Review Article

Diagnosis and management of lower urinary tract dysfunction in childhood

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Introduction

Functional disorders of the bladder and urethra often lead to incontinence and exert a huge psychosocial impact on the affected child and the family. In addition, increasing evidence suggests that these disorders are strongly associated with recurrent urinary tract infections (UTI), renal scarring, and persistence of vesico-ureteric reflux (VUR). However, functional lower urinary tract disorders (LUTD) are still largely underdiagnosed, and even if diagnosed, the treatment they receive is often suboptimal. Therefore, children continue to suffer with injurious corollaries, some of which may be irreversible[1-5].

Physiological functions of the bladder mature as children grow older and they achieve socially accepted volitional control of urination, usually between the ages of 3 to 5 years. In accordance with the classifications provided by the International Children's Continence Society (ICCS), LUTD can be best defined as "occurrence or persistence of lower urinary tract symptoms beyond the age of toilet training due to a functional abnormality of the detrusor muscle or urethral sphincters, without associated neurological or anatomical pathology of the lower urinary tract"[6]. Even though incontinence is the most frequently associated symptom, LUTD encompasses a myriad of other symptoms. Bowel dysfunction, manifested as encopresis or chronic constipation, is a common association of LUTD; the umbrella term 'Bladder Bowel Dysfunction (BBD)' is used to describe the concomitant occurrence of functional disturbances of bladder and bowel[6].

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The main aim of this article is to provide an overview of the pathophysiology, diagnosis, and management options of some important functional bladder disorders to increase awareness among the clinicians who are caring for children.

Classification of LUTD[6]

Disturbances of smooth and well-coordinated activities of detrusor or internal sphincter or external sphincter muscles can interrupt normal voiding mechanisms either during the filling or the voiding phases of the micturition cycle. Even though an exact classification remains debated, LUTD is often categorised according to following urodynamic abnormalities which may present in isolation or often in combination:

- Over-active bladder (OAB)
- Dysfunctional voiding (DV)
- Underactive or atonic bladder
- Voluntary voiding postponement
- Urethral instability
- Extraordinary daytime only urinary frequency
- Vaginal reflux

The 3 main functional disorders, OAB, DV and atonic bladder will be discussed in this article.

Overactive bladder (OAB)

This is the most common LUTD in children and is due to the uninhibited contractions of the detrusor muscle during the filling phase of the micturition cycle. Peak age of presentation is from 5–7 years and OAB tends to decrease with age[7-9]. According to the terminology described by ICCS, OAB is defined as the presence of urinary urgency, usually accompanied by frequency and nocturia, with or without urinary incontinence, in the absence of infection or other obvious pathology[6]. The sudden unexpected detrusor contractions cause pelvic muscle spasms and provoke various holding manoeuvres (Table 1 and Figure 1).

Table 1: ***Clinical features of the main functional bladder disorders***[1,7,9,10,16]

Urodynamic abnormality	Clinical features
Over-active bladder (OAB)	Urgency (subjective hall mark) Urge incontinence, frequency, nocturia Holding manoeuvres (crossing the thighs, pressing the buttock muscles with heel of the feet, tip toe walking, pressing genitalia or pinching the penis)
Dysfunctional voiding	Incontinence and recurrent urinary tract infections (UTI) (most common symptoms) Symptoms due to outflow resistance (difficulty of initiation, straining, hesitancy, intermittent flow, and sensation of incomplete bladder emptying after voiding) Dysuria, haematuria Scabbing at urethral meatus (in boys) Typical symptoms of OAB (urgency, frequency and urge incontinence) Non-specific symptoms (itching of genitalia, perineal pain, supra pubic pain and smelly urine)
Atonic bladder	No urge to pass urine, infrequent voiding, overflow incontinence, overdistended palpable bladder with large residual urine, secondary vesico-ureteric reflux, recurrent UTI

Figure1: ***Forcefully crossing thighs to prevent urine leaking 'Vincent curtsy posture'***

Dysfunctional voiding (DV)

DV, as the name itself suggests, is a voiding phase disorder. When the detrusor contracts during voiding, the pelvic floor muscles and the urethral sphincters should fully relax allowing free passage of urine. Contrary to this normal mechanism, children with DV habitually contract the pelvic floor muscles engaging the external urethral sphincter during voiding. This functional bladder outlet obstruction leads to incomplete bladder emptying, bladder muscle hypertrophy and raised intravesical pressure. If there is no intervention, raised bladder pressures will cause secondary VUR or persistence of primary VUR with compensatory hypertrophy of the detrusor muscle and subsequent fibrosis, leading to hypo-contractile bladders[1,9].

DV characteristically manifests after the age of toilet training and before puberty but may present at any age[1]. Common clinical symptoms are incontinence or recurrent UTI or symptoms due to outflow resistance. Confusingly, these children often have typical symptoms of OAB, which may reflect the reduced functional bladder capacity due to post-void residual urine or true overactivity provoked by detrusor muscle hypertrophy[1,9]. Passage of urine within a contracted sphincter often causes dysuria and may damage the urethral mucosa with resultant microscopic haematuria or even gross terminal haematuria[1,9,10].

Atonic or underactive bladder

Children with underactive bladder have lack of bladder sensation or urge to pass urine. Characteristically, they are infrequent voiders and may stay for hours to pass urine after waking up. They usually present with overflow incontinence, overdistended palpable bladders with large residual urine, secondary VUR, recurrent UTI and renal scarring. They generally have dampness in under pants, rather than soaking[1]. If intervention is delayed, it will lead to further fibrosis and ultimate myogenic failure of detrusor muscle which typically behave as a neurogenic bladder, giving its name 'non-neurogenic – neurogenic bladder'[1,9].

Pathophysiology

A widely accepted theory of OAB is a failure to suppress the detrusor contractions during the filling phase due to a maturational delay of the functions of the frontal cortex leading to persistence of immature infantile neuronal mechanisms[9].

Perseverance of infantile dyscoordinated patterns can also lead to DV beyond the age of toilet training. However, the commonest cause of DV is thought to be a learned or acquired pelvic floor-sphincter behaviour during voiding[1]. During normal voiding, the pelvic floor and the external sphincter should relax and allow free passage of urine. However, many potential triggers, such as difficult toilet

training, painful urination, emotional, psychological or environmental factors may provoke the child to voluntarily contract the pelvic floor engaging the external urethral sphincter during voiding to prevent urination and this can lead to subsequent habitual dysfunction[1,9-13]. Recent studies suggest that female sex and dilated VUR can be risk factors of BBD in children with UTI, though the exact mechanisms are not described[14].

Children with initial OAB can later develop DV and vice versa. Long-standing and uncontrolled DV can also lead to detrusor hypo-contractility secondary to muscular fibrosis; however, the primary causes of very early onset non-neurogenic neurogenic bladder are more likely to be secondary to intrauterine or inherited pathologies[9]. Even though genetic aetiology is suggested for all types of LUTD, the exact genes have been isolated only in a few conditions like trisomy 21, Ochoa syndrome and inherited syndromic neuropsychiatric disorders with abnormalities of the anterior cingulate gyrus of the fore brain[1,9].

Secondary factors that can interfere with bladder function

Bladder function can be affected by many external factors which can be found in as much as 40-50% of children who present with incontinence[6,10,14-16]. One main reason for lack of response to targeted treatment is a failure to adequately manage the secondary factors, and treatment of these conditions alone may cure the incontinence in some children[1,3,9,10]. e.g.,

1. Functional constipation can be the primary cause of LUTD or both may have originated from common neuro-muscular embryological pathways.
2. Conditions which overstimulate the bladder chemoreceptors like UTI, crystalluria, drugs, dysbiosis and local inflammatory conditions.
3. Emotional/behavioural disorders such as anxiety, depression, aggressiveness, social isolation, and social stress

Diagnosis of LUTD

The diagnostic tools are shown in Box 1.

Non-invasive urodynamic tools
1. Clinical tools
   a. Two-to-three-day bladder diary
   b. Seven-day bowel diary
2. Ultrasound scan of abdomen
3. Uroflow studies

Invasive urodynamic studies
1. Cystography
2. Pressure flow studies
3. Video-urodynamics
4. Cystoscopy
5. Micturating cystourethrogram and magnetic resonance imaging of spine

Box 1. Diagnostic tools

Clinical tools

These are the mainstay of diagnosis. Both child (whenever possible) and parent should get involved in history taking, which should include early voiding patterns, age of toilet training and characteristics of the urinary stream. Assessment of the onset of symptoms and whether incontinence is primary or secondary, persistent or intermittent, in daytime or in sleep, should be mandatory. Functional problems typically manifest around or after toilet training and are intermittent. Persistent dribbling suggests a neurological lesion more than a functional disorder. Symptoms since birth suggest either an anatomical or neurological pathology; however, exceptions to this rule can exist[6,9,10].

There is a compelling need to always exclude polyuria which can be the primary cause of incontinence. Assessment of the developmental age and cognitive functions and exclusion of environmental, psychological, or emotional factors, drugs or neuropsychiatric problems which can affect the normal voiding mechanisms, is quite useful. A complete system examination, including that of the abdomen, perineum, spine and lower limb, is essential.

Bladder and bowel diaries

Two-to-three-day voiding diary is often useful to identify frequency, voided volumes, presence of incontinence, and timing of incontinence. The largest voided volume, usually the early morning void, can be utilized to judge the approximate functional bladder capacity. However, this may not be accurate if the child had bed wetting immediately before waking up. A four-hour frequency diary is the ideal for those without any volitional control. Parental assurance of normal bowel function is a common misconception. Therefore, seven-day bowel diary is also mandatory and should include time of defaecation, stool consistency, volume and, any associated symptoms like anal pain, abdominal pain or undue straining. Diagnosis can be guided by the Bristol Stool Form Score and the Rome III criteria for functional constipation[1,8,10].

Ultrasound scan (USS) of abdomen

USS is the first radiological investigation recommended for all and may be the only investigation needed for most children with BBD. Specific ultrasonic characteristics especially pre- and post-void bladder volumes, bladder shape and wall thickness, upper tract dilatation, and renal sizes, shape and contour must be assessed.

Uroflow studies

Uroflow is a non-invasive, relatively inexpensive investigation, ideal for children who can urinate on request and old enough to follow instructions. Uroflow study assesses speed of flow which is

measured as the volume against the time. There are five recognized patterns of flow curves[1,6,9] (Figure 2). All four abnormal patterns are reported in normal children. Therefore, uroflow studies must be interpreted with other diagnostic tools and only repeatedly abnormal tests are considered significant. Staccato pattern is a very good indicator of DV when coupled with increased pelvic floor electromyographic (EMG) activity and increased post void residual urine[1,6,9].

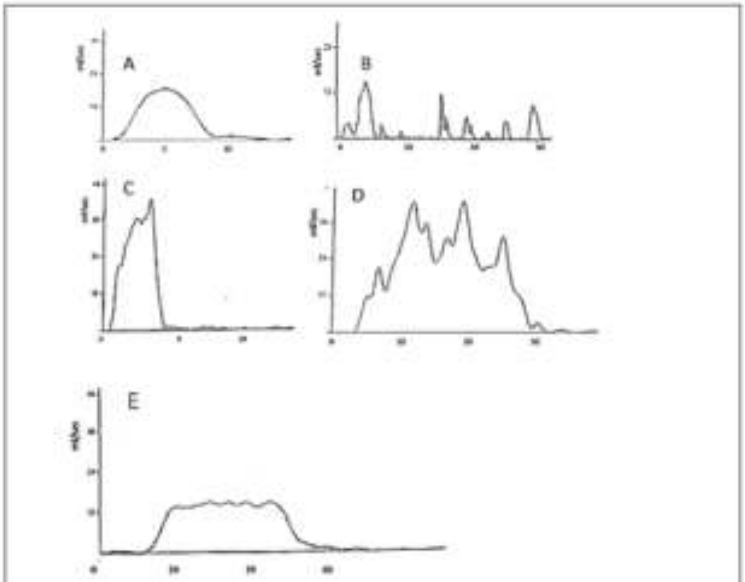

Figure 2: ***Uroflow curve patterns of real patients***
A. Normal bell-shaped curve
B. Interrupted flow suggests underactive or acontractile detrusor with abdominal straining. However, dysfunctional voiding also may produce a similar pattern.
C. Tower shape due to explosive voiding suggests overactive bladder or may be a normal phenomenon especially in girls.
D. Staccato pattern with fluctuating peaks and troughs suggests dysfunctional voiding; To qualify staccato, fluctuations should be larger than the square root of peak flow rate.
E. Low amplitude plateau shaped curve usually suggests an underactive detrusor or may be due to anatomic or functional obstruction of the bladder outlet.

Invasive urodynamic studies

Invasive studies are mainly reserved for high-risk patients (Box 2) or for patients whose initial assessment is highly suggestive of an anatomical or a neurological lesion[1,6,9,10]. Definite indications for pressure-flow studies are atonic or hypoactive bladder or suspected neurogenic bladder[6,10].

High risk or red flag signs

1. Distended and palpable bladder
2. Large residual urine or non-neurogenic neurogenic bladder
3. Lack of bladder sensation
4. Evidence of renal parenchymal damage in imaging
5. Rising serum creatinine

Signs of moderate risk

1. Early ultrasonic changes of dysfunctional voiding Eg: thickened irregular bladder wall, significant post void residual urine
2. Persistent dilatation of upper tracts in repeat scans
3. Recurrent urinary tract infection

Box 2: Risk assessment of lower urinary tract disorders

Note: Pyuria and asymptomatic bacteriuria are common in children with DV and may not always indicate clinical UTI[1,9,16].

Management

Initial steps in the management will depend on the risk of renal parenchymal damage. Those having a high risk of renal damage will need intensified assessment with imaging and/or advanced urodynamics and early institution of bladder decompression and detrusor relaxation to reduce intravesical storage pressures; therefore, they should be referred to a centre with such facilities and expertise without delay[1,6,8].

First line treatment - Urotherapy

If the risk of renal damage is low, initial management strategies are similar, irrespective of the urodynamic abnormality and is started with behavioural therapy, with the assumption that the disorder is either a maturational delay or a learned behaviour, and therefore potentially reversible.

Urotherapy has proven benefits in children above 4 years of age[1,6,9,10].

1. Educate on normal bladder and bowel function and try to reason out the specific reason why an individual child has wetting and also ensure that it is unintentional and not a misdeed of the child.
2. Train both the parents and the child, to enable the parent to reinforce the behaviour at home.
3. *Correct toilet posture*[9.10]: Straining with abdominal muscle contractions during voiding and defaecation increases the pelvic muscular tone and obstructs the elimination. The child should sit on the toilet seat in such a way that the weight of the trunk is completely transferred to the toilet seat and the abdominal muscles and buttock muscles are maximally relaxed. Lumbar spine should be kept in the neutral position with the shoulders and buttocks at the same vertical plane, a fully stabilized trunk (not rounded or extended), fully relaxed abdominal wall, the thighs kept at the level of hips, legs slightly abducted and, feet in a neutral, flat and supported position and not hanging; a stool can be used for this purpose (Figure 3).

Figure 3: ***Correct toilet posture***

If using squatting pans, child should be placed in the complete squatting position with relaxed abdominal and spinal muscles with thighs abducted, toes and soles of both feet nicely resting flat on the floor.

4. *Timed voiding, double voiding and adequate fluid intake*: Two hourly voiding by the clock often allows the child to void before the onset of sudden and unexpected urge which provokes pelvic spasms and tightening of external sphincter and thus, helps to break the vicious cycle[6,9].
5. *Identify and treat all secondary factors:* It is generally recommended to start a bowel management regimen considering all children with bladder dysfunction as having constipation and aggressive management is essential for those with chronic constipation[1,6,9]. Bowel functions must be assessed at each visit and gradual tailing-off of laxatives can be tried only several months after normalization of bowel functions. Those with neuropsychiatric, emotional or behavioural disorders must be promptly referred and, treatment of these conditions not only alleviate the root cause but also improves compliance to urotherapy[6].
6. For those having UTI, antibiotic prophylaxis is beneficial to prevent recurrences until bladder and bowel functions are improved[1].
7. Advise on adequate drinking: Limited fluid intake prevents the chances of the bladder to expand and build volume and concentrated urine can irritate the bladder and will worsen symptoms.

Clinical trials have shown that approximately 20% of children can achieve normal bladder function with the above approach[1].

Second line treatment

1. *Pelvic muscle exercises and biofeedback:* If there is no satisfactory improvement with first line treatment options, those children should be trained on pelvic muscle exercise. Success rates can be enhanced by using biofeedback tools in which children get feedback on urinary flow patterns, thus giving a chance to correct the voiding technique immediately[1,9,10].
2. *Medications:* Pharmacotherapy aims at correcting the underlying specific muscular dysfunction and in general it is reserved for those who fail to respond to initial management. A common reason for non-response to pharmacotherapy is failure to identify the underlying urodynamic abnormality and failure to address secondary factors. It is important to ensure normal bowel functions and maintain children on an effective bowel regimen especially while on anticholinergics, since these drugs are known to aggravate constipation, which can confound the success of the overall management[9]. In addition, children should be strictly maintained on the timed voiding schedule.

Drugs of choice for OAB are the anticholinergic medications. Oxybutynin and tolterodine are widely used in paediatric practice; but parents should be warned of the possible anticholinergic side effects. Beta-3 adrenergic receptor agonists (e.g., mirabegron, vibegron) selectively acts on the detrusor muscle and may be a better choice. Imipramine, which is a tricyclic antidepressant has been effective in some children who were resistant to antimuscarinic drugs; but must be used with caution since it can cause postural hypotension and cardiac arrythmias. Alpha blockers have been successfully used to treat DV associated with urine retention, especially when coupled with pelvic floor exercises and bio feed-back. Selective alpha blockers are better tolerated due to the lack of side effects. Botulinum A toxin intramuscular injection is reserved for refractory cases of OAB and DV. Repeat injections are often needed since relapses are common and for better results, urotherapy must be continued after injections. Newer drugs on the horizon like ATP sensitive potassium-channel transporters and drugs that act on sensory afferent pathways have shown some promising results.

Third line of treatment

1. *Neuromodulation:* This had been tried in children with DV with variable success rates. In one study, one third of those who responded needed repeated treatment[1,10].

2. *Clean Intermittent Catheterisation (CIC):* This must be started promptly when the risk of renal damage is high due to raised intravesical pressure or when having acontractile retentive bladders[1,9].

Box 3 gives some useful definitions of urodynamic studies.

- Expected bladder capacity (EBC): (age + 1) x 30 ml
- Normal frequency: 4–7 times a day
- Nocturnal polyuria: nocturnal urine output >130% of EBC
- Significant post-void residual urine (in repeat scans)
  4-6 years: >20ml or >20% of pre-void volume
  7-12 years: >10ml or >6% of pre-void volume
- Accepted pre-void bladder volume: ≥50% of EBC
  (For urodynamic studies)

Box 3: ***Useful definitions of urodynamic studies***[6]

Conclusion

LUTD in children is largely underdiagnosed and often inadequately treated. However, many patients can be satisfactorily treated by methodically using non-invasive diagnostic tools and, by adhering to customized and specific treatment strategies.

References

1. Clothier JC, Wright AJ. Dysfunctional voiding; the importance of non-invasive urodynamics in diagnosis and treatment. *Pediatric Nephrology* 2018; **33**: 381-94. https://doi.org/10.1007/s00467-017-3679-3
PMid: 28567611 PMCid: PMC5799351

2. Sillén U, Hjalmas K. Bladder function in preterm and full-term infants—free voidings during four-hour voiding observation. *Scandinavian Journal of Urology and Nephrology Supplement* 2008; **215**: 63–8. https://doi.org/10.1080/03008880410015318
PMid: 15545199

3. Burgers RE, Mugie SM, Chase J, Cooper CS, von Gontard A, Rittig CS, *et al.* Management of functional constipation in children with lower urinary tract symptoms: report from the Standardization Committee of the International Children's Continence Society. *Journal of Urology* 2013;**190**(1): 29–36. https://doi.org/10.1016/j.juro.2013.01.001
PMid: 23313210

4. Keren R, Shaikh N, Pohl H, Gravens-Mueller L, Ivanova A, Zaoutis L, *et al*. Risk factors for recurrent urinary tract infection and renal scarring. *Pediatrics* 2015; **136**(1): 13-21. https://doi.org/10.1542/peds.2015-0409
PMid: 26055855 PMCid: PMC4485012

5. Skoog SJ, Peters CA, Arant BS Jr, Copp HL, Elder JS, Hudson RG, *et al*. Paediatric vesicoureteral reflux Guidelines Panel summary report: Clinical practice guidelines for screening siblings of children with vesicoureteral reflux and neonates / infants with prenatal hydronephrosis. *Journal of Urology* 2010; **184**(3): 1145–51. https://doi.org/10.1016/j.juro.2010.05.066
PMid: 20650494

6. 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. *Neuro-urology and Urodynamics* 2016; **35**(4): 471-81. https://doi.org/10.1002/nau.22751 PMid: 25772695

7. Oliveira RG, Barroso U. Overactive bladder in children. *EMJ* 2018; **3**(2): 70-7.

8. Burgers R, de Jong TPVM, Visser M, Di Lorenzo C, Dijkgraaf MGW, Benninga MA. Functional defecation disorders in children with lower urinary tract symptoms. *Journal of Urology* 2013; **189**: 1886–91. https://doi.org/10.1016/j.juro.2012.10.064 PMid: 23123369

9. Franco I. Paediatric overactive bladder and lower urinary tract dysfunctions: diagnosis and treatment. *Paediatric Health* 2008; **2**: 189-202. https://doi.org/10.2217/17455111.2.2.189

10. Etienne Berard. "Pediatric Bladder Disorders". Pediatric Nephrology Edited by Avner E D Harmon W E Niaudet P, Yoshikawa N. Springer. 2016. 7th edition:1780-1814

11. Joinson C, Heron J, Von Gontard A, Butler U, Emond A, Golding J A prospective study of age at initiation of toilet training and subsequent daytime bladder control in school-age children. *Journal of Developmental and Behavioral Pediatrics* 2009; **30**: 385–93. https://doi.org/10.1097/DBP.0b013e3181ba0e77 PMid: 19827219

12. Jansson UB, Hanson M, Sillén U, Hellström AL. Voiding pattern and acquisition of bladder control from birth to age 6 years—a longitudinal study. *Journal of Urology* 2005; **174**: 289–93. https://doi.org/10.1097/01.ju.0000161216.45653.e3 PMid: 15947669

13. Duong TH, Jansson UB, Holmdahl G, Sillén U, Hellström AL. Urinary bladder control during the first 3 years of life in healthy children in Vietnam—a comparison study with Swedish children. *Journal of Pediatric Urology* 2013; **9**(6 Pt A): 700–6. https://doi.org/10.1016/j.jpurol.2013.04.022 PMid: 23759503

14. Gaither TW, Cooper CS, Kornberg Z, Baskin LS, Copp HL. Risk Factors for the development of bladder and bowel dysfunction. *Pediatrics* 2018; **141**(1): e20172797. https://doi.org/10.1542/peds.2017-2797 PMid: 29282207

15. Combs AJ, Van Batavia JP, Chan J, Glassberg KI. Dysfunctional elimination syndromes—how closely linked are constipation and encopresis with specific lower urinary tract conditions? *Journal of Urology* 2013; **190**(3):1015–20. https://doi.org/10.1016/j.juro.2013.03.111 PMid: 23545098

16. Kilis-Pstrusinska K, Rogowski A. Bienkowski P. Bacterial colonization as a possible source of overactive bladder symptoms in paediatric patients: A literature review. *Journal of Clinical Medicine* 2021; **10**: 1645. https://doi.org/10.3390/ jcm10081645 https://doi.org/10.3390/jcm10081645 PMid: 33924301 PMCid: PMC8069148