Original Research Article

Urodynamic study in enuretic children

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Abstract

Background: Nocturnal enuresis is probably the most common developmental disorder affecting 15-20% of children of 5 years age. Urodynamic study (UDS) today is a compilation of the results obtained by cystometry, uroflowmetry, uroprofilometry and electromyography. **Aim:** To establish a predictive correlation between symptomatology and urodynamic study abnormalities in enuretic children. **Materials and Methods:** This prospective study was conducted in 20 children who presented with nocturnal enuresis and day and night time incontinence and were attending the Child Guidance Clinic (CGC) of a teaching hospital in the city. The study included 20 patients with 9 girls and 11 boys between the ages of 5-14 years. **Results:** This study comprised of 20 enuretic children, 9 girls and 11 boys, who attended Child Guidance Clinic of a major teaching hospital. Their ages ranged between 5 years to 14 years. In this study, the incidence of primary nocturnal enuresis was found to be 45%. The radiological abnormalities were found in a significant number of patients. **Conclusion:** There is a high incidence of urodynamic abnormalities in children with both nocturnal and diurnal enuresis as compared to the nocturnal enuresis alone. The pattern of abnormalities was however, not different.
Key Worlds: Urodynamic Study, Enuretic Children.

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INTRODUCTION

Enuresis is the inappropriate or involuntary voiding of urine beyond the age at which bladder control is normally achieved (i.e., 4-6 years). Enuresis is derived from the Greek word "enourein" = to void urine.[1]

Enuresis has been divided into

a) Nocturnal enuresis is defined as the involuntary voiding of urine on at least 2 nights per month beyond the age at which bladder control is normally obtained (4-6 years) in the absence of congenital or acquired defects of the urinary tract.[2]
b) Diurnal enuresis is defined as the daytime wetting. Hallgren in 1957 has classified enuresis based on the aetiology[3]
c) Primary enuresis is used when the child has never achieved control over micturition.
d) Secondary or acquired enuresis is used when the child after having once obtained control of the urinary bladder, again loses it.

Nocturnal enuresis is probably the most common developmental disorder affecting 15-20% of children of 5 years this disturbance of vesicourethral function is intimately related to the evolution of normal urinary control mechanisms and is often associated with urodynamic abnormalities. Widespread use of advanced urodynamic techniques has permitted an accurate identification of these functional disturbances and provided a more rational basis for therapy. Urodynamics is a neurourologic diagnostic tool concerned with the identification and measurement of physiologic and pathologic factors involved in the storage, transportation and evacuation of urine.[5] Urodynamics, the term first coined by D.M. Davisin 1953[6], has gone through phases of evolution. This technology finds a place in various types of neurogenic bladder, incontinence, reflux, recurrent urinary tract infections, detrusor sphincter dyssynergia etc. With the recognition of these

abnormalities and rapid computerization and the use of videourodynamics, this technology has achieved a wide spread acceptance. In the pediatric population it serves as a valuable tool in the management of bladder involvement as in myelodysplasia, teethered cord, enuresis, neurogenic bladder etc.

Historical perspectives: Urodynamic has gone through phases of evolution. This science has evolved from Simple principles of hydrodynamics to video recording of micturition. Pouisseille and Laplace were the first to discover hydrodynamics.[6] ' 'Hydrodynamics ofMicturition' ' was first published in 1972. The term urodynamics was coined by D.M. Davis in 1953. The cystometrograph was the first urodynamic instrument, introduced clinically by D.K. Rose of St. Louis in 1927. Denny Brown and Robertson in 1932 used polygraphic recording to establish an understanding of basic pattern of micturition.[7] Visualisation oflower urinary tract during voiding, cinefluroscopy, was popularised by Earl R. Miller in 1954[6] Electromyography, which measures muscular activity in relation to voiding was first performed by Franksson and Petersen in 1955. With further advances in technology, in late 1980's and early 1990's, this technique has been taken over by videourodynamics. These advances in technology have, thereby enhanced its value, credibility, applications and verstality and hence urodynamics has slowly achieved universal acceptance. A urodynamic study (UDS) today is a compilation of the results obtained by cystometry, uroflowmetry, uroprofilometry and electromyography.

Urodynamic Studies in enuresis: There are different school of thoughts on the use and application of UDS in enuresis. Some of the earliest urodynamic studies were done by Hallman in 1950[1,8] and Muellner[9] in 1960. They showed that enuretic patients have reduced bladder capacity as compared with normal individuals. Troup[10] in 1971 showed that the disturbance causing reduction in capacity is functional rather than anatomic.

MATERIAL AND METHODS

This prospective study was conducted in 20 children who presented with nocturnal enuresis and day and night time incontinence and were attending the Child Guidance Clinic (CGC) of a teaching hospital in the city. There were 232 cases registered in the CGC during a period of one year. Out of this 80 patients were cases of enuresis. This study was successfully performed in 20 cases, 4 children did not follow up for their appointments and 4 did not cooperate for the procedure. The study included 20 patients with 9 girls and 11 boys between the ages of 5-14 years. A detailed history was taken which included the present urinary symptoms i.e. frequency, urgency, dribbling, burning, leaking and flow of urine. Also, a detailed family, birth, development, psychosocial history was taken. A detailed clinical examination was carried out with special emphasis on neurological examination of the lower limbs, lumbosacral area, spinal abnormalities (clinically evident) and a palpable bladder were *ruled out.* Only those children were included in the study who were neurologically normal. A general assessment of the psychological makeup of the child was made during the interview and the psychosocial atmosphere at home and school was judged during interrogation with parents. All the children underwent the following investigations

1. Urinanalysis - microscopy and culture.
2. X-ray of lumbosacral spine to rule out spinal defects.
3. Ultrasound of the abdomen for congenital abnormalities of kidney, ureter and bladder.

IQ testing was performed in these subjects by using Kamath's scale and the IQ of all these 20 subjects ranged between 70 to 110. Following this all children were subjected to a multichannel urodynamic evaluation on a Dantec 5500 urodynamic machine. This comprises of

a) Filling and voiding cystometry.
b) External sphincter electromyography, and
c) Measurement of residual urine.

This multichannel pressure recording allows simultaneous measurement of multiple variables. The results of cystometry may alter with crying, straining movement by the patients. The procedure was explained to the child and the parents to alleviate the child's anxiety. Oral sedation with phenargan was used in very anxious cases. The child is asked to empty the bladder before starting the procedure. For recording cystometrogram (CMG), the following method is adopted. First, a small balloon catheter (a modified plain rubber catheter) is inserted into the rectum to monitor intraabdominal pressure. The balloon is inflated with 5cc of water. The artefacts of movement or straining, which may be confused with contractions of the bladder during recording of intravesical pressure, can be eliminated. Next, the child is catheterized with an infant feeding tube (urethral catheter) of appropriate size, using liquid xylocaine jelly as a local anaesthetic. The urine in the bladder is allowed to drain in the graduated container and the volume of the urine is measured which is the residual urine. The urethral catheter is then connected through a 3-way cannula to the saline bottle which is warmed to the body temperature. The filling of the bladder is performed with the child in supine position. All transducers are zeroed prior to infusion to avoid arterfactual recording by incorrect placement of pressure lines or imprecise balancing or calibration of the monitoring equipment. Pressure line displacement into the urethra and presence of air in an inadequately flushed system are the two common causes

of vesical pressures that do not respond to initial zeroing attempts. The amount of saline infused was decided by using Koff's formula.

The formula states:

Bladder capacity (cc) = (Age in years + 2) x 30

This estimation of bladder capacity is accurate for the children older than 2 years of age. For children less than 2 years of age,

Bladder capacity (cc) = 7 x wt in kg.

10 of the calculated bladder capacity was infused. During bladder filling phase, the child's attention is diverted by engaging him in a conversation. This is necessary for gaining patients full cooperation. The patient is asked to cough during the filling phase in an attempt to elicit an uninhibited contraction. The child is asked to point when he feels first sensation of bladder fullness. When full capacity is reached, the child is asked to inhibit voiding as long as he or she can. Thus, the events noted during filling phase are: Empty resting pressure, First desire to void,

1. Urgent desire to void,
2. Bladder instability and frequency of waves,
3. Any urinary leakage,
4. Pressure at which any leakage occurred
5. Pressure when full bladder, and
6. Bladder capacity.

When voiding actually begins, the patient is asked to stop urination to determine how strongly he or she can block the micturition reflex. During this phase, the voiding pressures are recorded continuously in the bladder and urethra to determine if there is any increased resistance to flow. The normal voiding pressure in boys is between 60 and 90 cm 1-120 and in girls between 50 and 80 cm H20. During voiding phase, the patient is asked to interrupt the stream when maximum flow is reached. This is known as isometric contraction (Piso). Rarely, placement of suprapubic catheter to perform cystometry may be required in children who repeatedly fail to empty their bladder, have urethral pathology suggestive of outflow obstruction, prior to surgery for urinary diversion etc. The events noted during voiding are

1. Opening time, which is the time delay between the first rise in voiding pressure and the pressure at which urine flow begins.
2. Opening pressure
3. Maximum voiding pressure
4. Pressure at maximum flow rate
5. Maximum flow rate
6. Voided volume
7. Residual volume

Cystometry can be performed by using gas (carbon dioxide) as a medium. However, we preferred liquid because,

a. C02 is relatively a non physiological infusant.
b. It evokes bladder instability with even standard filling rates. it is unable to determine leak point pressure.
c. With C02, relative volume at capacity is less than fluid cystometry.
d. C02 dissolves in urine to form irritant compound, carbonic acid, which reduces the functional bladder capacity.
e. Abdominal pressure measurement during C02 cystometry is more difficult.

Synchronous sphincter electromyography (EMG) was recorded in all patients using surface electrodes. The shape, duration and rate of the firing were recorded. Surface electrodes can detect whether the pelvic floor muscles are contracting or relaxing at any given instant. During cystometric bladder filling, there should be an incremental increase in EMG activity with recruitment of more motor units. This reaches maximum when peak bladder capacity is reached and at the command to void, there should be sudden cessation of sphincter activity which persists throughout voiding. As the voiding starts, there is a fall in urethral pressure and a reduction of EMG activity. During voiding phase, the patient is asked to interrupt voiding in the middle of the stream, at which point there is an abrupt increase in sphincter activity. The information, thus, obtained was tabulated and analysed.

RESULTS

This study comprised of 20 enuretic children, 9 girls and 11 boys, who attended Child Guidance Clinic of a major teaching hospital. Their ages ranged between 5 years to 14 years. A. Observations on epidemiology of enuresis

Table 1: Age distribution of enuretic children

Age in years	No. of cases	Percentage
5-6	2	10%
6-7	1	5%
7-8	5	25%
8-9	2	10%
9-10	3	15%
10-11	2	10%
11-12	3	15%
> 12	2	10%
Total	**20**	**100%**

The maximum number of children in our study was in the age group of 7 to 8 years.

Table 2: Sex distribution of enuretic children

Sex	No. of cases	Percentage
Male	11	55%
Female	9	45%
Total	**20**	**100%**

The overall male to female ratio was 1.22: l.

Table 3: Distribution of children as primary and secondary enuretcs

Enuresis	No of cases	Percentage
Primary	15	75%
Secondary	5	25%
Total	**20**	**100%**

Table 4: Distribution of children with nocturnal and diurnal and only nocturnal enuresis

Enuresis	No. of cases	Percentage
Nocturnal and diurnal	8	40%
Nocturnal	12 60%	
Total	**20**	

In this study, the incidence of primary nocturnal enuresis was found to be 45% as against 75 - 80% as quoted by Mark and Frank.[2]

B. Observations on in vestigations in enuresis

Table 5: Frequencies of radiological abnormalities in enuresis

x-ray lumbosacral spine	No. of cases	Percentage
Normal	9	45%
Abnormal	11	55%
Total	**20**	**100%**

The radiological abnormalities were found in a significant number ofpatients. The figure ranged to 55%. These abnormalities were in the form of spina bifida (8cases), complete sacral agenesis (1 case), partial sacral agenesis with spina bifida (1 case) and sacralisation of lumbar 5 vertebra with transverse process abuting on the iliac crest (1 case).

Table 6: Ultrasonography findings in enuretic children

Ultrasound Abdomen	No of cases	Percentage
Normal	18	90%
Abnormal	2	10%
Total	**20**	**100%**

Ultrasound abdomen were abnormal in only 2 patients. One patient had low lying right kidney and the other patient showed moderate to severe hydronephrosis.

C. Observations on urodynamic study

Table 7: The urodynamic study was performed in 20 Subjects which showed following cyctotnetrie and electromyographic findings

Sr. No	Parameters	Results		
1	Functional cytometric capacity	Normal 12 (60%)	Small 4 (20%)	Large 4 (20%)
2	Filling phase detruser	Stable 18 (90%)		Unstable 2(10%)
3	Detruser contractility	Good 10 (50%)	9(45%)	Poor One Could not be commented
4	compliance	Normal 16(80%)	High 3 (15%)	Low 1 (5%)
5	Abdominal contractions	Present 16 (80%)		Absent 4 (20%)
6	Sphincter contractions	Present 18 (90%)	Absent 2 (10%	
7	Post void residue	Present 3 (15%)	Absent 17 (85%)	

The parameters used were defined as follows in our study. Fuctional cystometric capacity was defined by Koffs formula which states. Bladder capacity (cc) = (Age in years + 2) x 30 30 cc. Filling phase detrusor was labelled as stable or unstable depending upon the occurrence of involuntary detrusor contractions during filling phase. Detrusor contractility was defined as good or poor during the voiding phase of UDS depending upon the voluntary detrusor pressure generated by patient during voiding as compared to the pressure at full capacity of bladder. The compliance was calculated from detrusor pressure and volume at the full bladder capacity. A value of 10 ml / cm H20 was defined as normal. A value less than this was low compliance and more than 15 ml / cm 1-120 was labelled as high compliance. A post void residue of > 10% of the expected bladder capacity as measured by catheter was taken as significant value. Lastly, the sphincter coordination was determined by electromyographic record of the external sphincter using surface electrodes.

DISCUSSION

Bed wetting can conciderable emotional and psychological problems which may defect With normal development. Particularly if wetting is diurnal[16] 20 enuretic children participated in this study. Composing of 9 girls and 11 boys between the ages of 5 and 14years. The largest number of patients in our study was between 7-8 years of age, 15 of these patients presented with primary enurests while another 5 developed the

symptoms after a varying period of dryness lasting for at least 6 months. Nocturnal enuretics were 12 and those with both diurnal and nocturnal symptoms were 8 in number. Of the 8 patients with both day and night time symptoms, 2 were secondary enuretics. Similarly, of the 12 nocturnal enuretics, 3 were secondary enuretics. In our study, the urinary infection was found in 3 female patients, where pyuria was documented, however, the urine culture failed to reveal any growth. A study by Singh *et al*[11] in 1991 has shown urinary infection in 10% cases. 11 out of 20 patients in our study had a radiological abnormality of lumbosacral spine as mentioned earlier, 6 of these patients were diurnal enuretics. In an exhaustive study on 456 cases of diurnal enuresis, Ritchey and Sinha[17] studied plain radiograph of the lumbosacral spine in 127 cases of this study group. 48% of these 127 cases had spina bifida occulta. However, the UDS results in these patients were comparable to those normal. Therefore, this radiological finding was a fact coincidently noted. Of the 11 cases, 4 cases had hypocontractile bladder on UDS in our study. This abnormality represents a maturational delay and is not the result of any underlying neurological anomaly. 2 cases of sacral agenesis demonstrated a small capacity bladder. This finding was in keeping with the spinal defect. In one Indian study of epidemiological factors in enuresis, spina bifida was found in 4% patients.[11] The ultrasonography of abdomen revealed abnormal findings in 2 patients which were accidentally detected as a part of basic investigation in these patients. The results of cystometry in our 20 patients were as follows:

1. 7 patients with normal detrusor function (35%).
2. 4 patients with hypocontractile bladder as detected in the voiding phase (20%).
3. 3 patients with large capacity and high compliance bladder (15%), of which 2 had poor detrusor contractions.
4. 2 patients with detrusor instability (10%) with one patient having hypocontractile bladder with small capacity.
5. Small capacity with hypocontractile bladder in 2 cases (10%).
6. Small capacity with low compliance in 1 patient (5%).
7. Large capacity bladder in 1 patient (5%).

Correlating the symptoms with the urodynamic findings, we found that 6 of the 12 children with nocturnal enuresis alone had no abnormalities on urodynamic study. The remaining 6 patients were found to have hypocontractile bladder (2 cases), small capacity bladder (1 case), large capacity bladder (1 case), large capacity with high compliance (1 case) and small capacity with hypocontractile bladder (1 case), The 2 children with unstable bladder had both nocturnal and diurnal symptoms. Of the 8 cases with both day and night time symptoms, 2 had a normal study, 6 had abnormal findings, namely, large capacity, high compliant with hypocontractile bladder (2 cases), small capacity, low compliant, hypocontractile bladder (l case), unstable hypocontractile bladder (1 case) and unstable bladder alone in I case. Thus, no single symptom can predict the type of urodynamic abnormality to be found. In this study, we found that 7 out of 20 enuretic patients had normal UDS. This finding goes along with the study done by Linderholm[11] and Arnold[19] who performed cystometry in children with nocturnal enuresis and found a relatively small number with abnormalities. Using urodynamics Whitehouse and Arnold[2,14] showed a low incidence of abnormalities of bladder function in children with nocturnal enuresis alone (15%) compared with those with daytime symptoms (97%) in a study group of 50 patients from 6-49 years age. A project on a similar study population in 1995 in a teaching hospital in the city on 45 enuretic children revealed that 44% children had normal detrusor function; unstable bladder was noted in 34%, low compliant detrusor in 13% and hypocontractile bladder in 9% cases.[42] Mayo and Burns (1990)[12] performed urodynamic studies in children who wet. They evaluated 191 patients, 64 (34%) had normal bladder, 97 (51%) had unstable bladder and 30 (15%) had dyssynergic voiding with increasing volume of residual urine. Our study picked up only 2 patients with unstable bladder.

Detrusor instability has, however, been labelled as an important cause of enuresis. This may probably be related to the study done in supine position. In our laboratory, all the studies were done in supine position. Cystometry done only in supine position failed to identify correctly upto 2/3rd of children with unstable bladder activity.[7] There are various provocative tests which can detect overt detrusor instability[7]

1. The standing / sitting cystometrogram.
2. The micturition stop test.
3. Rapid filling with cold saline.

With such provocative measures, a much higher incidence of unstable bladder was reported by Mahony *et al*.[20] They observed detrusor instability in 44% of children. Bauer *et al*[1980][21] found that approximately one third were normal and two thirds were unstable. Recently, a study on 50 incontinent children was done by Khan, Starer *et al*[15] They found detrusor instability at reduced threshold volume in 74% cases which was attributed to be the main cause of primary enuresis. Ambulatory urodynamics can detect bladder instability in a very high percentage of patients.[13] A total of 8 patients, in our study, were found to have hypocontractile bladder.

4 of these patients also had other abnormalities on UDS and 3 had significant post void residue. These patients may present with nocturia, increased frequency and post void residue. This is also the group of children, who void with abdominal muscle contraction and thus, represent a group who have not received proper bladder training. We found a high proportion of cases with hypocontrctile bladder unlike other reports. This abnormal UDS finding was attributed to a maturational delay. All Of our children belonged to lower middle or lower socio-economic Strata and a lack of toilet training may have a role to play in the pathogenesis of enuresis in them,

Table 8: A comparison of various studies on cystometrogram

Various studies	Normal study	Hypocontractile bladder	Detruser instability
Present study	35%	40%	10%
1995 study[42]	44%	9%	34%
Khan *et al* [10]	26%	Not commented	74%
Mayo and Burns [20]	34%	Not commented	51%

3 of our patients also were found to have large capacity, high compliant bladder, 2 of them also with hypocontractile bladder. The chronically distended bladder in these patients lead to partial or complete myogenic failure. This is a behavioral abnormality where children learn to inhibit voiding voluntarily for long periods.[5] Paradoxically, these patients present with urgency and urge incontinence when the bladder is filled to its capacity. These cases have been described as 'lazy bladder syndrome/ and are seen in complicated enuretics.[4] A small group of patients (3 cases) in our study, had small capacity bladder. A small bladder capacity was reported by Hallman[8] and Starfield[22] However, this reduced bladder capacity is functional and not structural[10] A study was conducted by Agarwal, Rath *et al*[23] in 1995 on children with voiding problems and included secondary enuretic patients also. In a study group of 20 patients, they found non-neurogenic neurogeniC bladder (40%), small capacity hypertonic bladder (15%), atonic bladder (10%) and hyper-reflexic bladder (5%). Mehta *et al*[19] in their study of 21 children performed urodynamic evaluation in 16 and observed normal or decreased sphincter in 8 and non relaxing sphincter in remaining 8. We have not observed this abnormality in any of our patient. Out of 3 patients who presented with small capacity with a hypocontractile bladder, 2 patients, on X-ray lumbosacral spine revealed sacral agenesis, complete and partial. One of these patients showed low compliant bladder. Based on the urodynamic abnormalities detected, appropriate therapy can be instituted. The children with hypocontractile bladder need proper toilet training and those who do not respond, drug therapy in the form of cholinergic drug, bethanecol chloride can be used. In the enuretic children with detrusor instability, imipramine, can be instituted. The infrequent voiders with large capacity, hypocontractile urodynamic pattern, primarily require change of voiding habits and those with small capacity and low compliance; can be started on anticholinergic medication like oxybutynin or propanthelene bromide. However, the access to the investigation and the cost of Urodynamic study remains the limiting factor for the patients of enuresis.

SUMMARY AND CONCLUSION

Enuresis in children in the absence of organic disease is a common problem for both parents and paediatricians.

15 - 20% of children at 5 years of age are affected and the incidence drops to 1 - 2% by adolescence, with or without therapy. Diurnal incontinence does not have the same spontaneous resolution. This situation can produce secondary psychological disturbances that interfere with normal development. Hence, these children clearly warrant investigations to differentiate from organic pathology. Urodynamic study is one such investigation that can identify a number of intrinsic bladder abnormalities. With this study, we come to the conclusion that

1. Urodynamic abnormality cannot be predicted by any single clinical symptom.
2. There is a high incidence of urodynamic abnormalities in children with both nocturnal and diurnal enuresis as compared to the nocturnal enuresis alone. The pattern of abnormalities was however, not different.
3. The incidence of bladder instability by urodynamic study done in supine position is low.
4. There is high incidence of children micturating with abdominal contraction. These children require proper bladder training for micturition with detrusor contraction.
5. The presence of hypocontractile bladder on UDS indicates maturational lag in bladder control.
6. All children with diurnal symptoms and those with nocturnal enuresis not responding to therapy must undergo urodynamic evaluation.

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