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ORIGINAL PAPER

Are voiding volumes and frequencies different in the three-day voiding diary in children with lower urinary tract dysfunction?

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Summary

Aim: *The voiding diary (VD) yields crucial insights into voiding volumes (VV), voiding frequency (VF), and management habits in children with lower urinary tract (LUT) dysfunction. It is recommended to be conducted for a minimum of 2 days. Nevertheless, certain studies have indicated similarities in voided volumes between days in a three-day VD. This study aims to compare VV and VF values across days based on bladder capacity and symptom scores.*

Materials and Methods: *Children who applied to the pediatric urology clinic due to LUT symptoms between 2022 and 2023 were included in the study. Retrospective evaluation was conducted on the records. Children with neurological deficits and incomplete data were excluded from the study. All children were assessed following the guidelines of ICCS and EUA and underwent a 3-day voiding diary. Mean VV and VF values of the whole group for each day were compared and subgroup analyzes were performed in terms of gender, Voiding Dysfunction Symptom Score (VDSS), bladder capacity (BC), and diagnoses.*

Results: *A total of 109 (53 girls (48.6%), 56 boys (51.4%)) children with a median age of 8 (3-17) were included in the study. 77 (70.6%) children were diagnosed with overactive bladder, 8 (7.4%) with dysfunctional voiding, and 24 (22%) with monosymptomatic enuresis nocturne. The mean VVs between days were similar in the whole group (p = 0.759). Moreover, the mean VV of the first day was similar to the average of both the first two days and the three days (p = 0.021, p = 0.490). Also, the maximum and minimum VVs were similar between days (p = 0.942, p = 0.160, respectively). In subgroup analyses based on gender, bladder capacity, and symptom score, mean VV was also found to be similar. VF values were found to be significantly different between days. There was also a difference between VF values in children with VDSS > 8.5 (p = 0.012) and BC/EBC (%) > 65 (p = 0.030). In subgroup analysis for diagnoses, mean and maximum VV and VF were similar between the groups, except for VF (p = 0.026) in OAB.*

Conclusion: *While the voided volumes of children with non-neurogenic LUT dysfunctions appear to be consistent across the days of the VD, variations in VF might arise, especially among children with a VDSS of > 8.5 and normal bladder capacity. As a result, we believe that using a VD spanning at least two days could enhance diagnostic accuracy and help prevent unnecessary treatment.*

KEY WORDS: *Voiding diary; Lower urinary tract dysfunction; Bladder; Incontinence; Children.*

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INTRODUCTION

The presence of *lower urinary tract* (LUT) symptoms in children without congenital anatomical or neurological abnormalities indicates functional bladder disorders, and the *International Children's Continence Society* (ICCS) recommends using the term "*daytime LUT conditions*" for these cases (1). Initial evaluation of children presenting with LUT symptoms includes physical examination, urinalysis, symptom scores, *voiding diary* (VD), uroflowmetry, and residual urine measurement. VD is a highly useful tool that allows to show voiding habits, features of bladder function and is characterized by being an easy, non-invasive, no cost method. A properly completed VD provides information about *maximum voiding volumes* (MVV), *mean voiding volumes* (MVV), nocturnal urine volumes, *voiding frequency* (VF), presence and type of incontinence, enuresis, and fluid intake habits (2). It is recommended to be applied for at least 2 days in ICCS and *European Urology Association* (EAU) guidelines (1-3). However, some studies have reported similarities in VV between days at three-day VD (4, 5). *Franck et al.* reported that one-day VD was correlated with three-day VD and emphasized that one-day VD could be sufficient to evaluate LUT functions in children (5). However, a symptom score that gives information about the severity of symptoms was not evaluated together with VD parameters in these studies. We hypothesized that the VV and VF between days may vary depending on the severity of the symptoms. Therefore, in this study, it was aimed to compare VV and VF values between days according to bladder capacity and symptom score.

MATERIALS AND METHODS

Children who applied to the pediatric urology clinic due to LUT symptoms between 2022 and 2023 were includ-

ed in the study. The records were evaluated retrospectively. Ethical approval was obtained from the local ethics committee before the study (09.2023.674). Children with congenital genitourinary system anomalies such as ectopic ureter, duplicated collecting system, posterior urethral valve, bladder diverticula, epispadias, exstrophy vesica, etc., and congenital or acquired neurological deficits such as myelodysplasia, cerebral palsy, sacral agenesis, spinal cord injury, central and peripheral neural system malignancy, and children with missing data were excluded from the study. All children were evaluated in accordance with ICCS and EUA recommendations and underwent VD for 3 days (2). Mean VV and VF values of the whole group for each day were compared and subgroup analyzes were performed.

The first subgroup analysis was made by gender. The second subgroup was created according to *Voiding Dysfunction Symptom Score* (VDSS) (6). VDSS by *Akbal et al.* was filled in by all parents. Children were divided into two groups as below and above the cut-off value of 8.5 showing LUT dysfunctions. The third subgroup was formed according to *bladder capacity* (BC). Bladder capacity is calculated as: uroflowmetry voided volume + residual urine volume. The Koff formula was used to calculate the *expected bladder capacity* (EBC) by age (7). BC/EBC of less than 65% was considered a low-capacity bladder (8). The last subgroup was formed according to diagnoses *overactive bladder* (OAB), dysfunctional voiding, *monosymptomatic nocturnal enuresis* (MNE). Decreased VF was accepted as < 4 per day, normal VF 4-7 per day, and increased VF > 7 per day.

Statistical analysis

Data were analyzed using the IBM Statistical Package for the Social Sciences version 22 (*IBM SPSS Statistics for Windows, Chicago, IL, USA*). The normality of the distribution of the variables was evaluated using the Shapiro-Wilk test. As the distribution of continuous variables did not show a normal distribution, comparison of independent and dependent groups were done with Mann-Whitney U test and Wilcoxon Signed Ranks Test, respectively. Mc-Nemar test was used for binary categorical dependent data and Fisher's Exact test was used for independent data. The p value < 0.05 was accepted as statistically significant.

Results

A total of 109 (53 girls (48.6%), 56 boys (51.4%)) children with a median age of 8 (3-17) were included in the study. 77 (70.6%) children were diagnosed with OAB, 8 (7.4%) with dysfunctional voiding, and 24 (22%) with MNE. The mean VVs between days were similar in the whole group (p = 0.759) (Table 1). Moreover, the mean VV of the first day was similar to the average of both the first two days and the three days (p = 0.021, p = 0.490). Also, the maximum and minimum VVs were similar between days (1st day = 215.29+/-116.10 and 70.51+/-54.56 ml, 2nd day = 222.09+/-249.86 and 71.75+/-56.82 ml, 3rd day = 205.99+/-110.98 and 69.15+/-44.83 ml, p = 0.942, p = 0.160). In subgroup analyses based on gender, bladder capacity, and symptom score, mean VV was also found to be similar (Table 1). VF values were found to be significantly different between days. There was also a difference between VF values in children with VDSS > 8.5 (p = 0.012) and BC/EBC (%) > 65 (p = 0.030) (Table 2). In addition, 72 (66.1%) normal VF, 5 (4.6%) decreased VF, 32 (29.4%) increased VF were detected in first day; 75 (68.8%) normal VF, 10 (9.2%) decreased, 24 (22%) increased VF in second day; 77 (70.6%) normal VF, 6 (5.5%) decreased VF, 26 (23.9%) increased VF in third day (Table 3). When subgroup analysis was performed

Table 1.
Comparison of voiding volume in voiding diary.

	1st Day Mean VV (ml) (Mean+/-SD)	2nd Day Mean VV (ml) (Mean+/-SD)	3rd Day Mean VV (ml) (Mean+/-SD)	P value
All patients (n = 109)	134.11+/-69.83	127.30+/-69.43	131.10+/-64.69	0.759
Boys (n = 56)	125.51+/-60.47	121.37+/-69.47	127.22+/-61.21	0.099
Girls (n = 53)	144.62+/-78.03	134.28+/-70.30	136.62+/-68.74	0.488
VDSS < 8.5 (n = 33)	172.54+/-84.19	166.15+/-89.36	165.33+/-73.02	0.636
VDSS > 8.5 (n = 76)	117.42+/-55.36	110.43+/-50.82	116.23+/-54.87	0.334
BC/EBC (%) < 65 (n = 51)	122.72+/-70.52	108.66+/-57.64	115.11+/-58.53	0.345
BC/EBC (%) > 65 (n = 58)	144.12+/-68.25	143.68+/-75.07	145.15+/-67.03	

VV: voiding volume, VDSS: Voiding Dysfunction Symptom Score, BC: bladder capacity, EBC: expected bladder capacity.

Table 2.
Comparison of voiding frequencies in voiding diary.

	1st Day VF (Mean+/-SD)	2nd Day VF (Mean+/-SD)	3rd Day VF (Mean+/-SD)	P value
All patients (n = 109)	6.67+/-2.53	6.15+/-2.59	6.23+/-2.74	0.011
Boys (n = 56)	7.03+/-2.78	6.35+/-2.66	6.38+/-2.51	0.054
Girls (n = 53)	6.25+/-2.24	5.88+/-2.47	5.54+/-2.99	0.138
VDSS < 8.5 (n = 33)	6.06+/-2.13	5.37+/-1.84	5.75+/-1.90	0.663
VDSS > 8.5 (n = 76)	6.93+/-2.66	6.43+/-2.79	6.43+/-3.02	0.012
BC/EBC (%) < 65 (n = 51)	6.74+/-2.67	6.39+/-2.64	6.21+/-2.41	0.162
BC/EBC (%) > 65 (n = 58)	6.61+/-2.43	5.94+/-2.55	6.24+/-3.03	0.030

VF: voiding frequency, VDSS: Voiding Dysfunction Symptom Score, BC: bladder capacity, EBC: expected bladder capacity.

Table 3.
Comparison of number of decreased, normal and increased VF between days.

	1st Day	2nd Day	3rd Day
Decreased VF	5 (4.6%)	10 (9.2%)	6 (5.5%)
Normal VF	72 (66.1%)	75 (68.8%)	77 (70.6%)
Increased VF	32 (29.4%)	24 (22%)	26 (23.9%)
Total	109	109	109

P 1st & 2nd = 0.016, p 1st & 3rd = 0.237, p 2nd & 3rd = 0.289.
Decreased VF < 4x per day, normal VF = 4-7x per day, increased VF > 7x per day.

Table 4.
Comparison of mean and maximum voiding volumes and voiding frequencies according to diagnoses.

Diagnosis		1st Day (Mean+/-SD)	2nd Day (Mean+/-SD)	3rd Day (Mean+/-SD)	P value
OAB (n = 77)	Mean VV (ml)	130.11+/-73.25	126.81+/-74.18	127.71+/-67.75	0.798
	Maximum VV (ml)	209.63+/-121.05	228.48+/-292.29	199.77+/-112.28	0.743
	VF	6.93+/-2.62	6.30+/-2.80	6.46+/-2.96	0.026
DV (n = 8)	Mean VV (ml)	164.87+/-71.14	152.12+/-45.67	171.87+/-63.33	0.792
	Maximum VV (ml)	293.75+/-129.27	255.00+/-85.52	303.75+/-149.87	0.565
	VF	5.87+/-1.55	5.75+/-1.16	5.62+/-2.13	0.183
MNE (n = 24)	Mean VV (ml)	136.66+/-56.87	120.58+/-59.61	128.37+/-51.34	0.376
	Maximum VV (ml)	207.29+/-86.48	190.62+/-84.18	193.33+/-75.66	0.831
	VF	6.12+/-2.45	5.83+/-2.25	5.70+/-2.11	0.602

OAB: overactive bladder, DV: dysfunctional voiding, MNE: monosymptomatic enuresis nocturne, VV: voiding volume, VF: voiding frequency.

according to diagnoses, mean and maximum VV and VF were similar between the groups, except for VF (p = 0.026) in OAB (Table 4).

Discussion

VD is a highly useful tool that allows to show voiding habits, features of bladder function and is characterized by being an easy, non-invasive, no cost method. A properly completed VD provides information about VV, VF, presence and type of incontinence, enuresis, and fluid intake habits. Although at least two or three days of VD is recommended, it is known that this form is difficult for parents to fill out, especially during school days. Therefore, in the present study, we compared the parameters of one-, two-, and three-day VDs and evaluated the consistency of the one-day VD. Although we found similar mean VV between days in subgroup analysis according to gender, IBSS and ratio to EBC, we observed statistically differences in VF. Interestingly, even if there was a change in mean VFs between days, they were found to be remained within the normal daily voiding frequency. Hence, we believe that the clinical significance of this statistical difference between VFs should be considered with suspicion. However, since there can be a transition between normal and pathological voiding frequencies, as shown in Table 3, we think that children with IBSS > 8.5 or with bladder capacity below 65% according to EBC should be evaluated more carefully in terms of VF.

There are a limited number of studies in the literature comparing VD between days in children. In the study of *Franck et al.*, in which they evaluated the voiding diaries of 89 children (59 MNE, 30 OAB), it was reported that the VF, mean VV, and nocturnal volume were similar between the three days, but the maximum voiding volumes gradually decreased (5). They found that first day had 96% sensitivity, 71% specificity, and 75% overall accuracy in estimating bladder capacity. One of the interesting findings of the study is that the maximum VVs were lower than EBC in both the OAB (1st day: 69%, 2nd day: 67%, 3rd day: 53%) and MNE (1st day: 67%, 2nd day: 61%, 3rd day: 58%) groups. The authors stated that one day's VD may be sufficient to evaluate LUT dysfunctions and shows good correlation with the three-day chart. Unlike these results, present study showed that VVs are similar in all group and sub-group analyses but there are differences between VFs. Although the ages were similar between the two studies (8 years), only 45.7% of patients in this study had mean VV below 65% of EBC. Also, *Franck et al.* study, unlike ours (OAB %70.6), had an MNE (66.2%) dominant study group. Despite these differences, mean VVs were consistent between days in both studies.

In another study evaluating 92 children with LUT symptoms, mean VV, maximum VV, and fluid intake were shown to be similar between 2- and 3-day VD (4). In addition, high number of voids numbers and low bladder capacities were found to be close to each other. Moreover, 2- and 3-day VFs (7.05+/-3.83 & 6.87+/-3.85, p = 0.007) were reported to be different, similar to present study. It has been emphasized once again that a two-day VD may be sufficient for the evaluation of children with LUT dysfunctions. The prominent feature of the current study is the evaluation of VV and VF by creating subgroups according to symptom score and bladder volumes.

On the other hand, while VVs are similar between VD days, there are studies recommending longer VDs before moving on to invasive testing and other treatment modalities. *Elmer et al.* examined the impact of 1-day and 3-day voiding diaries on the test and treatment preferences of urogynecologists (9). In this study involving 186 women with urinary incontinence and other lower urinary tract symptoms, they found that a 1-day voiding diary led to a higher utilization of urine culture, urodynamics, cystoscopy, and other imaging techniques compared to a 3-day voiding diary. Likewise, they mentioned that shorter voiding diaries increased the probability of suggesting treatment methods like clean intermittent catheterization, pelvic floor rehabilitation, and surgical interventions. Nevertheless, they found a best agreement between the two voiding diaries for conservative approaches such as fluid restriction and scheduled voiding and medical treatments (kappa: 0.64, 0.61, 0.51, respectively). Thus, the authors recommend a three-day VD prior to invasive tests and treatments. However, to the best of our knowledge, we did not find any studies that investigated the impact of voiding diary duration on invasive tests and treatment preferences in children.

Completely and accurately filling out the three-day VD seems to be another challenge for patients. In a study conducted by The Symptoms of *Lower Urinary Tract Dysfunction Research Network* (LURN), a three-day VD was requested from 1064 (510 men, 545 women) volunteer participants with a mean age of 58.8 years (10). However, 84.8% (n = 902) of the participants returned a baseline voiding diary, and only 49.7% (n = 448) of them were completely filled out in terms of fluid intake and voiding records. While 57 patients filled less than three days, 306 patients were missing VVs, and 62 patients were lacking in fluid intake. Younger age and lower education levels were found to be associated with a higher probability of not submitting a diary or submitting an

unusable diary. Additionally, female gender was linked to a higher likelihood of submitting an unusable diary or a usable but incomplete diary. To the best of our knowledge, we believe that this process is more challenging for parents, even though there is no available data regarding appropriately filled voiding diary returns in children. We are aware that parents often express difficulties in completing voiding diaries, particularly when children are at school and engaged in play, or when the parents themselves are at work. In our own practice, we suggest completing the voiding diaries during weekends and holidays to facilitate this process.

The present has some limitations. We did not include fluid intakes of VDs in this study. We did not compare patients' control VDs after appropriate treatment. We did not perform subgroup analysis according to age groups, but we tried to compensate for this deficiency by proportioning the expected bladder capacity. We didn't investigate whether one-day and three-day VDs go on preference of treatment modalities.

CONCLUSIONS

Although the voiding volumes of children with non-neurogenic LUT dysfunctions are similar between the days of the VD, there may be differences in the voiding frequencies particularly in children with IBSS > 8.5 and normal bladder capacity. Therefore, we think that at least two daily voiding diary will contribute to strengthen the diagnosis and avoid overtreatment.

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