although higher, did not differ significantly as regards value of 23 ± 9 s for the normal children group. The residual urine volume was significantly greater in the patients with unstable bladder than in the controls (48 ± 19 ml *vs*. 22 ± 11 ml; $p < 0.007$). Also, the mean value of residual urine, expressed as a percentage of FBC was markedly increased in children with unstable bladder in respect to the control group (17 ± 8% *vs*. 7 ± 4%; $p < 0.002$).

The results of AFR and PFR measurements are depicted in Fig. 1. Mean values obtained in the children with unstable bladder

Table 1. Demographic data

Groups	Age (years)	Male	Female
Control	8.3±1.05	6	4
Unstable bladder	8.5±1.29	11	7

Table 2. Bladder capacity study

Groups	N°	FBC [ml]	EBC [ml]	Percentage of EBC [%]
Control	10	288 ± 33	292 ± 30	99 ± 6
Unstable bladder	18	244 ± 27*	299 ± 37	82 ± 6**

*p < 0.001 *vs.* control, **p < 0.0001 *vs.* control

Table 3. Voiding and residual urine volume

Group	N°	VV [ml]	RU [ml]	RU [% of FBC]	VT [s]
Control	10	267 ± 37	22 ± 11	7 ± 4	23 ± 9
Unstable bladder	18	202 ± 35*	42 ± 19	17 ± 8***	28 ± 14

*p < 0.0001 *vs.* control, **p < 0.007 *vs.* control, ***p < 0.002 *vs.* control

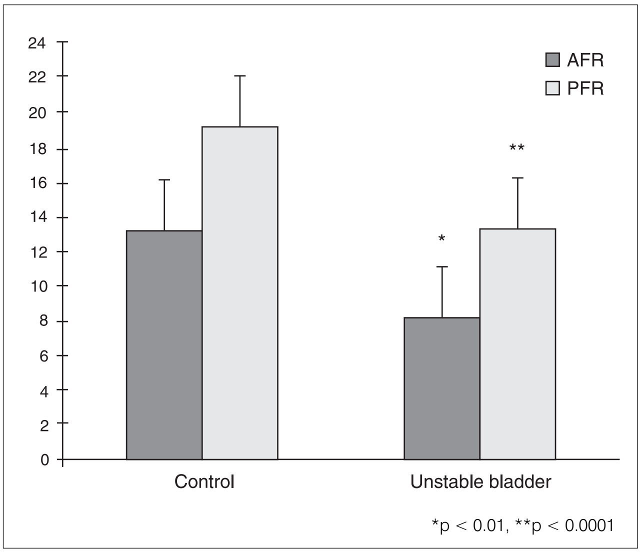

Figure 1. Urinary flow rates in children with unstable bladder and in healthy controls.

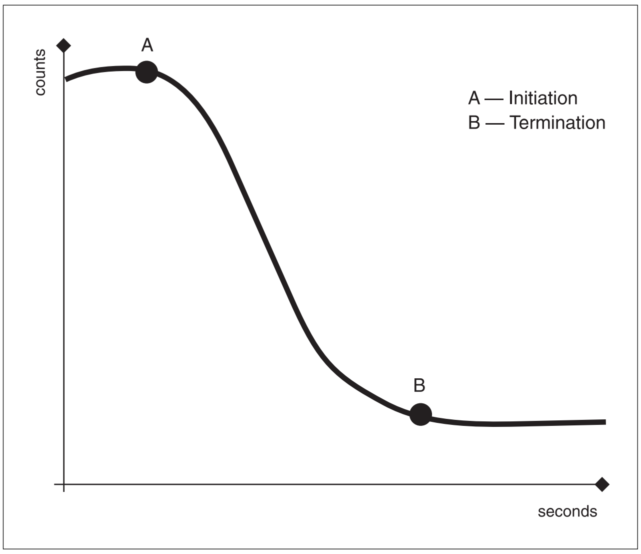

Figure 2. Time-activity curve in a child with normal voiding pattern.

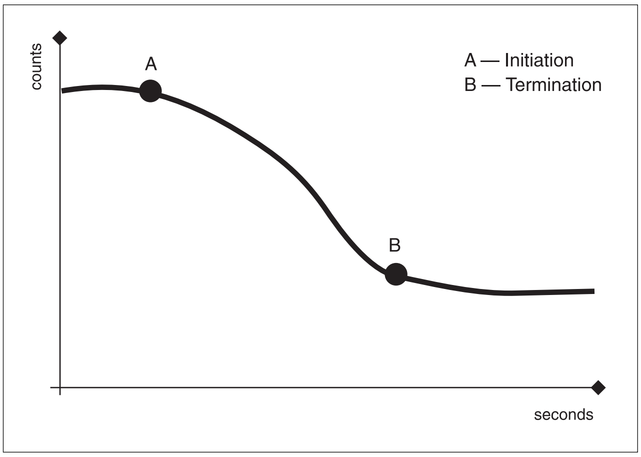

Figure 3. Time-activity curve in a child with unstable bladder.

for AFR of 8 ± 3 ml/s and PFR of 13 ± 3 ml/s were significantly lower than those for the control group of 13 ± 5 ml/s ($p < 0.01$) and 19 ± 2 ml/s ($p < 0.0001$), respectively.

The time activity curves of bladder emptying in a normal child and in a child with unstable bladder are presented in Figure 2 and 3.

Discussion

Until recently, the radionuclide evaluation of lower urinary tract dysfunction had not been well established. However, urodynamic tests by a combined pressure and flow study are widely accepted in determination of voiding efficiency in children. Besides the accuracy, urodynamic technique has disadvantages such as necessity for bladder catheterization and retrograde bladder filling. Apart from the risk of introducing infection, catheterization could be a traumatic procedure, particularly in children with nocturnal enuresis and daytime incontinence who are found to have impaired self-esteem, being uncooperative and irritable (11). Thus, our study group was selected from among children with psychological disorders.

Quantitative radionuclides cystography is a suitable non-invasive technique and allows for the provision of information on bladder and eventually reflux volumes during entire observation period and measuring residual bladder capacity and voiding flow rates.

It is well accepted that an accurate estimate of both expected (age adjusted) and functional bladder capacity is necessary when evaluating children with urinary tract pathology. Also, proper management decision often depends on determination of the functional bladder capacity expressed as percentage of expected volume (12).

The results of this study showed markedly decreased functional bladder capacity as well as the percentage of age-adjusted bladder capacity in the group with unstable bladder regarding to controls. Lower bladder capacity could be the consequence of uninhibited contractions found urodynamically in six of seven children with unstable bladder and daytime incontinence. Also, in those children significantly lower voided urine volume and near normal value of voiding time in respect of the children without urinary tract pathology were found.

The estimation of residual urine is important in the management of patients with voiding dysfunction. Radionuclide determination of residual urine volume as a simple and non-invasive method, avoided the most accurate quantitative assessment of residual urine using urethral catheterization. A high correlation was found (R = 0.985) between the measurements using two techniques (13). Children with unstable bladder were found to have significantly increased residual urine and percentage of functional bladder capacity in respect of normal values.

Besides the importance of bladder capacity and residual urine volumes determination, the major aspect of the total bladder function is urine flow rate. Because urine flow rate is the product of detrusor action against outlet resistance, variation from the normal flow rate might reflect the dysfunction of either. The children with unstable bladder were found to have markedly decreased both average and peak flow rates, respectively. Although those parameters using radionuclide methods have not been well established, especially in children with nocturnal enuresis, the urine flow rates obtained by radionuclide technique are found to be similar with urodynamic findings in patients with bladder outlet obstruction (14).

Moreover, low value of peak flow rate, combined with near normal voiding time obtained in our patients with unstable bladder, strongly support detrusor malfunction excluding outlet resistance.

Our results clearly delineate voiding pattern in children with unstable bladder including reduced functional bladder capacity, increased residual urine volume, decreased voiding volume, and both lower average and peak flow rate.

Radionuclide method, performed in physiological manner could be used both for screening and follow-up in children with bladder dysfunction. Moreover, additional important information including individual and total kidney function as well as ureterovesical junction competence, could be obtained in one act.

It may be concluded that quantitative radionuclide cystography is a simple, non-invasive method allowing separation of children with unstable bladder from the normal voiding pattern.

The widespread practical use of this quantitative approach, however, should await further clinical investigation.

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