Assessment of Nocturnal Enuresis and its Approach among Paediatric Population

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Background: Diurnal enuresis defines wetting while awake and nocturnal enuresis refers to voiding during sleep after a developmental age when bladder control should be established. According to International Children's Continence Society (ICCS), nocturnal enuresis (NE) is defined as intermittent incontinence during periods of sleep in children older than 5 years age in which the sphincters control is acquired. It is normal voiding that happens at an inappropriate and socially unacceptable time and place. The Diagnostic & Statistical Manual of Mental Disorders (DSM- IV) defines nocturnal enuresis as an involuntary voiding of urine during sleep, with a frequency of at least twice a week, in children older than 5 years in the absence of congenital or acquired defects of the central nervous system. The child has no control over this elimination, nor is he or she aware that it is happening. Specific neuropsychological disorders, such as attention-deficit hyperactivity disorder (ADHD) and autism spectrum disorders (ASD), have an increased prevalence of enuresis, increased therapy resistance, and are often characterized by a disrupted sleep. Decades ago, psychological problems were considered to be the primary cause of incontinence in general and nocturnal enuresis in specific. With a structured approach involving history and physical examination added to ultrasound imaging of kidneys and bladder, recording of urinary flow and measurement of postvoid residual, the diagnosis of monosymptomatic nocturnal enuresis can be made with confidence.

Keywords: Diabetes mellitus, Empowerment, social support and self-efficacy

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Introduction

Diurnal enuresis defines wetting while awake and nocturnal enuresis refers to voiding during sleep after a developmental age when bladder control should be established. According to International Children's Continence Society (ICCS), nocturnal enuresis (NE) is defined as intermittent incontinence during periods of sleep in children older than 5 years age in which the sphincters control is acquired. It is normal voiding that happens at an inappropriate and socially unacceptable time and place. The Diagnostic & Statistical Manual of Mental Disorders (DSM- IV) defines nocturnal enuresis as an involuntary voiding of urine during sleep, with a frequency of at least twice a week, in children older than 5 years in the absence of congenital or acquired defects of the central nervous system. The child has no control over this elimination, nor is he or she aware that it is happening **(1).**

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Diagnostic criteria for enuresis

Table (1): Diagnostic criteria for enuresis according to Diagnostic and statistical manual of mental disorders 5th ed. (DSM-5**).**

1.Repeated voiding of urine into bed or clothes (whether involuntary or intentional).
2. The behavior is clinically significant as manifested by either a frequency of twice a week for at least three consecutive months or the presence of clinically significant distress or impairment in social, academic (occupational) or other important areas of functioning.
3. Chronological age is at least 5 years (or equivalent developmental level).
4. The behavior is not due exclusively to the direct physiological effect of a substance (e.g. a diuretic or an antipsychotic medication) or another medical condition (e.g. diabetes, spina bifida, a seizure disorder).

Monosymptomatic nocturnal enuresis is considered to be a pathological condition associated with many etiologic factors. This is not least related to certain problems accompanying its treatment **(2).**

Nocturnal enuresis can be further categorized into primary, which is bedwetting in a child who had never been dry at night for six consecutive months and secondary, which describes bedwetting in an individual who was dry for six consecutive months and then began wetting again**.** Secondary nocturnal enuresis appears to be associated with organic causes or a higher incidence of stressful events particularly parental separation, disharmony between parents, birth of a sibling, early separation of the child from parents and psychiatric disturbance in a parent **(3)**.

***Prevalence* :**

The estimated prevalence of NE is highly variable depending on the geographical areas involved, the composition of the population studied and the diagnostic criteria. The study of (Nevéus and Sillén **(6).** described the prevalence of NE as approximately 10-15% at 5-year old, 5-10% at 7-year old, 3-8% at 10-years old children and 1-4% in adolescents with 0.5-2% in the untreated adults. A large population based study in Great Britain suggested that 20% of children in the first grade occasionally wet the bed**.** Given the prevalence of pediatric UI and associated symptoms, it is not surprising that it represents 7% and 40% of general pediatric outpatient referrals and pediatric urology visits, respectively Prevalence of nocturnal enuresis in Egypt. A study carried out in Assiut city, Egypt, they reported a prevalence rate of 17.8% among children of 5-12 years old joining a primary governorate school. **(4)**

A cross-sectional comparative study that was conducted on 723 students aged 6-18 years in Menoufia governorateshowed that Prevalence of NE was 11.5 % with significantly associated positive family history, however secondary type was 3.2%**.** In a cross-sectional study conducted on 450 students aged 6–12 years in Qaluobia governorate, the prevalence of NE was 15.7 %, where PMNE was 67.1%, and the secondary enuresis was 32.9%. Positive family history was 30% among the involved students **(5).**

Pathophysiology of nocturnal enuresis

The genitourinary system, under strict control by complex neural

pathways ensure to keep the child dry. An aberration of this mechanism results in either a pure NE or nocturnal enuresis with daytime symptoms termed functional voiding disorders (FVD) **(6).**

Nocturnal enuresis has often been considered as a simple benign self-limiting condition. However, there is increasing evidence that it is a complex, heterogeneous disorder, where multiple pathogenetic factors are involved. A single explanation for nocturnal enuresis has been elusive. The condition is multifactorial. 3 major pathogenetic mechanisms have been established as crucial: -

1- Nocturnal polyuria due to the lack of the normal nocturnal increase in vasopressin secretion with subsequent exaggerated urine production.

2- Detrusor over activity.

3- Increased arousal threshold, since neither the polyuria mechanism nor nocturnal detrusor over activity explains why the children do not awake **(7).**

1- Lack of nocturnal vasopressin release Decrease of renal urine production during the night allows for sleep not disturbed by a full bladder. In children this is the result of nocturnal release of hormones that regulate free water excretion (AVP) or solute excretion (angiotensin II and aldosterone). This results in increased urine concentration and reduced urine volume during sleep. This could explain why most children who are not enuretic tend to sleep through the night without being wet. Nocturnal polyuria is caused by a deficient circadian vasopressin regulation, resulting in high nocturnal urine production, which exceeds bladder capacity. Other renal circadian rhythms might also be disturbed,such as solute handling and glomerular filtration rate. It is well known that the circadian rhythm is regulated by central nervous system neurotransmitters and it is widely accepted that the majority of enuresis and nocturia patients have a mismatch between nocturnal diuresis and functional bladder volume overnight **(8).**

2- Detrusor over activity during the night The detrusor, in order to function appropriately, needs to be relaxed during filling and have an appropriate functional capacity. Detrusor over activity usually causes small voided volumes resulting in a decreased functional bladder capacity. The second organic characteristic involved in enuresis is bladder dysfunction. The following signs are indicative of detrusor over activity: -

In the daytime: frequency (more than 7 times per day) and urgency, holding maneuvers such as squatting or penile squeezing, low or variable functional bladder capacity (small voided volumes) and urge incontinence during the day At night: multiple wetting episodes each night, variability in the amount of urine in the diaper and waking during or immediately after wetting **(9).**

Dysfunctional voiding and overactive bladder (OAB) play a major role in NMNE, Bladder dysfunction is mainly related to inappropriate central nervous system control of detrusor and sphincter, much more frequent than spinal disorders**.** In children with NMNE, an underlying bladder dysfunction is clinically evident. However, this does not exclude a high nocturnal diuresis. Furthermore, a large majority of children with MNE might have high nocturnal diuresis, also not excluding an underlying over activity of the bladder at nighttime **(10)**

3- Lack of arousal from sleep: The fundamental mechanism resulting in nocturia or nocturnal enuresis is that the bladder fills to its capacity during sleep and needs to be emptied. The enuresis event results from the child‘s inability to awaken from sleep. Non-enuretic children are more likely to wake to void than enuretic children. Bedwetting children sleep normally but are unable to suppress nocturnal detrusor contractions or awaken in response to them or to

bladder fullness. The sleep of children with nocturnal enuresis is not deeper but more fragmented. It is assumed that sleep fragmentation leads to sleep deprivation in children with nocturnal enuresis, influencing the endocrine, metabolic, immune, inflammatory, and cardiovascular regulation **(11).**

Children with nocturnal enuresis are also more likely to wet in the first third of the night, often in the first two hours following sleep. Thus the point of bladder fullness for most enuretic children coincides with a time of night where they find it most difficult to wake from sleep. Increased delta component in computerized sleep electroencephalographic analysis suggests abnormally deep sleep in primary monosymptomatic nocturnal enuresis. Although in the past major attention was given to arousal, recent studies have demonstrated that the associated sleep disorder is much more complex. Arousal makes the difference between enuresis and nocturia, but does not explain the mismatch between nocturnal diuresis and functional bladder volume overnight **(8).**

Diseases associated with NE:

Upper airway obstruction (UAO) is estimated to be seen at 27% of pediatric population. The most common cause is adenotonsillar hypertrophy. Symptoms such as habitual snoring, apnea, excessive sweating at night and mouth breathing in the patient history or via sleep questionnaires. Sleep research has documented that nocturia and bedwetting are symptoms of OSA in children. A high incidence of comorbidity and correlation between nocturnal urine production and sleep disordered breathing, such as obstructive sleep apnea, has been found and investigated **(12).**

There are several hypotheses to explain the relationship between the UAO and the EN. Brooks and Topol believe that UAO have negative effects on arousal response. Maddern **(13).** suggested that EN is a result of decreased neuromuscular tonus during sleep which is more significant in patients with UAO **(13).**

Yeung et al. (10) suggested that temporary fall in oxygen saturation in UAO patients leads to loss of bladder control. Nocturnal polyuria is considered a cardiovascular response to negative pressure breathing (inspiration against a closed glottis), which is characteristic of OSA **(14).**

Moreover, patients with untreated obstructive sleep apnea syndrome (OSAS) excrete large amounts of sodium and urine overnight, probably because of increased secretion of atrial natriuretic peptide which is caused by the stimulation of right atrial receptors exposed to the exaggerated intra-thoracic pressure swings which accompany narrowing and obstruction of the upper airway. The natriuresis and polyuria are completely suppressed by effective treatment of OSAS **(14).**

The association between OSA and NE in pediatric subjects is supported by the decrease or complete resolution of bedwetting after successful treatment with adenotonsillectomy or the use of intranasal corticosteroids. Despite its high prevalence, Allergic rhinitis is frequently underestimated and undertreated in children. AR is classically characterized by sneezing, pruritus, rhinorrhea, and nasal congestion **(15).**

AR associated sleep disordered breathing is characterized by periodic breathing, obstructive sleep apnea and hypopnea, which result in microarousals during sleep, decreased total sleep time, decreased sleep efficiency and

change in sleep pattern and behavior. Persistent enuresis in some children is allergic in origin. It might be partly explained that nerve supply to the smooth muscle of bronchi and bladder derives from the parasympathetic system for the association between enuresis and asthma. Stimulation of the parasympathetic system may cause both bronchospasm and detrusor muscle contraction. Upon allergy diagnosis, allergen avoidance is suggested to reduce the risk of NE. Because NE is multifactorial, it is not possible to completely treat NE, despite elimination of allergens **(6).**

It is important to ensure optimal function of the bowels and bladder before starting treatment for nocturnal enuresis. Excessive stool in the colon can affect bladder capacity and cause the sensation of a full bladder. Relief of constipation has been shown to reduce the incidence of enuresis as well as symptoms of daytime urgency **(16).**

Oxyuris appears a highly successful parasite in countries where the socio-economic and environmental conditions are thought to be less hygienic. It is easily transmitted among family members through inhalation, contaminated hands and fomites. Other factors that are often believed to be related to the high transmission of Oxyuris are the area of the bedroom, the age of children and behavioral patterns **(17).**

Oxyuris has been reported to cause pathology in the genital and reproductive system of females**.** The association between enuresis and Enterobius vermicularis was reported in some studies. The prevalence of this problem as a cause of secondary enuresis is not clear. However, it would seem practical to check all children with enuresis, especially girls, for pinworm infestation. Spina bifida occulta is a developmental abnormality in which the vertebral arch does not close fully. It typically affects the 5th lumbar and 1st sacral vertebrae. SBO is fairly common in the general population, and it has not been known to have any clinical significance or to require any special treatment.

Several reports have suggested that the incidence of SBO is higher in those with incontinence, voiding dysfunction or lower urinary tract abnormality than in the general population. The presence of SBO in children with NE, verified by KUB, can facilitate the prediction of the response to NE treatment. A complete response could be more likely expected in children without SBO **(18).**

Neuro-psychological:

Specific neuropsychological disorders, such as attention-deficit hyperactivity disorder (ADHD) and autism spectrum disorders (ASD), have an increased prevalence of enuresis, increased therapy resistance, and are often characterized by a disrupted sleep. Decades ago, psychological problems were considered to be the primary cause of incontinence in general and nocturnal enuresis in specific. Enuresis often coincides with neurological and/or motor difficulties. Moreover, between 20 and 30% of the children with NE have at least one psychological disorder, which is twofold the rate of children without nocturnal enuresis. Bedwetting is the most stressful event after family fights and divorce. This problem can be stressful for the parents and other family members. Feelings of the parents may range from worried to frustrated, sad to angry, and even tired. Children may feel responsible for their parent‘s reactions and were reported to have significantly lower global self-esteem, scholastic skills, social acceptance, physical appearance, negative feelings and behaviors than children without nocturnal enuresis **(19).**

A minority of parents punish their children for bedwetting, either verbally, or to a lesser extent,

physically. Self-esteem scores increase following successful treatment. Effects on children's social and psychological development are frequently observed. Self-identity and sexual identity are acquired during childhood and adolescence; therefore, a number of additional problems like mood disorders are seen with NE. This condition may cause the fear of being noticed by others, humiliation, anxiety, social withdrawal, high anxiety levels and behavior problems **(19).**

APPROACH TO ENURETIC CHILDREN

With a structured approach involving history and physical examination added to ultrasound imaging of kidneys and bladder, recording of urinary flow and measurement of postvoid residual, the diagnosis of monosymptomatic nocturnal enuresis can be made with confidence. There are two levels of evaluation, that gives a good chance for choosing an appropriate strategy (**17)**

History taking

The history should be broad yet specific and include information from the child as well as the caregiver/parent. Detailed information is important, current or previous **daytime incontinence** must be asked about and, if present, described. How often does it happen and in which situations. Knowing whether there was ever a period of complete urinary control in a child of toilet-trained age can help distinguish between primary and secondary incontinence. Much of the history should focus on voiding habits. We must ask specifically about symptoms such as urgency, holding maneuvers (pressing the heel into the perineum, standing on tiptoe etc.), a weak stream, interrupted micturition and the need to use abdominal pressure to pass urine. A specific history of holding the perineum by hands and squatting to control urgency should be enquired **(20).**

A Frequency Volume diary is a meticulous record of the number of times a child voids and the volume of urine at each voiding recorded for at least 48 h, preferably over weekends or school holidays can be helpful in gathering information about voiding and elimination habits **(6).**

The urine voided each time gives an idea of the functional bladder capacity and this can be compared to the expected normal bladder volume for the age of the child. Abnormal patterns of voiding such as day time small quantity frequent (more than nine times) or infrequent voiding (less than four times) may be noted which otherwise may not be forthcoming in the initial history**.A**bnormal **frequency volume charting** strongly suggests an underlying FVD. It also helps rule out a condition associated with polyuria. R The family should also be asked whether the child has had any **UTIs**. Concomitant daytime bladder symptoms mean that the child has NMNE. Do the parents routinely wake the child at night or has evening fluid intake been decreased. **Nocturia** indicates that the child is not extremely difficult to arouse from sleep **(20).**

Since bladder and bowel function are closely interrelated, questions on bowel habits should also be posed. If concomitant **constipation** is not treated first, it may be difficult to get the child dry. If the child has bowel movements every second day or less often, or stool consistency is usually hard, constipation is probable. Fecal incontinence is also common in constipated children and it should specifically be asked about **(19).**

The presence or absence of heavy **snoring and/or nocturnal sleep apnea** in a bed wetter can be relevant information since some become dry after upper airway obstruction is relieved **(21).**

When there is secondary enuresis, we may also ask the parents whether there is any evidence of stressors at home such as parental

conflict or recent losses that could cause developmental regression and secondary incontinence.

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⁕ Physical Examination

A **Focused physical exam** can shed light on the etiology of a child 's incontinence, paying careful attention to the urogenital, neurologic, and gastrointestinal systems. Most children who have nocturnal enuresis will have normal findings on physical examination. Direct observation of the **urinary stream** in the office is important, especially if findings on the history suggest an abnormality. Children may have their voiding dysfunction ameliorated or even eliminated by correcting anomalies of body position detected when observing the child's micturition. **(20).**

Special attention should be paid to inspection of the male or female **genital region**, and of the urethral meatus. A patulous urethra in a girl with a widened pubic diastasis suggests female epispadias. Mouth breathing may suggest sleep apnea with associated enuresis due to adenoidal hypertrophy **(21).**

The child's **back** should be examined, with particular attention paid to recognizing signs of occult spinal dysraphism (hairy tufts, subcutaneous lipomas, skin discoloration, or sacral dimples above the gluteal cleft) The **neurological exam** should assess lower extremity reflexes, perineal sensation, anal tone and reflex and the presence of the bulbocavernosus reflex **(20).**

⁕ Non-ivasive diagnostic technique: -

- **Laboratory Studies**

Midstream urine specimen is the sole obligatory laboratory test in children with MNE. The ability to concentrate urine to 1.015 or greater rulesout diabetes insipidus and the absence of glucose rules out diabetes mellitus
as causes of nocturnal enuresis. Glycosuria means that diabetes mellitus
must be immediately excluded and proteinuria in repeat samples should
prompt investigations for kidney disease. A urine culture should be obtained
for symptoms suggestive of urinary tract infection. Further laboratory testing
is unnecessary for MNE **(6).**

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- **Ultrasound imaging of upper and lower urinary tract**

Because it is difficult to adequately reassure parents that a RBUS is unlikely to provide additional information that would change the treatment of PMNE, ongoing parental concern has led to include a RBUS in the initial evaluation of a child with PMNE, which does not follow the AAP and ICCS guidelines **(Kovacevic et al., 2012).**

RBUS should be considered an appropriate non-invasive test in most children with urinary incontinence. A small proportion of abnormalities seen on RBUS in children with PMNE require intervention and/or further evaluation. The identification of insignificant RBUS findings could lead to unnecessary additional investigations owing to parental concern **(6).**

Upper tract abnormalities such as duplex kidney, renal morphology and scarring, dilatation of the collecting system, and gross reflux nephropathy can be readily detected**.** Lower urinary tract abnormalities are even more difficult to assess for the inexperienced. Aside from bladder capacity and bladder wall thickening or irregularity, a bladder wall cross-section of more than 3-4 millimeters measured

at 50% of expected bladder capacity, is suspicious of detrusor over activity **(22).**

a) Post-void residual volume

Most children should be able to empty to 5cm3 or less, whereas repeated residual measurements of 20cm3 or more are concerning for pathology in the bladder and/or urethra. When discovered, high PVRs could require renal and bladder ultrasound, voiding cystourethrogram, and/or urodynamic studies to elucidate if the high residual is from an anatomic, neurologic, or functional cause **(6).**

In patients with gross vesicoureteral reflux urine from the ureters may enter the bladder immediately after micturition and may falsely be interpreted as residual urine. An isolated finding of residual urine requires confirmation before being considered significant, especially in infants and young children **(23).**

b) Ultrasound-flow-ultrasound

With ultrasound, bladder filling is assessed and when the bladder capacity is equal to the functional or expected bladder capacity for age, the child is asked to void into the flowmeter. After recording the flow, post-void residual is assessed again. This combination of imaging and uroflowmetry is a standardized procedure used to obtain representative data on both flow rate and flow pattern, as well as on postvoid residual volumes. This procedure avoids the registration of flow rates at unrealistic bladder volumes **(10).**

X-ray Imaging

A plain film of the abdomen should be considered in most cases as well, with particular attention directed towards identifying the amount of stool in the colon, and the presence of any vertebral bony anomalies (possibly indicating a neurogenic cause of urinary incontinence) and/or a widened pubic diastasis (possibly indicating a disrder along the epispadias-exstrophy spectrum) **(23).**

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If the history and/or physical investigations suggest a neurologic etiology, the spinal cord should be imaged to identify anomalies such as syringocele, cord tethering, or malposition, among others. **CT** and **MRI** are indicated to detect vertebral and spinal cord pathology. **MRU** can be performed when there is a suspicion of or to help define the anatomy of an ectopic ureter or other anatomic cause of incontinence such as common cloaca, urogenital sinus, or ano-rectal anomalies **(24).**

Frequency / volume charts: Bladder diary

The frequency/volume chart is a reliable non-invasive measure of maximum bladder storage capacity by a detailed diary recording fluid intake and urine output over 24-hour periods. The chart gives objective information about the number of voids, the distribution of day and night voids, along with the voided volumes and episodes of urgency, leakage or dribbling. From the frequency/volume chart the child‘s functional bladder capacity may be assessed as the largest voided volume, with the exception of the morning micturition, which actually represents nighttime bladder capacity **(3).**

A frequency/volume chart is recommended for several reasons:

1- It provides objective data that may support the history.

2- It helps detect children with NMNE.

3- It provides prognostic information.

4- It detects children who require extra evaluation.

5- It detects children with polydipsia.

6- It detects families with low adherence to instructions from health care providers **(22).**

Urinary flow and EMG

Uroflowmetry tests and measurements of PVR are the most frequently used first line tests in pediatric urodynamic practice because of their noninvasive characteristics **(6).**

Measurement of urinary flow is performed as a solitary procedure, with bladder filling by diuresis [spontaneous or forced], or as part of a pressure/flow study, with bladder filling by catheter. The child should be instructed to drink fluid in an amount equal to their estimated bladder capacity 60 min prior to the test. Also, two tests (each with a voided volume between 50% and 100% of estimated bladder capacity) should ideally be performed to account for variability between curves generated from the same individuals **(25).**

During examination, the uroflowmeter should be placed in a private and quiet place. The children should be kept well hydrated. Regarding the position of performing uroflowmetry, boys should void in a standing position and girls in a sitting position with adequate foot support **(10).**

One should keep in mind that the parameters generated from uroflowmetry and PVR tests including peak flow rate (Qmax), voiding time, voided volume (VV), and the shape of uroflow curves are determined by the volume of urine in the bladder, contractility of the detrusor muscle, abdominal straining force and bladder outlet resistance **(6).**

A voided volume > 50% of EBC is more reliable for the interpretation of uroflowmetry. EBC for children aged 3–12 years is defined as [(age in years) + 2] x 30 mL. RE VV of more than 100% of EBC was associated with high rates of abnormal uroflow patterns and elevated PVRs. Caution should be taken to avoid bladder over-distention during uroflowmetry examination. The variability in Qmax was small for consecutive uroflowmetry tests **(26).**

Uroflowmetry curves can be classified into two types: normal bell-shaped and abnormal non bell shaped curves (tower, plateau, staccato and interrupted). Abnormal uroflowmetry can be detected in healthy normal children. In cases with any abnormal flow pattern, repeat examination is mandatory. As there are no pediatric specific standardized flow rates, the pattern of the flow curve is used to distinguish pathologic from non-pathologic emptying. Although abnormal uroflow patterns are not guaranteed to represent the underlying disease, they are considered as signs suggestive of pediatric voiding dysfunction and risk factors for urinary tract infection **(25).**

Similarly, an uroflow with external sphincter electromyography (EMG) is a test that can easily be done in the clinician ‘s office that can provide clues as to the coordination of pelvic floor during micturition. The decision to exclude EMG from the uroflow can be made if a full urodynamic study (which includes external sphincter EMG) is going to be performed **(26).**

⁕ INVASIVE DIAGNOSTIC TECHNIQUES:-

The results of the non-invasive procedures will decide whether invasive diagnostic procedures are necessary or not.

Indications:

1. Voiding frequency of more than 3 per day.
2. A weak urinary stream or Straining during voiding.
3. Previous febrile urinary tract infection.
4. Continuous dribbling incontinence.
5. Pronounced apparent stress incontinence.
6. Vesicoureteral reflux and other genitourinary abnormalities.
7. Signs of neurological deficite or spinal dysraphism. **(12).**

a) Urodynamics

Urodynamics with external urethral sphincter EMG are indicated for those with a suspected or proven neurologic lesion (tethered cord on MRI, all patients with spina bifida, patients who have had radical abdominopelvic surgery), incontinent adolescent males with late diagnosis of posterior urethral valves, and in patients who fail behavioral or medical therapy**.** Both children and parents need careful preparation and adequate information before the study is done **(27).**

The study should be repeated at least 2 or 3 times. Only if during the first filling cycle no detrusor contractions are seen and also the voiding phase is in accordance with history and uroflow, it is probably sufficient to only do one complete filling and voiding cycle **(28).**

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Briefly, the test includes an 11Fr triple lumen urodynamic catheter in the bladder to measure intravesical pressure (Pves), a small balloon catheter in the rectum to measure intrabdominal pressure (Pabd), and either a 24-gauge needle electrode placed into the skeletal muscle of the external urethral sphincter or perineal patch electrodes to measure external urethral sphincter activity. The detrusor pressure (Pdet) is calculated by subtracting Pabd from Pves. These measuring devices are
connected to commercially available urodynamic systems to record and display the measurements. Upon inserting the urethral catheter, the bladder pressure should be noted. The initial voiding opportunity allows uroflowmetry with EMG, the detrusor and abdominal pressures during voiding, and the voided and residual urine volume to be measured. The bladder is then filled with warmed 37 degree saline at a rate equal to one tenth of the child‘s predicted or known capacity (capacity/10) **(24).**

Key measurements taken during bladder filling and storage include; the maximal bladder capacity and its associated detrusor pressure, detrusor leak point pressure, presence of detrusor over activity, whether leakage occurs with the increased abdominal pressure, and the volume at first leak. The instillation of radiopaque contrast medium instead of saline together with fluoroscopic equipment enables videourodynamics or real-time visualization of the bladder neck and urethra during the voiding phase, to be performed **(23).**

A **voiding cystourethrogram** (VCUG) is an invasive procedure and should only be done if the outcome will influence the management. It is indicated in incontinent children with a history of febrile UTI in order to detect reflux and in children with an abnormal flow pattern to detect bladder outlet abnormalities (like valves, strictures or a syringocele). In children with incontinence the lateral projection during voiding is the most important part of the study. Especially in children with stress incontinence or a neurogenic bladder, the position and configuration of the bladder neck during filling and voiding should be noted. In the
former, unless an obstructed ectopic ureter is found to be entering into the external urethral sphincter in girls, the VCUG is not likely to diagnose the cause of the urinary incontinence, but is important to rule out VUR and other sinister findings **(29).**

In children with non-neurogenic detrusor-sphincter dysfunction as well as in children with neurogenic detrusor-sphincter dyssynergia, the proximal urethra may show the so-called “spinning top” configuration, during filling and during voiding. With detrusor and pelvic floor muscles contracting at the same time, the force of the detrusor contraction will dilate the proximal urethra down to the level of the

forcefully closed striated external sphincter. The resulting "spinning top" configuration used to be seen as a sure sign of distal urethral stenosis, a concept held responsible for recurrent UTI in girls, with urethral dilatation or blind urethrotomy as the obvious therapy **(24).**

Finally, in difficult cases of incontinence, a **cystoscopy** can identify whether there is urethral cause (such as a diverticulum, urethral duplication, or large prostatic utricle all which would lead to post-void dribbling), bladder neck, or bladder pathology **(23).**

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