Özçift *African Journal of Urology* (2022) 28:9
https://doi.org/10.1186/s12301-022-00277-8

African Journal of Urology

ORIGINAL RESEARCH

Open Access

Correspondence of uroflowmetry and voiding diary in evaluation of voiding volume in children with lower urinary tract dysfunction

Burak Özçift[1,2*]

Abstract

Background: Objective assessment of voided volumes in children with lower urinary tract dysfunction is important. This study aimed to compare and evaluate voided volumes obtained from a 48-h voiding diary and uroflowmetry in children with lower urinary tract dysfunction.

Methods: In this retrospective cohort study, voided volumes obtained by 48-h voiding diary and contemporaneous uroflowmetry were compared in terms of age, sex, and the three most common subtypes of lower urinary tract dysfunction (monosymptomatic nocturnal enuresis, overactive bladder, and dysfunctional voiding) in children. Patients were stratified according to voided volume differences between uroflowmetry and 48-h voiding diary.

Results: A total of 242 children were included in the study. Maximum and average voided volumes in uroflowmetry were higher than those in 48-h voiding diaries in the entire population ($P < 0.001$). While there was a significant difference between maximum voided volume in the two methods when evaluating patients with overactive bladder and dysfunctional voiding, there was no significant difference in those with monosymptomatic nocturnal enuresis ($P = 0.001$, $P = 0.030$, $P = 0.206$, respectively). A significant difference was observed between the three subtypes of lower urinary tract dysfunction in voided volumes ($P < 0.001$). When maximum and average voided volumes were compared for age subgroups, there was no significant difference in maximum and mean voided volumes only in voiding diary measurements ($P > 0.05$). When the two methods were compared, there was a difference in maximum and average voided volumes of more than 30% of the estimated bladder capacity in 94 (38.9%) and 86 (34.3%) children, respectively.

Conclusions: Uroflowmetry and a 48-h voiding diary should not be used interchangeably when evaluating children with lower urinary tract dysfunction. The results of uroflowmetry measurements should be used to support the diagnosis of underlying lower urinary tract dysfunction.

Keywords: Children, Lower urinary tract dysfunction, Lower urinary tract symptoms, Uroflowmetry, Voiding diary, Voided volume

1 Background

Lower urinary tract dysfunction (LUTD) is a common problem in children [1]. Multiple anatomical, functional, and neurological factors can affect the storage and voiding stage and significantly impair the quality of life [2, 3]. Noninvasive urodynamic methods can be used to

*Correspondence: burakozcift@gmail.com
[2] Ismet Kaptan Mh, Sezer Dogan Sokagi No:11, 35210 Izmir, Konak, Turkey
Full list of author information is available at the end of the article

establish an accurate diagnosis and effective treatment of lower urinary tract symptoms (LUTSs) and LUTD. These methods can also be used to assess treatment response, correlate urinary symptoms with objective findings, and analyze clinical trial results. Both voiding diary (VD) and uroflowmetry (UF) are the most popular and useful helpful tools that can be considered as parts of the diagnostic evaluation [4].

VD is a semiobjective method for assessing LUTS and habitual physiological voided volume (VV). A 48-h VD is a simple and inexpensive tool used to record important clinical urinary symptoms such as VV, voiding time, fluid intake, voiding urgency, episodes of urinary incontinence, and the number of daily voiding events. Voiding diaries enable recording of the maximum, average, most common, most habitual, and ultimately physiological VV [4, 5]. Maximum and average VV (AVV) that can be determined from the VD is an important determinant of voiding behavior and can be used as a diagnostic tool, a benchmark for behavior change, and/or a measure of treatment success. However, not all patients/caregivers are willing or able to keep a VD. It is an important problem due to the fact that in some patients VD is not reliable. VD also reflects the largest VV as the maximum VV (MVV), excluding the first morning VV.

An alternative method for estimating MVV is uroflowmetry (UF), where the patient is instructed to wait until the bladder is full (MVV obtained during UF) [6]. UF is a noninvasive urodynamic test widely used as an objective tool to understand the presence of urinary dysfunction [4, 7]. Factors that may affect the diagnostic accuracy of UF include age, voiding position, repeated flows, psychological status, previous urethral catheterization, and VV [7]. To develop a strong contraction in micturition, the detrusor muscle fibers should be sufficiently stretched, but not excessively stretched to prevent muscle function. The literature indicates that VV between 50 and 115% of estimated bladder capacity (EBC) leads to a better interpretation of curve patterns in UF. [8–11]. Ideally, the three repetitive uroflows, excluding the first morning void, are stated to represent normal daily voiding in terms of accuracy and consistency [4, 10, 12].

MVV is well represented in both UF and VD. It is recommended to pick up whichever is larger [10]. Both MVV and AVV can be used for diagnosis, follow-up, and outcome measurements in children with LUTD during their daily activities [10]. In the case of a large difference in VV between VD and UF, UF may have been performed in unfavorable physiological conditions and have not reflected a normal voiding pattern. Therefore, it is recommended to use both VD and the UF measurements together in determining the underlying LUTD [4, 12]. However, the potential difference between VV measured by VD and the VV obtained during UF is still unclear to date. To our knowledge, there are not enough studies showing measured VV discrepancies between VD and UF in children.

This study aims to compare VV obtained during UF with VV measured by VD in children with LUTD and to evaluate the correspondence between them.

2 Methods

Patients who applied to the Pediatric Urology outpatient clinic of Izmir Dr. Behçet Uz Pediatrics and Surgery Training and Research Hospital between June 2017 and April 2021 and underwent UF were evaluated in this retrospective cohort study. LUTD was categorized according to International Children's Continence Society (ICCS) terminology by evaluating medical history, 48-h VD chart, and UF [4]. Overactive bladder (OAB) was defined as urinary urgency with or without urinary incontinence, usually accompanied by frequency and nocturia, in the absence of urinary tract infection or other obvious pathology. Dysfunctional voiding (DV) was diagnosed in patients with a staccato flow pattern with UF without OAB [4]. Patients who have increased pelvic floor electromyography (EMG) activity and a plateau voiding pattern in UF were also considered DV.

Inclusion criteria were diagnosis of LUTD, lack of systemic or chronic disease, age of > 5 years, completion of toilet training, and having fully completed a 48-h VD and 3 repetitive UF measurements. Patients with kidney and liver diseases, genetic and muscular diseases, neurological diseases, history of urological surgery, urological malignancies, psychiatric disorders, active urinary tract infection (UTI), and patients taking any medications that may affect LUTS were excluded from the study. The study followed the principles of the latest edition of the Declaration of Helsinki guidelines, and the study was reviewed and approved by the local committee (IRB approval number: 592/2021).

At the first visit, parents were briefed on how to record measurements in 48-h VD while the child is under their supervision. The MVV in the 48-h VD was recorded excluding the first morning voiding [4, 13]. None of the patients included in the study had a history of UF. UF was performed as outpatient procedure, starting from the second morning voiding until three different voids were obtained. The child was asked to urinate after feeling a normal urge to urinate. UF measurements were repeated three times during the same visit and recorded. Since PVR was not recorded in the VD, it was also not recorded in UF to ensure the comparison of homogeneous data. AVV and MVV values from 48 h of VD and UF were calculated for each patient.

For children, the EBC was calculated according to the formula of "30 x (in age + 1)" [14]. When evaluating VV, the elimination of bias that could be caused by variation in bladder capacity (BC) according to age was achieved by using the following formula VV/EBC (%) [12]. As the primary outcome, the VV values obtained from 48-h VD and calculated from UF were compared in the total cohort and the three most common subtypes of LUTD: monosymptomatic nocturnal enuresis (MNE), OAB, and DV. The VV values were also compared between sex and different age groups: ≤ 7 years of age, 7–11 years, and ≥ 12 years old.

The concordance between VV measured at VD and during the UF is one of the parameters indicating how physiological the micturition is. The greater the difference between VV measured at VD and during the UF, the less physiological is the urine flow [15]. As the secondary outcome, patients were classified according to the ratio of the difference between the MVV at 48-h VD and MVV calculated at UF to EBC, and according to the ratio of the difference between the AVV calculated at 48-h VD and AVV calculated at UF to EBC. The cohort was divided into four groups: group 1 included patients with a threshold difference between 0–10%, group 2 with a threshold difference between 10–20%, group 3 with a threshold difference between 20 and 30%, and group 4 with the threshold difference of more than 30%.

Statistical analyses were performed using IBM-SPSS for Windows 17.0 (IBM Corp, Armonk, USA). Kolmogorov–Smirnov and Shapiro–Wilk tests were used to evaluate the distribution of variables. Student t-test and Mann–Whitney U tests were used to compare continuous parametric and nonparametric variables. Continuous variables were reported as median or mean and standard deviation. The Wilcoxon-signed rank test was used to compare pairs of results. Kruskal–Wallis test was used when evaluating age and LUTD subgroups. The $p < 0.05$ was accepted as statistically significant.

3 Results

The study included a total of 242 toilet-trained children: 100 boys and 142 girls. The mean age of the patients was 9.16 ± 3.15 years (range 5–17). The mean age of boy and girl patients was 8.76 ± 3.12 years and 9.44 ± 3.15 years, respectively (P = 0.86). The patients' median voiding frequency was 6 (min–max: 2–22), and 120 (49.6%) patients had OAB, 86 (35.5%) had DV, and 36 (14.9%) had MNE.

The median MVV from UF (84.1% (23.6–24.6)) was higher than the median MVV from (73.1% (20–200)) from 48-h VD (P < 0.001). There was no significant difference between UF and VD in terms of MVV in < 12-year-old children, children with MNE, and girls (P > 0.05). When MVV was stratified according to age and gender, there was no significant difference in either group in MVV values only at 48-h VD (P > 0.05). Significant differences were observed between the MVV values obtained in the LUTD subgroups (P < 0.001) (Table 1).

Mean AVV in UF was significantly higher compared to 48-h VD (P < 0.001). When stratified by age, sex, and LUTD subgroups, the mean AVV in UF was significantly higher than the mean AVV in VD (P < 0.001). When AVV was stratified according to age and sex, there was no significant difference in either group in AVV values at UF and 48-h VD (P > 0.05). Significant differences were observed between the AVV values obtained in the LUTD subgroups (P < 0.001) (Table 2).

Based on the MVV and AVV differences between UF and 48-h VD, a VV difference of more than 30% of EBC was seen in 38.9% and 34.3% of patients. There was a difference of more than 20% of EBC that was seen in 57.9% and 53.7% of patients, respectively. MVV and AVV were comparable between the two methods only in 25.6% and 28.9% of patients, respectively (threshold difference 0–10%) (Table 3). Higher discrepancy between UF-MVV and VD-MVV is also shown by the Bland–Altman plot (Fig. 1).

4 Discussion

Evaluation of MVV is an important parameter in monitoring the diagnosis and treatment of children with LUTD [4]. There is no definite consensus on how to measure MVV [12, 13, 16, 17]. An accurate estimation of the MVV is important for several reasons. First, theoretically, if MVV is increased for any given condition, the number of voids can be reduced, provided that the 24-h VV remains similar. Second, changes in MVV provide an outcome measure by which treatment success or failure is assessed [18]. Third, the relationship between symptom severity, MVV, and BC provides a measure for understanding the pathophysiology [19]. In addition, an increase in AVV was evaluated as the primary outcome measure in the follow-up of therapy in patients with OAB. Assuming similar amounts of daily urine output, an increase in AVV reflects a decrease in frequency and an increase in habitual VV [20]. Finally, MVV and AVV provide useful information for developing diagnostic and therapeutic avenues in future research [21].

ICCS recommends keeping a minimum of a 48-h VD for adequate assessment of MVV and AVV. This time-consuming process requires motivation from the family and the child. UF is a reliable, simple, and noninvasive test. According to the ICCS, UF requires repetition for correct interpretation and reliability, as well as adequate VV (between 50–115% of EBC) [4]. It is well documented that uroflow is highly dependent on bladder volume (the larger the bladder volume, the greater the flow). For this

Table 1 Comparison of MVV reported by 48-h VD and UF in the entire study population and stratified according to the age, LUTD subtypes, and sex

	Pts, n	UF-MVV median (min–max)	VD-MVV median (min–max)	*P* value
All Pts. (ml)	242	224 (57–739)	200 (50–700)	**< 0.001***
(VV/EBC) (%)		84.1 (23.6–24.6)	73.1 (20–200)	
Age				
5–6 years (ml)	56	188.5 (57–433)	170 (50–360)	0.055*
(VV/EBC) (%)		91.9 (31.7–240.6)	83.3 (23.8–200)	
7–11 years (ml)	132	219 (78–558)	190 (60–700)	0.181*
(VV/EBC) (%)		75.8 (23.6–194.6)	66.7 (20–194.4)	
≥ 12 years (ml)	54	402 (160–739)	310 (100–600)	**< 0.001***
(VV/EBC) (%)		90.9 (31.4–189.5)	68 (25.6–153.9)	
P value		**0.01****	0.09**	
OAB (ml)	120	201.5 (57–663)	171.5 (50–600)	**0.001***
(VV/EBC) (%)		77.3 (23.6–170)	62.5 (20–153.9)	
DV (ml)	86	329 (80–739)	260 (80–700)	**0.030***
(VV/EBC) (%)		92.7 (31.4–240.6)	78.4 (33.3–200)	
MNE (ml)	36	215 (97–488)	200 (100–450)	0.206*
(VV/EBC) (%)		77.4 (35.9–167.4)	83.3 (29.8–166.7)	
P value		**< 0.001****	**< 0.001****	
Sex				
Boy (ml)	100	226.5 (86–637)	166.5 (50–620)	**< 0.001***
(VV/EBC) (%)		84.8 (37.8–178.8)	63.1 (23.8–172.2)	
Girl (ml)	142	223 (57–739)	200 (60–700)	0.063*
(VV/EBC) (%)		83.0 (23.6–240.6)	79.2 (20–200)	
P value		0.951**	0.062**	

Pts: Patients, MVV: maximum voided volume, UF: uroflowmetry, VD: voiding diary, VV: voided volume, EBC: estimated bladder capacity, LUTD: lower urinary tract dysfunction, OAB: overactive bladder, DV: Dysfunctional voiding, MNE: monosymptomatic nocturnal enuresis

Bold values indicate P value < 0.05

* Mann–Whitney test, ** Kruskal–Wallis test

reason, patients are often instructed to wait until the bladder is full before performing UF [22]. When the usual voiding pattern is achieved, the VV in UF is expected to be similar to that recorded in the VD. The concordance between VV measured in VD and UF is one of the parameters that show the physiological state of voiding. The greater the difference between these VV, the less physiological the urine flow [21, 23].

According to our study, although mean UF-MVV and UF-AVV were greater than VD-MVV and VD-MVV, VD-MVV and VD-AVV were greater in 42.1% and 23.1% of patients, respectively. Additionally, when calculating the difference between the two measurement tools as a percentage of the larger value, we found a discrepancy of the threshold difference of more than 30% (MVV/EBC) in 94 of 242 patients in the sample. This indicates that an MVV estimate can be inaccurate when only one measurement tool is used. MVV was comparable (threshold difference 0–10% (MVV/EBC)) in 62 of 242 patients between the two methods. When we examined the AVV threshold difference in UF and VD, we found a threshold difference discrepancy of more than 30% (AVV/EBC) in 83 of 242 patients in the sample, while AVV was comparable (threshold difference 0–10% (AVV/EBC)) between the two methods in 70 of 242 patients. These findings are important because the assessment of the patient's MVV and AVV through the use of a single VD or UF may be incomplete.

MVV is a representative parameter of maximum BC, rather than the usual and habitual physiological VV. Indeed, voiding may occur without or without a strong urge to void or large bladder filling volume, and voiding is often associated with other normal daily activities [24]. MVV may differ in UF compared to VD depending on environmental and psychological factors. While performing UF, the patient may experience an early or late urge to void due to the requirement of adequate VV for evaluation of UF or to avoid an incontinence episode [7–9]. These factors may limit the usefulness of UF alone for measuring MVV [4, 25, 26]. Rychik et al. showed that the mean VD-MVV (340.46 ± 147.83 ml) was higher than the UF- MVV (216.58 ± 152.11 ml) in

Table 2 Comparison of AVV reported by 48-h VD and UF in the entire study population and stratified according to the age, LUTD subtypes, and sex

	Pts (n)	UF-AVV median (min–max)	VD-AVV median (min–max)	*P* value
All Pts. (ml)	242	178.0 (51.5–579.7)	124 (28.5–521.4)	**<0.001***
(VV/EBC) (%)		64.2 (20.9–182.9)	42.8 (7.3–144.8)	
Age				
5–6 years (ml)	56	136.8 (51.5–265)	102.1 (29.6–222.5)	**<0.001***
(VV/EBC) (%)		65.5 (28.6–147.2)	48.6 (14.1–123.6)	
7–11 years (ml)	132	175.9 (65.6–439)	116.0 (33.1–521.4)	**<0.001***
(VV/EBC) (%)		60.8 (20.9–182.9)	41.9 (11–144.8)	
≥ 12 years (ml)	54	310.7 (145.7–579.7)	207.8 (28.5–500)	**<0.001***
(VV/EBC) (%)		69.2 (28.6–148.6)	40.9 (7.3–128.2)	
P value*		0.263**	0.410**	
OAB (ml)	120	166.8 (51.5–493.7)	112 (28.5–500)	**<0.001***
(VV/EBC) (%)		58.3 (20.9–126.6)	36.9 (7.3–128.2)	
DV (ml)	86	230 (75.5–579.7)	155.7 (45.4–521.4)	**<0.001***
(VV/EBC) (%)		72.9 (27.4–182.9)	47.5 (15.1–144.8)	
MNE	36	173.1 (65.7–366)	139.6 (61.5–232.3)	**<0.001***
(VV/EBC) (%)		64.6 (24.3–147.2)	51.1 (22.2–77.2)	
P value*		**0.001****	**<0.001****	
Sex				
Boy (ml)	100	178.8 (80.5–412.5)	117.9 (29.6–500)	**<0.001***
(VV/EBC) (%)		61.8 (31.1–163.1)	40.7 (14.1–128.2)	
Girl (ml)	142	178 (51.5–579.7)	128.3 (28.5–521.4)	**<0.001***
(VV/EBC) (%)		68.2 (20.9–182.9)	45.0 (7.3–144.8)	
P value*		0.991**	0.220**	

Pts: Patients, AVV: average voided volume, UF: uroflowmetry, VD: voiding diary, VV: voided volume, Med: median, EBC: estimated bladder capacity, LUTD: lower urinary tract dysfunction, OAB: overactive bladder, DV: dysfunctional voiding, MNE: monosymptomatic nocturnal enuresis

Bold values indicate P value < 0.05

* Mann–Whitney test, ** Kruskal–Wallis test

patients with LUTS (p < 0,001) [27]. Contrary to this study, Ertberg et al.'s study of women with and without detrusor overactivity found no significant difference between MVV measured by VD and UF [17]. In a study comparing cystometry, UF, and VD in children with OAB, Uluocak et al. found MVV significantly higher in the VD and reported that VD was more reliable in predicting MVV due to its physiological structure and ease of application in all age groups [28]. Maternik et al. compared UF and VD in patients with LUTD. They showed no significant difference was observed between MVV in UF and VD in children with LUTD. This study showed that UF can be used as an alternative when diaries are unreliable or unavailable [29]. Byeong et al. compared MVV in UF with MVV in VD in patients with enuresis nocturna; MVV in UF was measured as 127.3 ± 60.9 ml and 152.6 ± 74.6 ml in VD. The mean MVV/EBC ratios did not differ significantly between the two measurement methods (55.6% vs 48.9%; p > 0.05) [30]. In another study comparing UF-VV and VD-VV in adults with LUTS, mean VV was 256.27 ± 122.95.ml and 217.66 ± 81.05 ml, respectively. UF-mean VV was significantly higher than VD-mean VV (P < 0.01) [15].

Maternik et al. reported no significant difference between the MVV obtained from the VD and UF in patients with several LUTD (MNE, OAB, and DV) [29]. Here, in our present study, the difference in MVV between the two methods was higher in patients with OAB and DV than in those with MNE. No significant difference was measured between the MVV obtained from VD and UF only in patients with MNE. This result suggests that UF can be used as an alternative to predict MVV in children with MNE for whom VD cannot be performed. This finding loses its clinical significance, as UF is not indicated in the investigation of patients with MNE. For the estimation of MVV in patients with OAB and DV, UF should be taken into account when MVV from UF is much higher than from VD. VD can be useful to identify how much UF reflects natural voiding. Maternik et al. also evaluated the effectiveness of the two methods in different age groups and genders. They did not

Table 3 Stratification of patients according to VV threshold difference between VD and UF

Difference [(VV/EBC)(%)]	MVV (n) (%)	AVV (n) (%)
Group 1 (0–10)	**62 (25.6)**	**70 (28.9)**
OAB	**24 (20.0)**	**38 (31.7)**
DV	**22 (25.6)**	**24 (27.9)**
MNE	**16 (44.4)**	**8 (22.2)**
Group 2 (10–20)	40 (16.5)	42 (17.4)
OAB	24 (20.0)	11 (9.2)
DV	14 (16.3)	23 (26.7)
MNE	2 (5.6)	8 (22.2)
Group 3 (20–30)	**46 (19.0)**	**47 (19.4)**
OAB	**30 (25.0)**	**28 (23.3)**
DV	**14 (16.3)**	**11 (12.8)**
MNE	**2 (5.6)**	**8 (22.2)**
Group 4 (> 30)	94 (38.9)	83 (34.3)
OAB	42 (35.0)	43 (35.8)
DV	36 (41.9)	28 (32.6)
MNE	16 (44.4)	12 (33.4)

MVV: Maximum voided volume, AVV: average voided volume, UF: uroflowmetry, VD: voiding diary, VV: voided volume, EBC: estimated bladder capacity, OAB: overactive bladder, DV: dysfunctional voiding, MNE: monosymptomatic nocturnal enuresis

observe differences in mean MVV between ≥ 10 years old and < 10 years old, or between genders [29]. In our study, we found no significant difference between the MVV obtained from VD and UF only in girls and patients younger than 12 years old. The more hesitation and embarrassment that boys and patients ≥ 12 years old may feel when asked to void in UF than other children may be a possible explanation for this condition.

Since the AVV more reflects the habitual VV, it was used in conjunction with the MVV for follow-up in studies of OAB [20]. To our knowledge, only MVV was evaluated when comparing UF and VD in the literature. In this study, in addition to the MVV obtained in UF and VD, AVV was also compared within itself. There was a significant difference in the mean MVV and mean AVV values obtained from the two measurement methods within all patients. We also measured significant differences between the AVV from VD and UF in different ages, sex, and LUTD subgroups. When we examined the MVV and AVV reported in the VD, no significant difference was found between VV in age and sex subgroups. On the other hand, MVV and AVV in UF were similar only in the sex subgroups. These results show the importance of evaluating the MVV and AVV in VD and UF together when evaluating patients with LUTD.

Limitations of this study were the lack of an objective measure of accuracy for 48-h VD measurements that were done at home and the exclusion of PVR in VD and UF evaluations. The further limitations of the study were the uncontrollable stress states that can alter BC in VD and UF and the relatively small number of children with MNE. The results indicating the value of performing both assessments in this subgroup will need to be verified by studies of larger cohorts.

5 Conclusions

This study's results support the idea that both assessment methods should be used together, not interchangeably, to reach reliable results in patients with especially OAB and DV. For a more reliable assessment of MVV, the higher of

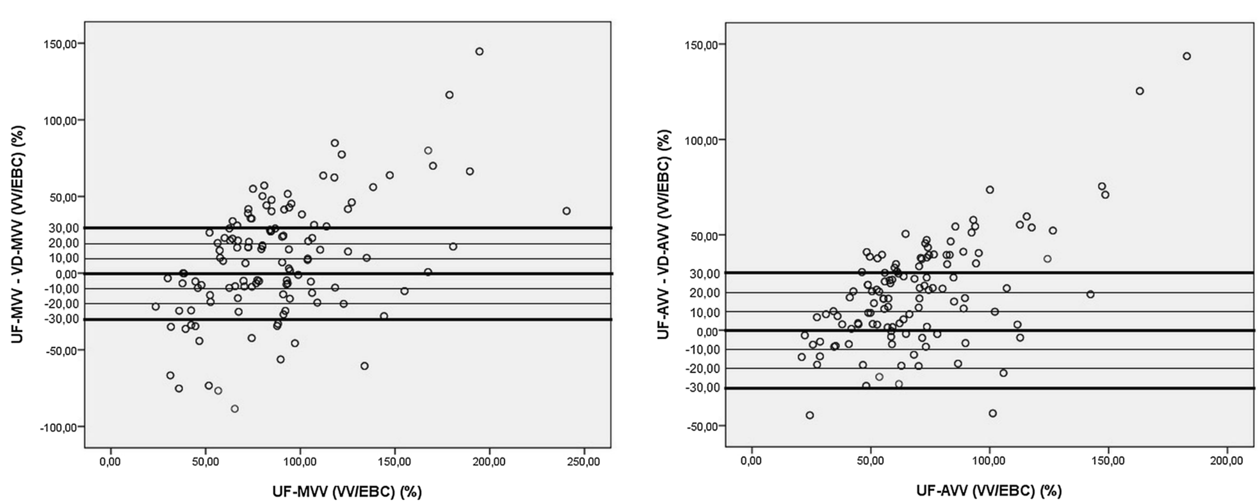

Fig. 1 Bland–Altman plot. MVV: maximum voided volume, AVV: average voided volume, UF: uroflowmetry, VD: voiding diary, VV: voided volume, EBC: estimated bladder capacity

the two values is a more reliable of MVV. UF can be used alone as an alternative to predict MVV only in children with MNE who simply cannot perform a VD.

Our study also showed that correspondence of VV measured in UF with those obtained in VD can be useful in clinical practice to identify how much the UF reflects natural voiding. Since UF is less reflective of habitual voiding, we believe UF should be repeated if the difference between UF-AVV and VD-AVV is high.

Abbreviations
LUTD: Lower urinary tract dysfunction; LUTS: Lower urinary tract symptoms; VD: Voiding diary; UF: Uroflowmetry; VV: Voided volume; AVV: Average voided volume; MVV: Maximum voided volume; EBC: Estimated bladder capacity; OAB: Overactive bladder; DV: Dysfunctional voiding; EMG: Electromyography; UTI: Urinary tract infection; MNE: Monosymptomatic nocturnal enuresis; ICCS: International Children's Continence Society; PVR: Post-void residual urine.

Acknowledgements
No agency to be acknowledged.

Authors' contributions
Author has read and approved the manuscript and contributed to the work. BÖ contributed to revision of the work and writing of the manuscript; supervision of the work and operative work; data collection and writing; idea of the work and supervision of operative work; and supervision of manuscript writing. Author has read and approved the manuscript.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on a reasonable request.

Declarations

Ethics approval and consent to participate
All patients signed informed consent. The study was carried out following the Helsinki Declaration and was approved by the local ethical committee of the Izmir Dr. Behçet Uz Child Diseases and Surgery Training and Research Hospital (IRB approval number: 592–2021).

Consent for publication
Patients and their parents had signed informed consent for use of their data in research and publication without the appearance of their names.

Competing interests
The author declares that I have no competing interests.

Author details
[1]Department of Pediatric Urology, Health Sciences University, Izmir Dr. Behcet Uz Child Diseases and Surgery Training and Research Hospital, Izmir, Turkey. [2]Ismet Kaptan Mh, Sezer Dogan Sokagi No:11, 35210 Izmir, Konak, Turkey.

Received: 28 January 2022 Accepted: 23 February 2022
Published online: 12 March 2022

References
1. Hoebeke P, VandeWalle J, Everaert K, Van Laecke E, Van Gool JD (1999) Assessment of lower urinary tract dysfunction in children with nonneuropathic bladder sphincter dysfunction. Eur Urol 35:57–69
2. Babu R, Gopinath V (2015) Role of uroflowmetry with electromyography in the evaluation of children with lower urinary tract dysfunction. Indian J Urol 31:354–357
3. Barroso U Jr, Nova T, Dultra A, Lordelo P, Andrade J, Vinhaes AJ (2006) Comparative analysis of the symptomatology of children with lower urinary tract dysfunction in relation to objective data. Int Braz J Urol 32:70–76
4. Austin PF, Bauer S, Bower W, Chase J, Franco I, Hoebeke P et al (2016) The standardization of terminology of lower urinary tract function in children and adolescents: Update report from the standardization committee of the International Children's Continence Society. Neurourol Urodyn 35:471–481. https://doi.org/10.1002/nau.22751
5. Lopes I, Veiga ML, Braga AANM, Brasil CA, Hoffmann A, Barroso U Jr (2015) A two-day bladder diary for children: is it enough? J Ped Urol. https://doi.org/10.1016/j.jpurol.2015.04.032
6. Ceyhan E, Asutay MK (2021) Standardization for reliable uroflowmetry testing in adults. Low Urin Tract Sympt 13:45–50
7. Gratzke C, Bachmann A, Descazeaud A, Drake MJ, Madersbacher S, Mamoulakis C et al (2015) EAU guidelines on the assessment of nonneurogenic male lower urinary tract symptoms including benign prostatic obstruction. Eur Urol 67:1099–1109
8. Choudhury S, Agarwal MM, Mandal AK, Mavuduru R, Mete UK, Kumar S et al (2010) Which voiding position is associated with lowest flow rates in healthy adult men? Role of natural voiding position. Neurourol Urodyn 29:413–417. https://doi.org/10.1002/nau.20759
9. Trabacchin N, Rubilotta E, Tiso L, Gubbiotti M, Giannantoni A, Illiano E et al (2019) Influence of emotional condition on uroflowmetry. Neurourol Urodyn 38:44–45
10. Bauer SB, Nijman RJ, Drzewiecki BA, Sillen U, Hoebeke P (2015) International Children's Continence Society standardization report on urodynamic studies of the lower urinary tract in children. Neurourol Urodyn 34:640–647
11. Hoebeke P, Bower W, Combs A, De Jong T, Yang S (2010) Diagnostic evaluation of children with daytime incontinence. J Urol 183:699–703
12. Neveus T, von Gontard A, Hoebeke P, Hjalmas K, Bauer S, Boer W et al (2006) 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 176:314–324
13. D'Ancona C, Haylen B, Oelke M, Abranches-Monteiro L, Arnold E, Goldman H et al (2019) The International Continence Society (ICS) report on the terminology for adult male lower urinary tract and pelvic floor symptoms and dysfunction. Neurourol Urodyn 38:433–477. https://doi.org/10.1002/nau.23897
14. Abrams P, Andersson K, Birder L, Brubaker L, Cardozo L, Chapple C et al (2010) Fourth international consultation on incontinence recommendations of the international scientific committee: Evaluation and treatment of urinary incontinence, pelvic organ prolapse, and fecal incontinence. Neurourol Urodyn 29:213–240
15. Rubilotta E, Righetti R, Trabacchin N, Curti P, Costantini E, Antonelli A et al (2020) Is the voided volume at office uroflowmetry physiological and reliable? A comparison between voiding diary and uroflowmetry. Urol Int 104:908–913
16. Yoon E, Swift S (1988) A comparison of maximum bladder capacity with maximum environmental voided volumes. Int Urogynecol J Pelvic Floor Dysfunct 9:78–82
17. Ertberg P, Moller AL, Lose G (2003) A comparison of three methods to evaluate maximum bladder capacity: cystometry, uroflowmetry and a 24-h diary in women with urinary incontinence. Acta Obstet Gynecol Scand 82:374–377
18. Abrams P, Kelleher C, Staskin D, Rechberger T, Kay R, Martina R et al (2015) Combination treatment with mirabegron and solifenacin in patients with overactive bladder: efficacy and safety results from a randomised, double-blind, doseranging, phase 2 study (Symphony). Eur Urol 67:577–588
19. Blaivas JG, Li ESW, Dayan L, Edeson ME, Mathew J, O'Boyle AL et al (2021) Overactive bladder phenotypes: development and preliminary data. Can J Urol 28:10699–10704
20. Snijder R, Bosman B, Stroosma O, Agema M (2020) Relationship between mean volume voided and incontinence in children with overactive bladder treated with solifenacin: post hoc analysis of a phase 3 randomised clinical trial. Eur J Pediatr 179:1523–1528

21. Schäfer W, Abrams P, Liao L, Mattiasson A, Pesce F, Spangberg A et al (2002) Good urodynamic practices: uroflowmetry, filling cystometry, and pressure-flow studies. Neurourol Urodyn 21:261–274
22. Chang S, Chen J, Chiang I, Yang S (2017) Lowest acceptable bladder capacity for interpretation of uroflowmetry tests in children. Low Urin Tract Symp 9:161–165
23. Rosier PFWM, Schaefer W, Lose G, Goldman HB, Guralnick M, Eustice S et al (2017) International continence society good urodynamic practices and terms 2016: urodynamics, uroflowmetry, cystometry, and pressure-flow study. Neurourol Urodyn 36:1246–1260
24. De Wachter S, Wyndaele JJ (2003) Frequency-volume charts: a tool to evaluate bladder sensation. Neurourol Urodyn 22:638–642
25. Boci R, Fall M, Walden M, Knutson T, Dahlstrand C (1999) Home uroflowmetry improved accuracy in outflow assessment. Neurourol Urodyn 18:25–32
26. De La Rosette JJMCH, Witjes WPJ, Debruyne FMJ, Kersten PL, Wijkstra H (1996) Improved reliability of uroflowmetry investigations: results of a portable home-based uroflowmetry study. Br J Urol 78:385–390
27. Rychik K, Policastro L, Weiss J, Blaivas J (2021) Relationship between maximum voided volume obtained by bladder diary compared to contemporaneous uroflowmetry in men and women. Int Braz J Urol 47:1189–1194
28. Uluocak N, Oktar T, Ander H, Ziylan O, Acar O, Rodoplu H et al (2009) Which method is the most reliable in determination of bladder capacity in children with idiopathic overactive bladder? A comparison of maximum voided volume, uroflowmetry and maximum cystometric capacity. J Pediatr Urol 5:480–484
29. Maternik M, Chudzik I, Krzeminska K, Zurowska A (2016) Evaluation of bladder capacity in children with lower urinary tract symptoms: Comparison of 48-hour frequency/volume charts and uroflowmetry measurements. J Pediatr Urol 12:214.e1–5
30. Byeong J, Chung J, Lee S (2020) Evaluation of functional bladder capacity in children with nocturnal enuresis according to type and treatment outcome. Res Rep Urol 12:383–389