Normal voiding pattern and bladder dysfunction in infants and children☆

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Abstract

The normal voiding pattern and bladder dysfunction including neurogenic and non-neurogenic bladder, nocturnal enuresis and the relation between constipation and the bladder dysfunction has been reviewed in this paper. The dynamic property of lower urinary tract is complex as mature bladder function takes place in growth of the child. Recent studies have shown that cortical centre is responsible for the arousal reaction associated with voiding reflex in both healthy preterm and normal infants indicated that the mechanism involved in the infantile voiding is unclear. Neurogenic and non-neurogenic bladder dysfunction widespread occurred in childhood. Etiology of most bladder dysfunction in many aspects is still unclear, although a lot of fundamental and clinical researches have been performed. The most prominent symptoms of bladder dysfunction are urinary infection, urgency, frequency, fractional voiding, underactive bladder syndrome, and urinary incontinence. The applicability of urodynamic testing has become an essential element in the evaluation of bladder dysfunction. Based on urodynamic parameters, the natural outcome of the early functional investigation has been the advocacy of early aggressive management of children who are in the risk of renal deterioration. Classifying the bladder dysfunction only urodynamically is insufficient and the specific information is needed about the disease. The International Children's Continence Society has suggested a functional urodynamic classification system. The detailed knowledge of the bladder dysfunction and their treatment, are still limited in many aspects and further research is necessary in the future. [Life Science Journal. 2007; 4(4): 1 – 9] (ISSN: 1097 – 8135).

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1 Introduction

The normal voiding patterns in infants and children has not been completely established although several studies have been performed in infants and children with no apparent symptoms[1,2]. If overactive bladder and detrusor-sphincter dyssyncrgia (or intermittent voiding pattern) is normal in healthy infant is still a matter of debate. Recently, the traditional concept of micturition occurs spontaneously or recognized as a spinal cord reflex in infants has been also challenged[1,3].

The neurogenic and non-neurogenic bladders, and nocturnal enuresis are most often confronted bladder dysfunction in infants and children. Etiology of bladder dysfunction in many aspects is still unclear. The dynamic property of lower urinary tract is complex as mature bladder function takes place with the growth of the child[1]. In addition, there is the physical growth of the bladder-sphincter unit apart from gaining neurological control over the bladder. Urodynamic studies have led to a better appreciation of the pathophysiological processes of bladder dysfunction[4].

Furthermore, it has been noted that the congenital dysfunction that has no anatomical abnormality in the lower urinary tract but which takes place in the central nervous system. Their appreciation has had a considerable impact on the treatment of bladder dysfunction[2]. The outline of normal voiding patterns and bladder dysfunction in infants and children including normal bladder function, classification of bladder dysfunction, neurogenic bladder, non-neurogenic neurogenic bladder, urinary incontinence, and the relationship between the constipation and bladder dys-

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function is reviewed in this paper. The terminology used in this article is in accordance with the International Children's Continence Society (ICCS) recommendations[5,6].

2 Normal Lower Urinary Tract Function

It has been well known that the normal lower urinary tract indicated that efficient bladder filling and storage at low pressure, and subsequent efficient involuntary expulsion in newborn and voluntary expulsion of urine with growth of child, while the urinary striated muscle sphincter constricts progressively to prevent incontinence during the bladder filling and the detrusor contract to increase the intravesical pressure and the sphincter relaxes to permit the bladder to empty during voiding stage[1]. Traditionally, micturition occurs spontaneously and had ever been recognized as a spinal cord reflex without cortical influence. However, recent studies showed that cortical centers are responsible for the arousal reaction associated with voiding reflex in both healthy preterm and normal infants. However, two thirds of void in preterm occurred during sleeps without any body movement indicated that the mechanism involved in the infantile voiding is not fully clarified[7,8].

2.1 Maturation of bladder control

It has been noted that the neural pathways involved in micturition in the infant are incompletely developed, especially in preterm neonates. With the growth of the child, maturation of the central and peripheral nervous systems gradually brings the act of micturition under voluntary control. The first conscious awareness of bladder function usually occur between one and two years of age although the cortical centers might have joined the voiding reflux in the early of newborn. Voluntary control over the periurethral striated muscle sphincter usually occurs by the age of 3 years[1]. The toilet training success and the development of an adult type of bladder control depend on at least three separate events, i.e. the increase in voided volume, voluntary control over the periurethral striated muscle sphincter, and direct volitional control over the spinal reflex. Eventually, median age for attaining daytime and nighttime dryness was 3.5 and 4 years, respectively. No significant difference was found between girls and boys and the child attained daytime dryness an average of 10 months before attaining nighttime dryness[9]. A delay in the maturation of bladder control has been associated with bladder dysfunction such as primary nocturnal enuresis, detrusor overactivity, and dysfunctional voiding[10].

However, urodynamic studies have also led to further questions of the physiology of the bladder function in infants[7]. Recently, studies have indicated that postnatal development of bladder control in mammals is associated with a prominent reorganization of neural pathways that already exist at birth[9]. Therefore, bladder control probably involves a sophisticated integration of pre-existing central and peripheral neural pathways and is not mediated by simple spinal reflexes alone.

In addition, the results from the polysomnographic recordings did show that in sleeping new-borns there was clear evidence of cortical arousal in response to bladder distension[8]. These observations further challenge the traditional belief that human infants have bladders which empty automatically by a simple spinal reflex. Consequently, the concepts of those infants are born with uninhibited bladders needs to be reconsidered.

2.2 Parameters of normal lower urinary tract function

2.2.1 Voiding frequency. During first year of life the voiding frequency is 20 times per day or once per hour with great variability. During the next 2 years this frequency decreases to about 11 voids per day with the mean voided volume increases fourfold. By the age of 12, the frequency of voiding is 4 – 6 voids per day[9]. Estimates of voiding frequency are relevant from age 5 years and thereafter or from the attainment of bladder control. The observation that the child consistently voids 8 times or more daily denotes increased daytime frequency, whereas 3 or fewer voidings daily are called decreased daytime frequency. Note that in this article the word daytime is consistently used instead of diurnal. The latter term is ambiguous, in that it is sometimes used to denote all 24 hours of the day and night, and sometimes just the daytime hours. Caregivers may be unable to report voiding frequency until they have had a chance to observe the child at home and complete a bladder diary, which is an important adjunctive measure to objectively assess this and other parameters. The relevance of these observations increases when interpreted in conjunction with fluid intake.

2.2.2 Voided volume. Voided volume increases with the growth of the child. However, the formula used for evaluating normal voided volume with age has not been fully established and a great variety exists. Studies in healthy infants and toddlers have shown that they do not empty their bladders completely every time but do so at least once during a four hour observation period[3]. Now, we need a standard for comparison, and this standard is termed " expected bladder capacity (EBC) " . EBC is estimated by the formula [30 + (age in years × 30)] ml[11], a formula that is useful up to twelve years of age, after which age EBC level

is at 390 ml[6]. EBC is compared to the maximum voided volume (with the addition of residual urine, if present and known), as recorded in a bladder diary. This is supported by our study of cystometry in infants and children with no apparent voiding symptoms[2]. Maximum voided volume is considered small or large if found to be less than 65% or greater than 150% of EBC, respectively. It is obvious that the relation between age and voided volume is not a linear for all ages. Kaefer *et al*[12] described a non-linear model for the relation between age and voided volume, for children less than 2 years old: Capacity (in ounces) = 2 × age in years + 2 and for those 2 years or more: Capacity (in ounces) = age in years/2 + 6.

2.2.3 Post-void residual urine (PVR). Post-void residual (PVR) is defined as the volume of urine left in the bladder at the end of micturition[6]. Today PVR is assessed by ultrasonography after a uroflow measurement. In the diagnostic setting real-time ultrasound equipment is preferred. The PVR integrates the activity of the bladder and outlet during the emptying phase of micturition; a consistently high PVR generally indicates an increased outlet resistance, decreased bladder contractility, or both. Previous study showed that the PVR is less than 10 ml, with no relationship with age, sex or voided volume in children with the mean delay for catheterization being 4 – 5 minutes[6,10,13]. Jansson *et al* reported that median post-void residual volume was 5.5 ml, 0 ml and 2 ml at ages 1, 3 and 6 years, respectively[9]. It has been noted that the unavoidable delay of a few minutes after finishing voiding until ultrasonography results in bladder refilling with up to 5 ml, which is the upper value of residual urine not associated with urinary tract infection. A range of 5 to 20 ml may be associated with insufficient emptying, so that the examination should be repeated. More than 20 ml residual urine found on repetitive occasions indicates abnormal or incomplete emptying, provided that 1) there has not been any time delay exceeding 5 minutes from the end of voiding until ultrasonography is performed and 2) the child has not over ambitiously delayed micturition and, thus, achieved a state of bladder fullness in excess of what is normal for him or her. The case of a longer time delay can be compensated for by subtracting 1 or 2 ml from measured residual urine for every minute beyond 5 minutes. An uneasy child voiding in unfamiliar surroundings may yield unrepresentative residual urine volume. The absence of PVR does not exclude infravesical obstruction or bladder-sphincter dysfunction.

2.2.4 Normal pressure at voiding. Normal pressures at voiding have not been well defined, and it is achieved by a voluntarily initiated continuous detrusor contraction that leads to complete bladder emptying within a normal time span, and in the absence of obstruction. Natural filling cystometry showed that mean maximum voiding detrusor pressure (P_{det}) in normal infants (3 – 10 months old) is 107 – 117 cmH_2O in male and 75 in female, which recorded by a suprapubic catheter[2]. In another study, however, the conventional cystometry showed that normal mean P_{det} was 66 cmH_2O in male and 57 cmH_2O in female, which recorded by a transurethral catheter; there is no significant different of P_{det} between infants and children[4]. The great variety of P_{det} in infants and children might due to using different urodynamic investigative methods and different interpretation of the urodynamic recording. In a recent study, during the first months of life, urodynamics were characterised by small voided volume and high voiding pressure levels, the latter especially marked in male infants. Also dyscoordination at voiding was a common finding. However, detrusor overactivity during filling was uncommon in infants[6].

3 Bladder Dysfunction

3.1 Classification of bladder dysfunction.

Various classifications have been used to evaluate the bladder dysfunction during the past few decades, but most useful classification is urodynamic classification and International Continence Society Classification[5,6]. The urodynamic classification of bladder function is dependent upon the functional state of the detrusor during the filling and voiding phase of the cystometry. Detrusor function may be normal, overactive, underactive and areflexia[14]. The International Continence Society Classification is in many ways an extension of a urodynamic classification system.

3.2 Urodynamic detrusor dysfunction.

Normal detrusor function means to allow bladder filling with little or no change in pressure. No involuntary phasic contractions occur despite provocation[14]. Detrusor overactivity is an urodynamic observation characterised by involuntary detrusor contractions during the filling phase which may be spontaneous or provoked. There is no lower limit for the amplitude of an involuntary detrusor contraction but confident interpretation of low pressure waves (amplitude smaller than 5 cmH_2O) depends on "high quality" urodynamic technique[6]. There are certain patterns of detrusor overactivity: 1) Phasic detrusor overactivity is defined by a characteristic wave form and may or may not lead to urinary incontinence. 2) Terminal detrusor overactivity is defined as a single, involuntary detrusor contraction, occurring at cystometric capacity,

which cannot be suppressed and results in incontinence usually resulting in bladder emptying. 3) Detrusor overactivity incontinence is incontinent due to detrusor overactivity. It is clear that there may be overlap – even in the same patient whom might have phasic contractions early in cystometry and then has a terminal detrusor contraction with a large amount of urinary incontinence that might be labeled detrusor overactivity incontinence[14].

For a given detrusor contraction, the magnitude of the recorded pressure rise will depend on the degree of outlet resistance. Abnormal detrusor activity can be subdivided: 1) Detrusor underactivity is defined as a contraction of reduced strength and/or duration, resulting in prolonged bladder emptying and/or a failure to achieve complete bladder emptying within a normal time span. 2) A contractile detrusor is one that cannot be demonstrated to contract during urodynamic studies[6].

3.3 Common bladder dysfunction.

3.3.1 Neurogenic bladder dysfunction. Any lesion that directly injures the sacral spinal cord or interferes with the spinal pathways to the higher centers can result in a neuropathic bladder. The definition of neurogenic bladder has evolved over the years[15]. The neurogenic bladder may function deficiently in storage of urine or voiding, or any combination, of these respects. Consequently, three categories of lower urinary tract dynamics has been suggested according to the bladder contractility and external sphincter function during emptying of the bladder: dyssynergic, synergic, and completely denervated. Dyssynergy indicated that the external sphincter fails to decrease, or increase its activity during a detrusor contraction or a sustained increase in intravesical pressure during bladder filling phase. Synergy is characterized by silencing of sphincter activity during detrusor contraction or when capacity is reached at the end of filling. Voiding pressure is usually within the normal range. Complete denervation indicates that bioelectric potentials are undetectable in the sphincter region at any time during the micturition cycle or in response to the Crede's maneuver[16].

Bladder dysfunction due to neurologic lesions seems to occupy at least 25% of the clinical problems in pediatric urology. In infants and children, most neurogenic bladders are due to congenital abnormality of spinal cord and seldom caused by trauma or medical treatment, such as spinal cord injury and pelvic surgery.

Congenital abnormality of spinal cord. Closed spina bifida is the main congenital abnormality of spinal cord, which consists of a heterogeneous group of developmental anomalies that include meningocele, lipomeningocele, primary tethered cord, diastematomyelia, intradural lipoma, dermoid cyst, syrix, and sacral agensis[17]. These abnormalities may induce distortion of the developing neural tissues. Tethered cord syndrome (TCS) is a stretch-induced disorder of the spinal cord. Tethering is due to an inelastic structure anchoring the caudal end of the spinal cord as a short and thick filum terminale. Spinal dysraphism is occasionally associated, but the etiological relationship between these disorders remain unclear[18]. Closed spinal defects may be heralded at birth by a skin lesion, such as a lipoma or a hairy tuft. It might not be recognized until the onset of urinary incontinence, urinary tract infection, or orthopedic problems in later childhood when there has been growth of the spine or increased mobility. Radiologically, the most common finding is a defect in the lumbar or sacral laminae. Sacral deformities include deviated, partly absent or complete sacral agenesis. Myelograms and/or magnetic resonance imaging studies may help to confirm the exact source of the neurologic deficit[13].

Urodynamic evaluation has found that forty-three percent of these infants have an areflexic bladder and lack detrusor contraction; compliance during bladder filling is either good or poor. Consequently, it has been recommended that urodynamics should be performed as a routine before and after spinal closure[19]. The neurologic lesions in children are often not stable but change with the growth and development of the individual.

Spinal cord injury. The immediate result of a spinal injury is depression of neuronal activity below the level or the lesion manifesting flaccid, noncontractile bladder leading to painless retention of urine and an overdistenison injury to the bladder[20]. The level and extent of spinal cord injury determine the pattern of abnormal detrusor and sphincter activity. Suprasacral lesions allow the micturition center to be located in the sacral cord and tend to cause an increase in compliance. Thereafter, an uncoordinated pattern of bladder and sphincter activity will occur[21,22].

Assessing the exact degree of dysfunctional voiding has become increasingly important with the realization that bladder and outlet behavior cannot be predicted solely on the level of the neurological lesion. Bladder compliance is the critical factor in neurogenic bladder disease and any management scheme must be designed to keep the bladder compliant. Preservation of the upper urinary tracts can be achieved by keeping low filling pressures, high bladder compliance and a pressure at the time of urinary leakage of less than 40 cmH_2O[23].

Pelvic surgery and bladder function. Pelvic nerve injury is the most common complication of pelvic surgery. The nerve fibres most at risk are the preganglionic parasympathetic nerve and the sympathetic hypogastric nerves[24]. However, the majority of surgical injuries to the

pelvic nerves are partial and followed by varying degrees of reinnervation. Consequently, different urodynamic abnormalities may occur. The immediate results of pelvic nerve injury is that post-operative retention of urine. This is usually treated by prolonged catheterization. Thereafter the child can expel the urine by straining or manual compression although a large residue may remains. At this stage there is no sensation of fullness of the bladder, and the bladder neck is somewhat relaxed.

The occult neuropathic bladder. The clinical manifestation of occult neuropathic bladder are identical to that observed in overt neurological disease such as spina bifida, but there is no clinically demonstrable neurological lesion or anatomical obstruction. Recently, as the developing of the magnetic resonance, it has been found that nearly 50% of such children will have some neurourologic deficit. Consequently, an organic neuropathy of obscure pathology and non-organic manifestation of dysfunctional voiding has been suggested[25].

The etiology of this syndrome is unclear and debated due to the paucity of neurological and urodynamic tests that can specifically diagnose neurogenic disease. Symptoms of occult neurogenic bladder may occur from the early months of life, but the urinary incontinence invariably occurs and often present since toilet training child, and combined with variable patterns of overflow, dribbling or urgency incontinence[26]. Urodynamic feature is characterized by an impediment to bladder emptying, and detrusor-sphincter dyssynergia. Urography typically shows a pear-shaped or dumb-bell-shaped trabeculated thick-walled bladder. Various of degree of upper urinary tract dilation and damage may be proportional to the age of the child and the duration of the pathological process. No bladder outlet obstruction is founded. The same therapy as those with neuropathic lower tracts has been widely accepted for occult neurogenic bladder treatment[27].

3.3.2 Non-neurogenic neurogenic bladder. Non-neurogenic bladder dysfunction in childhood has been associated with urinary obstruction, incontinence, infection, or reflux, and at the end stage, not only day and night wetting and urinary tract infection but also constipation, encoprcsis, and morphologic lower urinary-tract changes[28].

The main underlying problem with non-neurogenic bladder is the unstable bladder. This may due to delay in central nervous system maturation rather than pathologic condition of the urinary tract[29].

Hinman–Allen syndrome, also known as non-neurogenic neurogenic bladder, occurs when there is a habitual and voluntary tightening of the external sphincter during an overactive detrusor contraction resulting in a learned failure to relax the external sphincter during voluntary voiding. Urodynamic techniques allow an accurate identification of the pathophysiology of bladder dysfunction and provide a more rational basis for their therapy in non-neurogenic bladder.

The detrusor and external sphincter "incoordination" results in hypertrophy of the detrusor, elevation of ureteral resistance, and allowed the accumulation of residual urine resulting in infection, and it produced episodic incontinence as well. Urodynamically, these children have vesicosphincteric dyssynergia with uninhibited bladder contractions that are opposed by abrupt contractions of the pelvic floor and external sphincter. Fifty percent have severe vesical ureter reflux (VUR)[10]. Two thirds of the children have hydrouretcronephrosis[28].

The treatment begins with an antibacterial agent and an anticholinergic medication such as imipramine to control both the infection and the reflex symptoms. Biofeedback can achieve good results. The surgical procedures should not be undertaken until the maximum benefit has been gained and the dyssynergia has been controlled[30].

3.3.3 Enuresis. Enuresis means incontinence in discrete episodes while asleep. The term is used regardless of whether daytime incontinence or other lower urinary tract symptoms is also present. Enuresis may be called nocturnal enuresis to add extra clarity but the ambiguous term diurnal enuresis is obsolete and should be avoided. Enuresis in children without any other lower urinary tract (LUT) symptoms (nocturia excluded) and without a history of bladder dysfunction is defined as monosymptomatic enuresis. Other children with enuresis and any other LUT symptoms are said to experience nonmonosymptomatic enuresis. LUT symptoms relevant to this definition are increased/decreased voiding frequency, daytime incontinence, urgency, hesitancy, straining, weak stream, intermittency, holding maneuvers, a feeling of incomplete emptying, post-micturition dribble and genital or LUT pain. If a subdivision is made according to the onset of enuresis, the term secondary enuresis should be reserved for children who have had a previous dry period of at least 6 months[25]. Otherwise the term primary enuresis should be used.

The most important period of attaining nocturnal urinary control is 2 to 3 years of age. Nearly 90% of children attained nocturnal urinary control by 5 years old[31]. Night wetting after the age of 5 year is generally considered a social concern. Epidemiological data showed that the overall prevalence of enuresis in children aged 7 – 12 was from 3.62% – 15.1%, and 0.5% – 2.3% of them persist to adult[32–37]. Nocturnal enuresis is a heterogeneous disorder with various underlying pathophysiological mechanisms, causing a mismatch between the nocturnal bladder capac-

ity and the amount of urine produced during sleep at night, in association with a simultaneous failure of conscious arousal in response to the sensation of bladder fullness[44].

The vast majority of primary enuretics, however, do not suffer from obvious psychiatric, neurological or urological disturbances; instead, the enuresis creates secondary psychological problems for the child, especially affecting self-esteem[38]. Polyuria at night has been suggested to play a role in inducing enuresis[39]. Reducing nocturnal urine production is important for achieving daytime and nighttime dryness in children, which occurs as a result of acquiring a circadian rhythm in the secretion of pituitary hormones, which generally takes place by age 3 – 4 years. Research has shown that antidiuretic hormone (ADH) levels did not increase during sleep in enuretics but they increase in normal non-neurotic children, which gives a physiological explanation for bedwetting. Although nocturnal polyuria has been suggested to be responsible for enuresis, antidiuretic treatment with desmopressin is only moderately effective in curing enuresis. This indicates that high urine output induced by low night-time ADH level in enuretics does not itself cause enuresis.

In urodynamic examination, nocturnal detrusor overactivity has been proven to be 29% – 90%, and small voided volume has been the most important early urodynamic observation in enuretics[40,41]. Although a direct causal relationship probably does not exist between unstable contractions and enuresis, the anticholinergic therapy aimed at eliminating uninhibited contractions is effective ranging from 5% to 40%[42].

Proven, reproducible and effective therapy has evolved from the drug therapy and behavioral modification. Imipramine can cure enuresis in about 40% – 50% of cases and will improve another 10% – 20%. However, discontinuation of medication will cause up to 60% of patients to relapse[10]. Desmopressin (DDAVP) has been shown to have a significant antienuretic effect because it produces a state of nocturnal antidiuresis. Although DDAVP is effective in reducing urinary volume and the number of wet nights, it has a high relapse rate and does not solve the underlying condition[29]. Retention control training involves forcing fluids and increasing the retention interval between voids, the goal being to gradually increase voided volume. When this therapy is combined with conditioning therapy using the urinary alarm, results can be highly successful[43]. Recently, in animal research, vasopressin and desmopressin increase motor activity via the dopaminergic system, raising the possibility that treatment with desmopressin might facilitate arousal[10,44].

3.3.4 Posterior urethral valve. Posterior urethral valve is a congenital urethral obstruction, which induced bladder dysfunction early during the gestation stage of the male fetus[45]. In infancy, the urodynamic pattern is characterized by hypercontractility and instability. During the first years of life the urodynamic pattern changes with vanishing hypercontractility and increasing voided volume with commonly an unsustaincd voiding contraction causing emptying difficulties. With time hypercontractility resolves and in many cases the pattern changes to over distention. In childhood and post-pubertal periods, bladder dysfunction is often pronounced by high capacity bladder with low contractility and poor compliance[46]. Over distension with detrusor decompensation is the predominant form in post-pubertal period. Incontinence is common complain during childhood and adolescence but it is rare in patient after puberty[47]. Obviously, early treatment is important for preserving the bladder function. In cases with high voiding pressure the indication for bladder treatment is assessed by the ability to empty the urinary' system. In cases of low pressure and high capacity it is important to differentiate between reflux and residual urine. Early clean intermittent catheterization is recommended and instillation of intravesical anticholinergics is a good complementary option. However, urodynamic pattern does not change immediately after valve resection[48].

3.3.5 Vesicoureteral reflux. The association between vesical ureter reflux and various types of bladder dysfunction like detrusor overactivity and bladder/sphincter dyssynergia has been reported[10]. The increase in bladder pressure associated with the dysfunctional voiding may magnify the potential renal damage by providing the force needed to drive the bacteria into the parenchyma inducing devastating pyelonephritis. VUR occurs in these children from not only the commonly accepted embryologic causes, but also from high intravesical pressure that may contribute to the weakening of the support musculature beneath the ureter. Therefore, bladder dysfunction may be a significant factor in the initiation and perpetuation of reflux[49].

However, urodynamic studies have shown that bladder decompensation with high end filling pressure, rather than high voiding pressure, is the mechanism for reflux and help to explain the seemingly paradoxical relationship among obstruction, reflux and high bladder pressures. In addition, the characteristics of potential bladder dysfunction were not uniform and there was a striking difference between female and male infant patients. In female, the urodynamic pattern included an over distended bladder with high capacity, normal or slightly increased voiding detrusor pressures, high post-voiding residual urine. Reflux occurred early during filling without any change in detrusor pressure, and no hypercontractility was noted[49].

In male, a hypercontractile bladder was the most common urodynamic pattern, which was associated with low voided volume, instability, high pressure levels at voiding. However, the interesting thing is that the incidence of VUR was significantly greater in girls than in boys, although urethral pressure values showed no difference between them. Therefore, the relationship between dysfunctional voiding and reflux is not a casual one, although they may be closely related[50].

3.3.6 Dysfunctional voiding. Dysfunctional voiding, which is preferred instead of voiding dysfunction, is characterized by incomplete relaxation of the pelvic floor muscles during micturition. This term cannot be applied unless repeat uroflow measurements show curves with a staccato pattern or unless verified by invasive urodynamic investigation. Voiding parameters often show high voiding pressures, sometimes with increased abdominal activity (straining) and with paradoxal pelvic floor activity. Residual urine is often present[51]. This spectrum of disorders may be collectively described as dysfunctional elimination syndromes (DES)[52]. The term DES recognizes that functional gastrointestinal disorders may play a prominent role in lower urinary tract dysfunction.

3.3.7 Overactive bladder syndrome and urge incontinence. Urgency, with or without urge incontinence, usually with frequency and nocturia, can be described as the overactive bladder syndrome (OAB), urge syndrome or urgency-frequency syndrome[14]. We agree with the current adult urology community practice of dropping the nebulous term bladder instability[2] and replacing it with OAB. The subjective hallmark of OAB is urgency and, thus, children with this symptom can be said to have an OAB. Incontinence is often also present, as is increased voiding frequency, but these symptoms are not necessary prerequisites for the use of the term OAB. The reason for not including increased voiding frequency is that it is not at all clear if it carries any clinical or pathogenetic significance, especially when fluid intake is not considered. Children with OAB usually have detrusor overactivity but this label cannot be applied to them without cystometric evaluation (see above). Urge incontinence simply means incontinence in the presence of urgency and, thus, it is a term that is applicable to many children with OAB.

The OAB is characterized by its smaller capacity and detrusor overactivity, whereas the dysfunctional voiding bladder consists of a larger capacity and detrusor hypoactivity. The condition is often caused by detrusor overactivity, early in the filling phase, often reacts with a contraction of the pelvic floor, and accompanied by external compression of the urethra (hold-maneuvers such as squatting, crossing the legs, curtsey sign)[53]. Detrusor overactivity is a urodynamic observation characterized by involuntary detrusor contractions that are spontaneous or provoked during the filling phase, involving a detrusor pressure increase of greater than 15 cmH_2O above baseline. In an adult with normal sensation urgency is likely to be experienced in conjunction with such detrusor contractions. In children reporting the sensation of urgency is less reliable. Detrusor overactivity may also be qualified, when possible, according to cause into neurogenic detrusor overactivity when there is a relevant neurological condition (this term replaces the term detrusor hyperreflexia) or idiopathic detrusor overactivity when there is no defined cause. The term detrusor overactivity replaces the previous term detrusor instability. The signs and symptoms in each patient with detrusor overactivity vary and depend on the frequency and forcefulness of the contractions and on the effectiveness of sphincteric constriction. Urgency, frequency, and precipitate voiding occur in about 60% – 70% of patients[1,12]. Frequent contractions of the detrusor may cause the pelvic floor muscles to become overactive, resulting in staccato or fractionated voiding[20].

Detrusor overactivity occurs in children who have failed to gain complete voluntary control over the micturition reflex, which might represent either a delay in central nervous system maturation or a developmental regression with persistence of the infantile pattern of spontaneous bladder contraction. It has been observed that detrusor overactivity do not occur in most of normal infants and more rarely after the age of toilet trained children[2,4]. However, if detrusor overactivity is a neuropathy is still in debated[2,3,6].

3.3.8 Underactive bladder. Detrusor underactivity is a contraction of decreased strength and/or duration, resulting in prolonged bladder emptying and/or failure to achieve complete bladder emptying within a normal time span. An acontractile detrusor demonstrates no contraction whatsoever during urodynamic studies. The two conditions can be observed in the clinical setting. They were formerly called lazy bladder but are now referred to as underactive bladder[29].

This term is reserved for children with low voiding frequency and a need to increase intra-abdominal pressure to initiate, maintain or complete voiding, ie, straining. The children often produce an interrupted pattern on uroflow measurement. The chronically distended bladder is likely responsible to urinary infection or overflow or stress incontinence. The child with underactive bladder is neurological normal. It is prominently important considering every notice about infrequent micturition in a paediatric case history or a large capacity bladder, noticed by chance

too[54].

Long-standing dysfunctional voiding may result in the underactive bladder, or myogenic failure. This condition is seen in about 7% of all dysfunctional voiders and typically occurs in females with a ratio of 5 : 1 to males. Infrequent voids, large-volume post-void residuals with chronic retention of urine, and urinary tract infections (UTIs) are the prevalent symptoms and signs[29].

Urodynamic studies demonstrate a very large capacity, highly compliant bladder with either normal, unsustaincd or absent detrusor contractions[8]. Straining is a common characteristic of emptying. Especially, after myogenic failure from the chronic distention, detrusor contractions are absent and abdominal pressure is the driving force for voiding[10]. Sphincter EMG reveals normal responses to sacral reflexes, filling, and attempts at emptying. The patients do not empty their bladders upon awakening in the morning has diagnostic value[1]. Sometimes, underactive bladder was noted during a voiding cystourethrogram when a bladder larger than normal (for age). Treatment of underactive bladder includes patient education and bladder retraining using frequent timed voiding[1,10,54].

3.3.9 Relationship between constipation and bladder dysfunction. Rectal dilatation may influence the function of the urinary tract leading to bladder dysfunction. The close proximity of the rectum to the posterior wall of the bladder is such that any gross distension of the rectum by stools can result in compression of the bladder[10]. In addition, large fecal accumulations may induce uninhibited bladder contractions resulting in all the attendant symptoms of urgency, frequency and urge incontinence. Consequently, urinary tract infection, enuresis, and vesicoureteral reflux may occur[43]. The risk of UTI and urgency is increased in chronic functional constipation, but that of other voiding dysfunctions like urge incontinence do not change significantly in animal research, an increased incidence of bacteriuria occurs in rats in whom fecal retention is surgically induced[55]. In addition, the correlation between constipation and high incidence of enuresis was described, and the treatment of coexisting constipation resulted in the cessation or improvement of enuresis. Furthermore, the relationship between constipation and VUR was also described in the literatures. A higher incidence of VUR was found in children with severe functional constipation than in those with Hirschsprung's disease. Also, constipation may cause ureteral dilation with hydronephrosis and when relieved, may allow for resolution of urinary dilatation. In addition, successful treatment of Hirschsprung's disease results in resolution of the vesicoureteral reflux has been reported[44,49].

4 Conclusion

It is known that with the growth of the child, maturation of the central and peripheral nervous systems gradually make the micturition under voluntary control. A delay of maturation of bladder control may result in bladder dysfunction. However, the neural pathways involved in micturition in the infant are incompletely developed and the mechanism of neurogenic and non-neurogenic bladder dysfunction in many aspects is still unclear.

The main consequences of neurogenic and non-neurogenic bladder dysfunction are renal damage and urinary incontinence, others, like urgent syndrome, fractional voiding, underactive bladder, urinary tract infection and enuresis may occur. Renal damage in bladder dysfunction is related to either high intravesical pressure or the association of vesicoureteral reflex and infection. The detrusor-sphincter dyssynergia or decrease detrusor compliance can increase the bladder pressure and resulting in vesicoureteral reflux. The causes of urinary incontinence are complicated. The mechanisms of incontinence include chronic retention of urine and low urethral resistance. The chronic retention of urine may be caused by detrusor atonia with a nonrelaxing sphincter, lack of storage capacity caused by hyperreflexia or poor compliance. Low urethral resistance is caused by denervation of the sphincter. The clinical manification of non-neurogenic neurogenic bladder is similar to that of the neurogenic bladder although there are no neurogenic pathological changes can be found. The etiology of enuresis is still unclear although it may represents a developmental delays of bladder control. Recently, multiple factors, such as behavioral, genetic, developmental, neurological, psychological, organic causes and difficult to arousal have been suggested to be related to enuresis.

Interpretation of a changed behavior or other comparisons between the normal and the abnormal, pathophysiologic situation of lower urinary tract might be difficult or even impossible in infants and children. However, our knowledge regarding pathophysiology of bladder dysfunction is steadily increasing. Neural, muscular, vascular, and hormonal components might be subject to change, and new components might be added.

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