Aims: This study aimed to evaluate the noninvasive methods to diagnose bladder bowel dysfunction (BBD) and its extrapolation on biofeedback therapy and pelvic floor exercises (PFE) to treat these children.

Settings and Design: A retrospective cohort study at a tertiary care center was conducted between January 2010 and December 2020, on 204 children, aged 4–18 years, arbitrarily divided into two groups-4–12 and 13–18 years.

Subjects and Methods: Details of lower urinary tract dysfunction were recorded as International Children’s Continence Society nomenclature. Bowel habits were recorded and functional constipation was graded using ROME IV. The data recorded were urine analysis, a voiding diary, a dysfunctional voiding symptom score, and uroflowmetry with or without electromyography. Ultrasonography, voiding cystourethrogram, and magnetic resonance imaging were done in appropriate cases. Dysfunctional Voiding Severity Score was used to assist the evaluation and outcome. The treatment protocol included urotherapy, uroflow biofeedback, PFEs, prophylactic antibiotics, pharmacotherapy, and treatment of constipation.

Statistical Analysis Used: Statistical analysis was done using SPSS version 26 and paired *t*-test was used for comparison and calculating *P* value.

Results: There was a significant improvement in DVSS and uroflow parameters. However, the magnitude of change produced varied among the age groups. Patients who failed to show any clinical benefit were subjected to alternative therapies such as intrasphincteric Botulinum A toxin with or without neuromodulation.

Conclusions: Integrated uroflow biofeedback (IUB) and PFEs expedite the recovery by supplementing the effect of urotherapy; hence, this should be offered to all children with BBD.

Keywords: Biofeedback, bladder bowel dysfunction, dysfunctional elongation syndrome, dysfunctional voiding, electromyogram, uroflowmetry

INTRODUCTION

Bladder bowel dysfunction (BBD) previously known as dysfunctional elimination syndrome occurs secondary to failure of relaxation of the external sphincter-pelvic floor complex at the time of voiding resulting in bladder outflow obstruction.[1-3] BBD is not a singular disorder but comes with a spectrum of lower urinary tract dysfunction (LUTD), urinary tract infection (UTI), and fecal elimination issues.[4] Diagnosis of BBD is many times missed due to its varied presentation and children presenting late may land into chronic kidney disease (CKD) or even end-stage renal disease (ESRD). As far as the etiopathogenesis is concerned, there is no underlying neurological or anatomical cause, and the condition is postulated to

Address for correspondence: Dr. M. S. Ansari, Department of Urology, SGPGIMS, Lucknow - 226 014, Uttar Pradesh, India.
E-mail: ansarimsa@hotmail.com

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be a largely learned behavior. The diagnosis of BBD is mainly based on a comprehensive medical history, which includes voiding habits and patterns, i.e., voiding frequency, urgency, timing of any urinary incontinence both day and night, and enuresis. Postponement tactics such as Vincent’s curtsy, crossing one’s legs and bending down from the waist, and pinching the glans of the penis between fingers, are typical maneuvers used by children with urge incontinence. Assessment of gastrointestinal parameters, such as stool consistency, frequency, pain with defecation, and encopresis, must be recorded. Details on functional constipation using ROME IV criteria should be collected from caregivers. Further, examination of gait, muscle atrophy of lower limbs, and gluteal asymmetry along focal neurological examination should be done to rule out subtle neurologic conditions, which might give a similar presentation.

Besides history, other tests which assist in diagnosis are voiding diary, dysfunctional voiding score system (DVSS), ultrasonography (USG), uroflowmetry (UFM), pelvic floor electromyography (EMG), video-urodynamics (VUDS), and magnetic resonance imaging (MRI) in select cases to rule out occult neurological element. Voiding cystourethrogram (VCUG) is mainly advised in the presence of documented recurrent febrile UTIs to rule out vesicoureteric reflux, especially in the setting when the upper tracts are dilated and/or bladder wall thickening. UFM and pelvic floor EMG are not only noninvasive but also provide objective support to subjective parameters drawn through clinical history. Outpatient-based simple test UFM has been used with or without EMG not only in diagnosis but also in biofeedback therapy for the treatment of BBD. Biofeedback therapy as pelvic floor and external urethral sphincter relaxation have been applied for children with dysfunctional voiding with encouraging results. Herein, authors evaluate these noninvasive methods to diagnose BBD and their extrapolation as biofeedback therapy to train pelvic floor muscles for the relaxation of external sphincter as treat these patients.

**Subjects and Methods**

The study was conducted between January 2010 and December 2020, with the children presenting with LUTD and fitting the diagnostic criteria of BBD. A total of 210 patients were identified of which six patients were excluded due to irregular follow-up and poor compliance. All the children (4–18 years) underwent urological work which included detailed history related to LUTD (daytime incontinence, nighttime incontinence, urgency, straining, intermittency, dysuria, holding maneuvers, feeling of incompletable emptying, and abnormal bladder capacity or frequency) and bowel habits. Details of LUTD were recorded as International Children’s Continence Society (ICCS) nomenclature. Bowel habits were recorded and functional constipation was graded using ROME IV. The evaluation also included a physical and focused neurological examination.

The data recorded were urine analysis and urine culture to assess UTI, a voiding diary, a dysfunctional voiding symptom score (DVSS), and UFM with or without EMG. UFM was considered valid for interpretation only when the voided volume (VV) was a minimum of 50% of the expected bladder capacity (EBC) that was measured by the formula \( mL = \left(\frac{\text{age in years} + 1}{30}\right) \times 30 \). At least three UFM were done and two best (VV >50%, reproducible) were considered for the study. USG was done to evaluate the upper urinary tract, hydrenephrosis, anomalies, bladder capacity, and postvoid residual urine (PVR). VCUG was done in patients who had febrile UTI or hydrenephrosis on ultrasound [Figure 1a]. Urine flow patterns were defined with respect to the ICCS uroflow classification that includes bell-shaped, staccato, plateau, interrupted, and tower-shaped curves. To record pelvic floor EMG activity during voiding, two surface EMG electrodes were placed on the perineum at 3 and 9 o’clock positions. For combined UF/EMG studies, children underwent at least two tests in separate sessions to avoid any artefactual component [Figure 1b]. Dysfunctional voiding symptom score (DVSS), a 10-point qualitative and quantitative item instrument, was used to assist the evaluation and outcome. Where appropriate, MRI lumbosacral spinal cord (to exclude neurological causes) and cystoscopy (to rule out posterior urethral valve in male children) were done. VUDS was done in select cases such as

![Figure 1](image-url) (a) Voiding cystourethrogram showing dilated posterior urethra with spinning top deformity (b) Combined uroflowmetry and electromyography showing staccato flow with electromyography activity.
marked symptoms of the overactive bladder to establish the presence of detrusor overactivity and or low compliance.

The integrated treatment protocol included urotherapy, uroflow biofeedback, pelvic floor exercises (PFE), prophylactic antibiotics, pharmacotherapy (anticholinergics), and stepwise treatment of constipation (indigenously made bowel program was given to caregivers). For the uroflow-biofeedback therapy, the patient was facilitated to observe, interpret, and understand his graph of uroflow pattern and the pattern of pelvic floor contraction and relaxation on the attached computer screen, in each session, as he voided during UFM-EMG. PFEs were explained by trained health personnel and a printed pamphlet with text and pictorial details was also given for further understanding. Results were evaluated as per the improvement of UFM (maximum flow, i.e., maximum flow rate \( Q_{\text{max}} \), the shape of curve, and PVR), DVSS, and criteria laid by the ICCS. All these parameters were compared at least 3 months after the start of the therapy. Those who failed were subjected to neuromodulation and or intrasphincteric Botulinum A toxin. Various measures were taken to assess patients’ compliance. Biofeedback was done by the institute’s trained health personnel. PFE were taught by the same person. Execution of PFE at home was confirmed primarily from parents/caregivers and patients were asked to demonstrate it on follow-up clinics whenever needed necessary to cross-check. Compliance check was more frequently needed in slow or nonresponders.

Exclusion criteria included age under 4 years presence of anatomical abnormalities, mental deficiency, behavioral disorders, and neurological diseases.

The data were analyzed using "IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA) predictive analytics software and paired \( t \)-test was used for comparison and calculating \( P \) value.

**RESULTS**

The study was conducted on toilet trained patients of age group 4–18 years, attending pediatric urology outpatient department between January 2010 and December 2020 and fitting the diagnostic criteria of BBD. A total of 204 patients were included in the study, 123 were female and 81 were male. The female: male ratio of 1.5:1. Since we had a wide range of patients belonging to different age groups, for the sake of uniformity and comparison, the patients were arbitrarily divided into two age groups—group-1 i.e., 4–12 years, and group-2 i.e., 13–18 years [Table 1]. The median value of DVSS in the study group before the commencement of treatment was 17, while after receiving the treatment the median value was 14. In addition, the mean DVSSs, before and after treatment, were 17.12 and 13.67, respectively (\( P < 0.05 \)).

A staccato urine flow curve was most common and observed in 112 (54.9%) patients [Figure 1b], followed by mixed [Figure 2a], interrupted [Figure 2b], and plateau [Figure 2c], 51 (25%), 31 (15.2%), and 10 (4.9%) patients, respectively. Other UFM parameters such as \( Q_{\text{max}} \) and urine PVR for the defined age groups and the observations are mentioned in Table 2. A significant benefit was recorded across all ages in terms of improvement of \( Q_{\text{max}} \) and decrement in PVR (\( P < 0.05 \)). However, the magnitude of change produced varied among the age groups. Improvement in mean \( Q_{\text{max}} \) observed in age groups 4–12 and 13–18 years was 40.45% and 31.52%, respectively. Reduction in the PVR observed in age groups 4–12 and 13–18 years was 45.82% and 31.39%, respectively [Table 2].

Follow-up ranged from 4 to 132 months (mean 36). As per the ICCS criteria following 3 months of biofeedback therapy, daytime incontinence resolved in 123 (60.31%) children and nighttime incontinence in 112 (54.9%) children. A further 45 (22.5%) reported a partial improvement in daytime and nighttime wetting. Both these groups showed an improvement in mean VVs on bladder diary (BD) so that 90% of them could achieve a bladder capacity >80% of the EBC for age. Thirty-six (17.6%) patients failed to show any clinical benefit and were subjected to alternative therapies such as intrasphincteric Botulinum A toxin with or without neuromodulation.

Late presentation was common among all the age groups to the extent that 14.7% (\( n = 30 \)) and 2.5% (\( n = 5 \)) of the patients had CKD (estimated glomerular filtration rate [eGFR] <60 ml/min) and ESRD (eGFR <15 ml/min), respectively.

**DISCUSSION**

A comprehensive history plays a vital role in the diagnosis of BBD. This should record information regarding birth history, developmental milestones, the timing of toilet training, and current LUTD.

**Table 1: Distribution of demographic profile of children between the groups**

| Group 1 (4-12 Years) | Group 2 (13-18 Years) | Total |
|----------------------|-----------------------|-------|
| No.                  | 162                   | 42    | 204  |
| Percentage           | 79.4                  | 20.6  | 100  |
| Male : Female        | 62:100                | 19:23 | 81:123 |
| Median Age Group     | 9                     | 14    | 10   |
Description of LUTD should further specify storage LUTD such as urgency, frequency, or urge incontinence. Obstructive LUTD should include straining on micturition, hesitancy, and a sense of incomplete evacuation. Parents should be inquired specifically about the delaying tactics such as Vincent’s curtsy, crossing one’s legs and bending down from the waist, and pinching the glans of the penis between fingers, which are typical maneuvers. A BD is a simple and noninvasive method of evaluating children with LUTD. A complete 2–3 days BD is an important tool to evaluate LUTD. A study by Lopes et al. showed that a BD maintained over 2 days, not necessarily consecutive, has been shown to provide data that are similar to those obtained over a 3-day period. In the present study, a 2-day BD was maintained by all children/caregivers to record all events related to LUTD.

Currently, the first-line treatment is urotherapy, which is a combination of behavioral measures including fluid intake monitoring, time voiding, and a diet with high roughage. Anticholinergics, β3 agonists, and neuromodulation are supportive therapies to manage overactive bladder symptoms, not responding to urotherapy. Biofeedback to teach the child how to relax the external urethral sphincter during micturition

### Table 2: Comparison of outcome parameters

| Age Group | DVSS pre-treatment | DVSS post-treatment | Qₘₐₓ pre-treatment | Qₘₐₓ post-treatment | PVR pre-treatment | PVR post-treatment |
|-----------|--------------------|---------------------|--------------------|---------------------|-------------------|-------------------|
| 4y-12y (n=162) | 17.22 | 13.72 | 8.79 | 12.35 | 43.36 | 23.49 |
| Mean | 3.44 | 3.47 | 2.71 | 3.12 | 8.13 | 4.83 |
| 13y-18y (n=42) | 16.74 | 13.38 | 13.60 | 17.88 | 67.50 | 46.31 |
| Mean | 3.01 | 3.09 | 2.58 | 2.44 | 14.11 | 18.11 |
| Total (n=204) | 17.12 | 13.67 | 9.78 | 13.49 | 48.33 | 28.19 |
| Mean | 3.35 | 3.39 | 3.31 | 3.74 | 13.72 | 13.05 |
| Median | 17.00 | 14.00 | 10.00 | 13.00 | 45.00 | 25.00 |

Statistical Significance:
- P < 0.5
- t 45.72
- 95% Confidence Interval 3.307-3.605
- 46.74
- 19.297-20.997

![Figure 2](image1.png)

**Figure 2:** (a) Mixed type of uroflow pattern (b) Interrupted type of uroflow pattern (c) Plateau type of uroflow pattern

![Figure 3](image2.png)

**Figure 3:** Box chart showing the change in Dysfunctional Voiding Score System after the treatment
along with urotherapy further improves the success rate in these children.

The DVSS, proposed by Farhat et al., is the most commonly used voiding score worldwide which has proven to be effective for diagnosis and assessment of treatment of BBD. The other scoring system such as the Vancouver symptom score for dysfunctional elimination syndrome has also been validated and has been proven to be effective. These sores are complementary tools to BBD not only to evaluate the actual voiding but also the self-reported behavior, a direct impact of LUTD.

In the present study, median DVSS before the start of the treatment was 17, and the posttreatment median DVSS was 14. In addition, the mean DVSSs, before and after treatment, were 17.12 and 13.67, respectively (P < 0.05) [Table 2 and Figure 3].

Measurement of bladder capacity, bladder wall thickness, and urine PVR using a renal and bladder ultrasound or a bedside bladder scanner can further supplement BD and DVSS to further diagnose the diagnosis and monitoring treatment of BBD. Further, ultrasound may also assist in diagnosing constipation in these cases as transverse rectal diameter ≥3 cm correlates well with evidence of rectal fecal impaction.

UFM along with the measurement of PVR is a noninvasive method usually used to assess LUTD in children. This is simple to perform and fast to do and provides important data such as VV, voiding time, maximum flow (Q_max), and curve pattern. UFM results with a VV of at least 50 ml or 50% of the EBC for age ([age in years + 1] × 30) is considered optimal. Various uroflow patterns described by the international continence society are interrupted, staccato, mixed, plateau, tower, and bell shaped. In cases of BBD, abnormal urine flow patterns such as staccato, interrupted, and mixed types of curves have more commonly been described.

In the present study, a staccato urine flow curve was most common and observed in 112 (54.9%) of patients, followed by mixed, interrupted, and plateau, 51 (25%), 31 (15.2%), and 10 (4.9%), patients, respectively. A definitive improvement in Q_max was recorded across all ages. However, the magnitude of change produced varies among the age groups. Improvement in mean Q_max observed in age groups 4–12 years was almost 40%, while in the 13–18 years age group, improvement was almost 30% [Table 2].

Uroflow curves are only suggestive of BBD and diagnoses based purely on uroflow patterns, especially done once or twice, may sometimes lead to overdiagnosis. Thus, simultaneous pelvic floor EMG is therefore extremely useful for improving diagnostic accuracy. This is commonly done with surface EMG electrodes rather than needle EMG in pediatric patients. Biofeedback relaxation of the pelvic floor and electroneurostimulation for BBD helps to consciously modulate pelvic floor muscles with/without real-time EMG feedback to achieve optimal UFM curves and low residual urine. Maizels et al. first described biofeedback in 1979, and McKenna et al. first described animated biofeedback in 1999. The biofeedback technique aims to ensure that the pelvic floor muscles, which play an important role in voiding control, are used correctly and effectively. Biofeedback, when combined with computerized training programs, enables the children to visualize their pelvic floor muscle contraction and relaxation in the form of animation with a soundtrack on a computer monitor. This helps them to understand, coordinate, and facilitate in achieving control of external urethral sphincter relaxation and contraction.

In the study by Krzemińska et al., daytime incontinence resolved in 34/67 (50.7%) children and nighttime incontinence in 22/41 (53.6%). A further 40.3% declared partial improvement in the daytime and 26.7% in nighttime wetting after 2 months of biofeedback therapy. These patients were resistant to the initial conventional urotherapy. Similarly, another study by Kibar et al. reported a significant improvement in outcomes in children with DV using combined urotherapy plus biofeedback compared with standard urotherapy. The authors included 94 patients in this study. Although a current meta-analysis does not support the effectiveness of biofeedback in the management of BBD, earlier reviews with comprehensive analysis showed a pooled estimate of 83% improvement in recurrent UTI among patients with BBD. In the present study as per the ICCS criteria following 3 months of biofeedback therapy, daytime incontinence was resolved in 123 (60.31%) children and nighttime incontinence in 112 (54.9%). A further 45 (22.5%) reported a partial improvement in daytime and nighttime wetting. Both these groups showed an improvement in mean VVs on BD so that 90% of them could achieve a bladder capacity >80% of the EBC for age. Thirty-six (17.6%) patients failed to show any clinical benefit and were subjected to alternative therapies such as intrasphincteric Botulinum A toxin with or without neuromodulation.

BBD has a direct association with constipation, this condition should also be assessed through the use of questionnaires such as the Rome IV diagnostic criteria and the Bristol stool scale. Gastrointestinal parameters, i.e., stool firmness, frequency, pain with defecation, and encopresis, are recorded. The study...
population was treated in a stepwise manner that included dietary instructions to increase roughage with fruit pulps from fruits known to have laxative effects and fruit juices strained through coarse filters to have more fiber content. The children who are constipated need further treatment with polyethylene glycol at doses of 1–1.5 g/kg in the first 3 days and 0.25–0.5 g/kg thereafter. Finally, this is to highlight that ours is a referral center, and patients usually reported late to us, and by the time they sought consultation, 14.7% (n=30) and 2.5% (n=5) of the patients had CKD (eGFR <60 ml/min) and ESRD (eGFR <15 ml/min), respectively.

The strength of the study is a sizable number of patients with good intermediate-term follow-up with good compliance from patients and caregivers. The weakness is the retrospective nature of the study.

CONCLUSIONS
Integrated uroflow biofeedback (IUB) and home PFE is an effective method of treating BBD in children with over 80% achieving resolution of symptoms. Integration of IUB and PFE expedites the recovery by supplementing the effect of urotherapy; hence, this should be offered to all children with BBD right from the beginning.

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Conflicts of interest
There are no conflicts of interest.

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