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4.1 Introduction

The bladder function of young children is different from that of adults. In fact during the first years of life, there is still a progressive development of the micturition, from the initial indiscriminate way of voiding to a conscious and voluntary adult way. During growth, the functional storage capacity of the bladder increases, the voluntary micturition control matures and the ability to control the initiation and inhibition of the micturition through the sphincter-bladder unit starts [1].

The increase in bladder capacity during growth is a crucial step in the development of the bladder function and for urinary continence.

According to the international children continence society (ICCS), the recording of voiding symptoms at home under normal conditions is crucial for the assessment of lower urinary tract (LUT) function in childhood, and it is relevant after attainment of bladder control of age 5 years [2].

The assessment of lower urinary tract symptoms (LUTS) in children should be detailed and must include consistent and structured medical history and physical examination; and for assessment of the voiding diary, enough time must be taken [2, 3].

The International Continence Society (ICS) has proposed three main forms to record the micturition events: the *micturition time chart* that records only

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micturition times for at least 24 h, the *frequency volume chart (FVC)* that sets the time and the volume of each micturition and the *bladder diary* that registers the time and the volume of each micturition, incontinence episodes, pad usage and other information such as fluid intake, degree of urgency and urine loss [4].

In the paediatric population, bladder diaries or FVC are routinely used in clinical practice and provide a non-invasive method to evaluate children with LUTS.

4.2 Voiding and Bowel Diaries

Voiding diaries are a part of the diagnostic tools and play an important role in children with micturition problems. However, they always need to be accompanied by the assessment of patients' medical history, physical examination and often other questionnaires. The medical history generally starts at the perinatal or prenatal period and often regards eventual foetal distress, anoxia, birth trauma, oligohydramnios or prenatal hydronephrosis. Information regarding toilet training and the presence of incontinence, urge or age in which continence appeared is important to assess [3]. Other questions, such as holding manoeuvres, post-micturition dribble and urinary retention, should be addressed as well, together with previous surgery or urinary tract infections.

The most common voiding diaries used in clinical practice include properly filled out records of the daily fluid intake, the total voided volume and frequency in 24 h, given information about the mean voided volume, lowest and largest voided volume in 24 h, the distribution of urinary volume during day and night and episodes of urgency and leakage.

Concerning paediatric storage symptoms, it has been proved that voiding frequency is variable and it is mostly influenced by age, as well as by diuresis and fluid intake and in lesser terms the bladder capacity [5–7]. An increased frequency is considered when the child has a micturition frequency of ≥ 8 per day and a decreased daytime micturition frequency when the frequency is ≤ 3 a day [7].

Incontinence occurs when involuntary leakage of urine is seen, and continued incontinence, daytime incontinence, intermittent incontinence and enuresis have to be considered [7].

With a bladder diary it is also important to understand the increase or the decrease of the nocturnal bladder capacity elemental to diagnose nocturnal polyuria. Nocturnal polyuria is considered when the nocturnal urine production exceeds 130% of the expected bladder capacity (EBC) for age. The current formula to calculate the EBC in children is $(30 \times [\text{age in years} + 1])$ ml. EBC is advised to be applicable in children between 4 and 12 years old [2, 7].

In literature, the ideal minimal time for completing the bladder diary is controversial. In adults, several studies have been performed investigating the optimal duration of the voiding diary without reaching an agreement. For the paediatric population, the 2016 ICCS report states that the complete bladder diary (Fig. 4.1) consists of a seven-night recording of incontinence episodes and night-time urinary measurements to evaluate enuresis and a 48 hour daytime frequency and volume chart (not necessarily recorded on 2 consecutive days) to evaluate the LUTD [7].

Bladder Diary

Name: ROSSETTIA Date: 04/10/2000

Time	Urine Passed/Volume	Urgency	Leakage episode	Drinks volume/Type and Time	Comments
07 ⁰⁰	250	✓	+++	water 150	
09 ⁰⁰	100	✓	+	no	
12 ⁰⁰	300	✓	+	water 300	
12 ³⁰	50				
15 ⁰⁰	200	✓	+		
18 ⁰⁰	150	✓	++		
21 ⁰⁰	100	✓	+	water 150	
06 ⁰⁰	230	✓	+++		

Fig. 4.1 Example of paediatric bladder diary

In the adult population, according to literature, a voiding diary is recommended to be recorded for at least 3 or more days [8, 9]. In the EAU guidelines for non-neurogenic male LUTS, the recommendation is to use the FVC or a bladder diary to assess male LUTS with a storage component or nocturia but without any mentioning about how longer has to be filled [10–12]. Some studies for the adult population stated that the time has to be long enough to avoid sampling errors and short enough to avoid non-compliance [13].

Schick et al. analysed women with LUTS and compared various variables of the FVC for 1 up to 6 days and studied the reliability and compliance for each recorded parameter each day during 7 days. While days 1, 2 and 3 presented a different results from the total 7 days diary, the rest, day 3 (4, 5 and 6), were comparable, and they concluded that a 4 day diary gives accurate clinical information [14].

In literature there has been a lack of studies regarding bladder diaries for children.

A study comparing a 3-day versus a 2-day voiding diary in children showed that regarding urinary frequency, the 3-day diary had an agreement of 83.4% compared to the 2-day diary, but the average number of urinations was greater in the 2-day bladder diary. No statistical difference regarding the voided volume was seen. Their conclusion was that a 2-day diary gives comparable result and stated that when using the 2-day diary, a false-negative rate of 16% for frequency can be expected and a 2-day diary is sufficient to evaluate bladder capacity and fluid intake in children [15].

The international consensus of the ICCS for the management of enuresis recommends a *daytime diary* (has to be taken ideally during holidays or weekends), used to assess the child's bladder capacity. The measurement of maximum voided volume (excluding the first morning void) needs to be done for at least 3–4 days

[16, 17]. However, is also recommended a *bedwetting diary*, that has to be completed for seven consecutive days/nights, to access the presence of nocturnal polyuria; in this case, to calculate the night-time urinary production, the first morning voided volume must be added to the difference in diaper weight. In case of nocturia, it is recommended to add the night-time voided volume [16].

In children from 5 years old with incontinence, the pad test, the assessment of urine loss by repeating measurements of the weight of the absorptive pads placed in the underwear, is also important to be recorded [7].

There is an important relationship between bladder and bowel dysfunction. In fact, the genitourinary tract and the gastrointestinal tract share the same embryological origin, aspects of innervation and pelvic location, and they both pass through the levator ani muscle.

It is seen that after treatment of constipation, 66% of children with increased PVR had also an improvement in bladder emptying [18]. Moreover, in 1997, another study demonstrated an improvement of 89% of daytime wetting and a 63% resolution of night-time wetting with prevention of urinary tract infection [19]. For this reason, bowel diaries are helpful to evaluate and monitor children with voiding problems.

According to the ICCS, regarding this close relationship between bladder and bowel function described above, the bowel diary is required in association with bladder diary to rule out the bladder bowel dysfunction and to manage the functional constipation in children with LUTS. The Bristol stool scale is a useful tool in children, and constipation is stated when type 1 or 2 stool is present [20], but the most common diagnostic criterion used for constipations is the Rome-III criteria [7].

4.3 Why Do We Use Voiding Diary in Paediatric Population

Dysfunction of the lower urinary tract in children is common and can be related to detrusor and sphincter disorders, structural abnormalities (acquired or congenital) and other conditions, such as giggle incontinence or the Hinman syndrome [2]. However, according to the ICCS, a child with intact neurological system with dysfunctional voiding habitually contracts the urethra sphincter or pelvic floor during voiding [7].

In children the most common conditions for which diaries are useful are, enuresis and LUTS, including bladder bowel dysfunction.

The first non-invasive step to understand the micturition mechanism together with the medical history and questionnaires in paediatric population is through the compilation and the analysis of voiding and bowel diaries.

In studies of children presented with wetting problems, it was demonstrated that 32% of them had dysfunctional voiding [21]. Considering that dysfunctional voiding is often overlooked by families, the child and family education regarding the correct bladder and bowel management through timed voiding, adequate fluid intake during daytime, correct dietary advices (such as avoiding a high protein diet or salt

in the evening), correct position to void, hygiene and remembering to void before bedtime is an important tool for the clinical practice to start the management of bedwetting [22, 23].

In the management of enuresis, the consensus of ICCS proposed to provide families of a child with no apparent symptoms of non-monosymptomatic enuresis (NMNE) with bladder diaries the completion also before the second appointment (evidence level 3 grade B) [16]. It has been shown that the nocturnal urine output in many enuretic children is exceeding the bladder capacity during sleep at night [24].

In this way a bladder diary should help to distinguish between monosymptomatic enuresis and NMNE, giving important information about the bladder capacity and the nocturnal urine production.

4.4 Limitations of Bladder Diary in Children

With a bladder diary, it is impossible to obtain the PVR, being the biggest limitation of its diagnostic function.

The evaluation of the bladder before and after voiding should demonstrate residual urine, which is an important diagnostic parameter.

To be reliable, the PVR must be obtained immediately, within <5 min after voiding. Based on an Taiwanese study, the 2016 ICCS terminology stated that for children of 4–6 years old, abnormal PVR is considered when a single PVR >30 mL or 21% of the bladder capacity, where the BC is determined as voided volume + PVR expressed as percent of the expected bladder capacity. For children of 7–18 years old, a single PVR >20 mL or 15% BC or repetitive PVR > 10 mL or 6% BC is considered significant [2, 7].

This is why without PVR, the voiding diary is lacking.

Another limitation of completing the voiding diary is the parents', caregivers' or child's motivation. When some errors and mistakes during registration are identified, or changes on fluid intake are made, it will influence the clinical evaluation.

In conclusion, a diary is an important tool to evaluate voiding symptoms and bowel habits and help clinicians in better diagnostic and therapeutic approach. It is important to combine the voiding diaries with bowel diaries to obtain the best knowledge of bladder bowel dysfunction and other voiding disturbances.

References

1. Yeung CK. The normal infant bladder. *Scand J Urol Nephrol Suppl.* 1995;173:19–23. PubMed PMID: 8719561.
2. Neveys T, von Gontard A, Hoebeke P, Hjalmas K, Bauer S, Bower W, 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(1):314–24. PubMed PMID: 16753432.
3. Hoebeke P, Bower W, Combs A, De Jong T, Yang S. Diagnostic evaluation of children with daytime incontinence. *J Urol.* 2010;183(2):699–703. PubMed PMID: 20022025.

4. Abrams P, Cardozo L, Fall M, Griffiths D, Rosier P, Ulmsten U, et al. The standardisation of terminology of lower urinary tract function: report from the standardisation sub-committee of the international continence society. *Neurourol Urodyn*. 2002;21(2):167–78. PubMed PMID: 11857671.
5. Bower WF, Moore KH, Adams RD, Shepherd RB. Frequency-volume chart data from incontinent children. *Br J Urol*. 1997;80(4):658–62. PubMed PMID: 9352709.
6. Mahler B, Hagstroem S, Rittig N, Mikkelsen MM, Rittig S, Djurhuus JC. The impact of daytime diuresis on voiding frequency and incontinence classification in children. *J Urol*. 2008;179(6):2384–8. PubMed PMID: 18433779.
7. Austin PF, Bauer SB, Bower W, Chase J, Franco I, Hoebeke P, et al. 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*. 2016;35(4):471–81. PubMed PMID: 25772695.
8. Yap TL, Cromwell DC, Emberton M. A systematic review of the reliability of frequency-volume charts in urological research and its implications for the optimum chart duration. *BJU Int*. 2007;99(1):9–16. PubMed PMID: 16956355.
9. Homma Y, Ando T, Yoshida M, Kageyama S, Takei M, Kimoto K, et al. Voiding and incontinence frequencies: variability of diary data and required diary length. *Neurourol Urodyn*. 2002;21(3):204–9. PubMed PMID: 11948713.
10. Cornu JN, Abrams P, Chapple CR, Dmochowski RR, Lemack GE, Michel MC, et al. A contemporary assessment of nocturia: definition, epidemiology, pathophysiology, and management--a systematic review and meta-analysis. *Eur Urol*. 2012;62(5):877–90. PubMed PMID: 22840350.
11. Weiss JP, Bosch JL, Drake M, Dmochowski RR, Hashim H, Hijaz A, et al. Nocturia think tank: focus on nocturnal polyuria: ICI-RS 2011. *Neurourol Urodyn*. 2012;31(3):330–9. PubMed PMID: 22415907.
12. Gratzke C, Bachmann A, Descazeaud A, Drake MJ, Madersbacher S, Mamoulakis C, et al. EAU guidelines on the assessment of non-neurogenic male lower urinary tract symptoms including benign prostatic obstruction. *Eur Urol*. 2015;67(6):1099–109. PubMed PMID: 25613154.
13. Bright E, Drake MJ, Abrams P. Urinary diaries: evidence for the development and validation of diary content, format, and duration. *Neurourol Urodyn*. 2011;30(3):348–52. PubMed PMID: 21284023.
14. Schick E, Jolivet-Tremblay M, Dupont C, Bertrand PE, Tessier J. Frequency-volume chart: the minimum number of days required to obtain reliable results. *Neurourol Urodyn*. 2003;22(2):92–6. PubMed PMID: 12579624.
15. Lopes I, Veiga ML, Braga AA, Brasil CA, Hoffmann A, Barroso U Jr. A two-day bladder diary for children: is it enough? *J Pediatr Urol*. 2015;11(6):348 e1–4. PubMed PMID: 26386888.
16. Vande Walle J, Rittig S, Bauer S, Eggert P, Marschall-Kehrel D, Tekgul S, et al. Practical consensus guidelines for the management of enuresis. *Eur J Pediatr*. 2012;171(6):971–83. PubMed PMID: 22362256. Pubmed Central PMCID: 3357467.
17. Hansen MN, Rittig S, Siggaard C, Kamperis K, Hvistendahl G, Schaumburg HL, et al. Intra-individual variability in nighttime urine production and functional bladder capacity estimated by home recordings in patients with nocturnal enuresis. *J Urol*. 2001;166(6):2452–5. PubMed PMID: 11696810.
18. Dohil R, Roberts E, Jones KV, Jenkins HR. Constipation and reversible urinary tract abnormalities. *Arch Dis Child*. 1994;70(1):56–7. PubMed PMID: 8110010. Pubmed Central PMCID: 1029685.
19. Loening-Baucke V. Urinary incontinence and urinary tract infection and their resolution with treatment of chronic constipation of childhood. *Pediatrics*. 1997;100(2 Pt 1):228–32. PubMed PMID: 9240804.
20. Heaton KW, Radvan J, Cripps H, Mountford RA, Braddon FE, Hughes AO. Defecation frequency and timing, and stool form in the general population: a prospective study. *Gut*. 1992;33(6):818–24. PubMed PMID: 1624166. Pubmed Central PMCID: 1379343.

21. Hoebeke P, Van Laecke E, Van Camp C, Raes A, Van De Walle J. One thousand video-urodynamic studies in children with non-neurogenic bladder sphincter dysfunction. *BJU Int.* 2001;87(6):575–80. PubMed PMID: 11298061.
22. Hjalmas K, Arnold T, Bower W, Caione P, Chiozza LM, von Gontard A, et al. Nocturnal enuresis: an international evidence based management strategy. *J Urol.* 2004;171(6 Pt 2):2545–61. PubMed PMID: 15118418.
23. Vande Walle J, Vande Walle C, Van Sintjan P, De Guchteneere A, Raes A, Donckerwolcke R, et al. Nocturnal polyuria is related to 24-hour diuresis and osmotic excretion in an enuresis population referred to a tertiary center. *J Urol.* 2007;178(6):2630–4. PubMed PMID: 17945292.
24. Hjalmas K. Pathophysiology and impact of nocturnal enuresis. *Acta Paediatr.* 1997;86(9):919–22. PubMed PMID: 9343267.