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Evaluation of bladder capacity in children with lower urinary tract symptoms: Comparison of 48-hour frequency/volume charts and uroflowmetry measurements

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Summary

Introduction
Objective evaluation of bladder capacity (BC) in children with lower urinary tract symptoms (LUTS) is important for recognizing types of bladder dysfunction. Bladder capacity is evaluated from 48-hour frequency/volume (48-h F/V) charts or by uroflowmetry with ultrasound post-void assessment. There are limited data on the reliability of both methods of assessment in children.

Objective
The aim of the study was to compare two modalities of assessment, (F/V chart and uroflowmetry) in cohorts of children with bladder dysfunctions.

Study design
Maximum bladder capacity (MBC) obtained from 48-h F/V charts was compared with volumes calculated from uroflowmetry in a cohort of 86 children with different bladder dysfunctions. The BC obtained by the two modalities was compared for the three most frequent subtypes of bladder dysfunction: monosymptomatic nocturnal enuresis (MNE), overactive bladder (OAB), and dysfunctional voiding (DV). Considering a 48-h F/V chart as standard, the sensitivity, specificity, negative and positive predictive values of uroflowmetry measurements were calculated for detecting low bladder capacity.

Results
The mean maximal bladder capacity (188 ± 99.42 ml) obtained from home 48-h F/V chart measurement was 17 ml lower than the mean value obtained from uroflowmetry (205 ± 112.11 ml) ($P = 0.58$). The differences between bladder capacities estimated by 48-h F/V chart and uroflowmetry for subjects were not significant (Figure). Concordance between 48-h F/V chart and uroflowmetry categorization of BC was present in 64 (74%) subjects. The sensitivity and specificity of uroflowmetry, in comparison with 48-h F/V chart evaluation, for recognizing low bladder capacity were 75.5% and 73.17%. The sensitivity and specificity for the different types of LUTS achieved 68.42% and 58.83% for OAB, 80% and 83% for MNE, and 50% and 83.3% for DV.

Discussion
According to the International Children's Continence Society, the management of MNE in children can be made without uroflowmetry. History and MBC evaluation by 48-h F/V charts yields sufficient information. Nevertheless, in situations where F/V charts are unreliable or unavailable, uroflowmetry can be used as an alternative method. The highest discrepancy between both methods of BC evaluation was found in DV; this was mainly due to the mean PVR of 31 ml.

Conclusion
For children with MNE, both 48-hour frequency/volume charts and triplicate urine flow measurement with PVR evaluation are reliable methods of maximum bladder capacity evaluation. For children with OAB or DV, both methods may be necessary for accurate evaluation of decreased BC, as F/V chart and uroflow results may not be comparable.

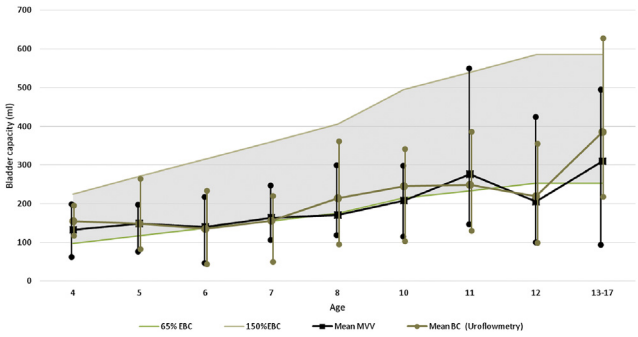

Figure Maximal voiding volume (48-hour frequency/volume chart) and bladder capacity (uroflowmetry) distribution according to age, plotted against reference bladder capacity distribution for children (65–150% estimated bladder capacity).

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Introduction

The objective evaluation of bladder capacity (BC) in children with lower urinary tract symptoms (LUTS) is of major importance for recognizing the different types of bladder dysfunction. The International Children's Continence Society (ICCS) recommends the use of 48-hour frequency/volume (48-h F/V) charts for this assessment, during which the volume and timing of every void and fluid intake is recorded [1]. The maximal voided volume (MVV) represents the functional capacity of the bladder. This method is non-invasive and is representative of the everyday bladder function of a child. The utility of a 48-h F/V chart assessment has recently been demonstrated in children [2]. Nevertheless, chart evaluation does not recognize post-void residual (PVR), and may underestimate BC when this is significant. Alternatively, BC estimation can be performed during uroflowmetry with PVR measurement [3]. Uroflowmetry repetition increases the reliability of this method in reflecting the child's bladder capacity and function [4]. Uroflowmetry studies yield additional information on PVR, flow-curve shape, and maximal urine flow rate during uroflowmetry (Qmax) values, thus enabling prompt categorization of bladder dysfunction. The disadvantage of this method of BC evaluation in all children presenting with LUTS is its higher cost and personnel involvement. Furthermore, uroflowmetry is not necessary for the diagnosis and management of one of the most frequent types of bladder dysfunction: monosymptomatic enuresis (MNE) [5].

There are limited data on the reliability of both methods of evaluating functional BC in children. The aim of the present study was to compare 48-h F/V chart and uroflowmetry measurements in a cohort of children with well-defined bladder dysfunctions.

Material and methods

All incident, previously untreated subjects referred for LUTS between August 2014 and August 2015 to the Children's Incontinence Clinic of Medical University Gdansk were included in the study (following exclusion of neurological and/or anatomical abnormalities). Bladder dysfunction was categorized according to ICCS terminology on the basis of the medical history, 48-hour daytime F/V chart, 2-week bladder diary, and uroflowmetry. Overactive bladder (OAB) was recognized in subjects with urinary urgency accompanied by frequency with or without incontinence, and a tower-shape curve with increased Qmax on uroflowmetry. Dysfunctional voiding (DV) was diagnosed in patients with a staccato flow pattern on uroflowmetry and a history of recurrent UTI, and, in some cases, significant PVR. Underactive bladder was diagnosed when increased bladder capacity was accompanied by decreased voiding frequency in a subject with straining during voiding and an interrupted flow pattern on uroflowmetry.

A total of 103 children were enrolled: 86 subjects completed the study, 17 were excluded due to non-compliance. The average age of the analyzed cohort, which included 44 girls and 41 boys, was 8 $\pm$ 3.08 years (range 4—17).

Bladder capacity values obtained from the 48-h F/V charts and those calculated from uroflowmetry studies were compared for the total cohort, and for the three most frequent subtypes of bladder dysfunction: monosymptomatic nocturnal enuresis (MNE), overactive bladder (OAB), and dysfunctional voiding (DV). During the initial visit, the parents were instructed by the physician on the performance of void measurements, which were carried out during the weekend when the child was under parental supervision. The maximal BC noted on the 48-h F/V chart, excluding first morning voids, was recorded as maximum voiding volume (MVV). Uroflows were performed, with an Ellipse device (Andromeda Medizinische Systeme GmbH, Germany), as outpatient procedures from the second morning void onward until two further voids were obtained on desire under voluntary water intake; the child was asked to urinate following a normal desire to void. Uroflowmetry measurements were repeated and documented three times on the same visit, and PVR was evaluated by transabdominal ultrasound immediately after voiding [6]. Maximal bladder capacity was recorded from uroflowmetry as the sum of the largest volume of voided urine and its corresponding PVR [7]. The largest bladder capacity was used for further analysis. Low bladder capacity was defined as $<$65% of expected bladder capacity (EBC) and normal bladder capacity as 65—150% EBC [1]. The EBC was calculated according to the Koff formula (30 $\times$ (age in years+1) for children between 4 and 12 years, and 390 ml for older children) [8].

Statistical analysis

Statistical analysis was performed using a commercially available statistics program (STATISTICA 12). The Shapiro—Wilk test was used to evaluate the distribution of variables. Continuous variables were presented as the mean and standard deviation. Probability values of $<$0.05 were considered statistically significant. The Wilcoxon Signed-Rank Test was used to compare pairs of results. Considering the 48-h F/V chart as standard, the sensitivity, specificity, negative and positive predictive values of uroflowmetry BC measurements were calculated for detecting low bladder capacity.

Results

Among the 86 treatment-naïve children who completed the study, 33 (38%) were found to have MNE, 36 (42%) had OAB, and 12 (14%) had DV. Three (4%) subjects demonstrated giggle incontinence, one had an underactive bladder, and one had voiding postponement.

The mean MBC (188 $\pm$ 99.42 ml) obtained from the 48-h F/V chart measurements was 17 ml lower than the mean value obtained from uroflowmetry (205 $\pm$ 112.11 ml) (P = 0.58). The mean MVV obtained by both methods for subjects with OAB, MNE, and DV are presented in Table 1, and their distribution is plotted against age-dependent EBC in Fig. A mean PVR of 30 ml (0—130 ml) was calculated for the DV subgroup.