Pathophysiology of Daytime Urinary Incontinence in Children

I-Ni Chiang, M.D.[1,2], Stephen Shei-Dei Yang, M.D.[3,4], Shang-Jen Chang, M.D.[3,4]

Division of Urology[1], Department of Surgery, Keelung Hospital, Keelung, Taiwan; Department of Urology[2], National Taiwan University Hospital. Taipei, Taiwan; Division of Urology[3], Department of Surgery, Buddhist Tzu Chi General Hospital, Taipei Branch, Taipei, Taiwan; Department of Urology[4], School of Medicine, Buddhist Tzu Chi University, Hualien, Taiwan

ABSTRACT

Daytime urinary incontinence is common in children. Children usually attain daytime bladder control before the age of 4 to 6 years. The prevalence of daytime incontinence decreases with age, although the reported prevalence figures vary widely because of differences in definition and geographic areas. According to a nationwide questionnaire study in Korea, the prevalence rates of daytime incontinence were 31.0% and 6.5% at the ages of 5 and 12 years, respectively. The International Children's Continence Society defines urinary incontinence as an involuntary loss of urine due to anatomical or functional etiology. The pathophysiology of daytime incontinence in children could be attributed to anatomical or non-anatomical factors. Anatomical factors include neurogenic bladder secondary to myelomeningocele, bladder extrophy, ectopic ureter, urethrovaginal reflux, labial adhesions and trauma. Functional causes include late toilet training, overactive bladder, dysfunctional voiding, giggle incontinence, urinary tract infections and voiding postponement. To manage children with daytime incontinence, a detailed history and physical examination is paramount. Non-invasive diagnostic tools including a urinalysis, voiding diary, uroflowmetry with a post-void residual test and/or electromyography, dysfunctional voiding symptom score, and ultrasound of the kidney and bladder may be of benefit in improving the diagnosis. Invasive complete urodynamic studies and voiding cystourethrography were usually reserved for children refractory to initial management or suspected of having a neurogenic bladder or anatomical anomaly.

Key word: children, urinary continence, toilet training

INTRODUCTION

Attaining bladder control is a complex developmental process requiring fine coordination between the nerve and motor systems. Children generally attain daytime bladder control before 4 to 6 years old [1]. At the age of 6 years, about 30% of children still have occasional daytime incontinence [2]. Unlike incontinence in the adult population which is usually pathological, incontinence in children is more common and usually functional. It will resolve as they grow and does not require invasive diagnostic tools and intensive treatment [3]. Under some specific conditions, however, incontinence may be a sign of underlying pathology. A structured clinical evaluation and diagnosis is warranted when managing children with incontinence. Therefore, we need to know the underlying pathophysiology of the incontinence in children. According to the International Children's Continence Society (ICCS), pediatric urinary incontinence is defined as uncontrollable leakage of urine [4]. The presentation of incontinence can be classified into continuous and intermittent incontinence. The etiology of continuous incontinence could be a congenital anatomical anomaly such as ectopic ureter or persistent urogenital sinus. Intermittent incontinence is defined as urine leakage in discrete amounts which can occur during the day (diurnal) and/or at night (nocturnal).

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Address correspondence to: Dr. Shang-Jen Chang, Division of Urology, Department of Surgery, Buddhist Tzu Chi General Hospital, Taipei Branch, 289, Jianguo Road, Xindian District, New Taipei City, Taiwan
E-mail: krissygnet@yahoo.com.tw

EPIDEMIOLOGY

In a longitudinal study following children from birth to 6 years old, daytime urine leakage was reported to be 13% at 1.75 years old and was 30% at 6 years old [2]. Kajiwara et al reported a prevalence of daytime urinary incontinence of 6.3% which was inversely related to age, decreasing from about 9% at age 7 to 2% at age 12 years [5]. According to a nationwide questionnaire study in Korea, the prevalence rates of daytime incontinence were 31.0% and 6.5% at the ages of 5 and 12 years, respectively [6]. The remarkable differences in the prevalence rate of daytime incontinence occurred because of differences in the study methods, populations and definitions of incontinence. Sureshkumar et al found that daytime urinary incontinence occured in 21.9% of girls over a 6-month period, but only occurred more than once a week in 3% of girls [7].

GENETIC FACTORS

An Australian population-based study found that 26% of moderate to severe daytime incontinence was attributed to family history [7]. The chromosome related to primary nocturnal enuresis was attributed to chromosome 22 and chromosome 13q [8]. In addition, children with attention deficit hyperactivity disorder [9] and Prader-Willi syndrome [10] had high prevalence rates of diurnal and nocturnal incontinence. Children with urofacial syndrome (Ochoa syndrome), a genetic inherited autosomal recessive disease, are also at risk of non-neuropathic bladder-sphincter dysfunction with accompanying daytime incontinence [11]. The clinical association of facial expression and non-neuropathic bladder-sphincter dysfunction could occur because the location of the center controlling laughing and crying in the upper pons is close to the micturition center [11].

NERVE CONTROL OF THE URINARY BLADDER

The major function of the urinary bladder is storage and emptying, which involve complex coordination between the parasympathetic, sympathetic and somatic nerves [12]. Any disruption in the nerve cir-

cuit interrupts the storage and emptying functions of the bladder will result in incontinence. The parasympathetic nerve originates from the spinal cord at S2-S4 while the sympathetic nerve originates from T10-L2. The somatic nerve controls the rhabdosphincter and originates from S2-S4.

ETIOLOGY

Although pediatric incontinence is usually self-limited, some specific conditions presenting with incontinence need careful differential diagnosis and management. The etiology of daytime incontinence could be classified as anatomical or non-anatomical.

Anatomical anomalies

1. Neurogenic bladder

The most common etiology of neurogenic bladder in children is spinal dysraphism which is due to a neural tube defect in which the bones of the spine do not completely form. Myelomeningocele accounts for 90% of cases. The clinical presentation of myelomeningocele includes loss of bladder and bowel control, lack of sensation, and weakness or paralysis of the hips and legs. Other etiologies include occult spinal dysraphism, anorectal malformation, urogenital sinus, sacral agenesis, imperforate anus, and cloacal malformation. The urodynamic findings of neurogenic bladder could be detrusor sphincter dysynergia, detrusor overactivity with urge incontinence, and detrusor underactivity with overflow incontinence [12].

2. Posterior urethral valves

Posterior urethral valve is the most common cause of bladder outlet obstruction in male infants, affecting only 1 in 4,000-7,500 infants [13]. According to Young's classification, posterior urethral valves cam be classified into three types. Type I has sail-like folds from the verumontanum extending distally along the urethra and accounts for 95% of posterior urethral valves. Type II valves may only represent hypertrophied urethral folds and are rarely met in clinical practice. Type III valves have cannulated septa because of incomplete dissolution of the urogenital membrane [13]. About 80% of children with posterior urethral valves have bladder dysfunction and the most common findings are detrusor overactvity, and poorly compliant bladder with myogenic failure.

3. Ectopic ureter

An ectopic ureter is defined as a ureter in which the insertion of the orifice lies distal to the normal insertion on the trigone of the bladder [14]. Most ectopic ureters are asymptomatic. In symptomatic females, an ectopic ureter commonly presents with urinary continence. Ectopic ureters are commonly associated with a duplex kidney. The insertion of an ectopic ureter in boys could be into the posterior urethra, seminal vesicle, vas deferens, bladder neck, prostate, and epididymis. The ectopic ureter is always above the external urinary sphincter in boys. As such, boys with ectopic ureters do not have urinary incontinence. In girls, the insertion of an ectopic ureter orifice could be distal to the external sphincter or even outside the urinary tract, resulting in classic symptoms with incontinence and constant dribbling. Surgical correction with a nephrectomy, ureteroureterostomy, ureteropyeloplasty ortransarterial embolization of the hypoplastic kidney with ectopic ureter is warranted in these patients.

4. Labial adhesion

The prevalence of labial adhesion in girls ranges from 0.6% to 5% and most are asymptomatic [15]. Therefore, treatment is not indicated in these asymptomatic children. Labial adhesion in prepubertal girls could occur because of local irritation of the vulva which causes the two sides of the labia to adhere to form a membrane. Labial adhesion may cause urinary tract infections, urine retention and disturbed uroflow and associated daytime wetting in girls. The mainstay of treatment is estrogen or steroid ointment application. Surgical correction is rarely needed in these patients.

5. Urethrovaginal reflux

Urethrovaginal reflux, defined as urine retained in the vagina after micturition, is common in girls. According to the study of Kelalis et al, 69% of girls had variable degrees of vaginal reflux on vesicocystourethrography examination [16]. The diagnosis is easily obtained by an adequate history, with a specific bladder diary. Reflux can occur because the patient has pelvic floor overactivity during voiding. Videourodynamic study is of great benefit when the diagnosis is controversial. The problem is easily resolved by proper instruction about the correct voiding position. Biofeedback may also be of great help in treating the problem.

Functional anomaly

1. Overactive bladder (OAB)

The key symptom in OAB is urgency with or without associated urinary frequency and incontinence [4]. Children with OAB are usually assumed to have detrusor overactivity. The prevalence of urgency in children decreases with age. According to a nationwide questionnaire study in Korea, the prevalence rates of urgency (OAB) were 22.99% and 12.16% at the ages of 5 and 13 years, respectively [6]. The urge incontinence rate was 26.97% in children with OAB. The flow pattern of children with OAB may have a tower-shaped curve. A bladder echo will show a thickened bladder wall (>2 mm). The mainstay of treatment is urotherapy (non-surgical, non-pharmacological behavioral treatment of lower urinary tract dysfunction which includes timed voiding, adequate fluid intake and proper toilet posture), anticholinergics, and biofeedfack therapy.

2. Voiding postponement

Children who habitually hold urine because of toilet refusal or other conditions are said to have voiding postponement [4]. Voiding postponement may lead to bladder overdistention and overflow incontinence. Also, it may impair the emptying function of the urinary bladder since bladder over distention in children leads to elevated rates of abnormal flow patterns and incomplete bladder emptying [17].

3. Underactive bladder (lazy bladder)

The traditional term "lazy bladder" has been replaced by "underactive bladder" which describes low urinary frequency and detrusor underactivity [4]. The patient needs abdominal straining during mcturition. The uroflow patterns are usually interrupted in shape. Urotherapy should be offered to these patients.

4. Dysfunctional voiding

Dysfunctional voiding in children is a multifactorial disease with prevalence figuires ranging from 2% to 7% in children in the community. It accounts for 30% of visits to pediatric urology clinics [18,19]. The cause of dysfunctional voiding is habitual contraction of the urethral sphincter during voiding. Children with dysfunctional voiding usually present with a variety of symptoms including daytime incontinence, urgency, holding maneuvers such as squatting on the heel (Vincent's curtsy), difficult voiding and constipation. Associated complications

include recurrent urinary tract infections, poor treatment outcomes of vesicoureteral reflux, and chronic renal insufficiency. According to the ICCS, diagnosing pediatric dysfunctional voiding mainly relies on clinical evaluation with a thorough history, physical examination, and uroflowmetry with a check of the post-void residual urine and/or electromyography. Full urodynamic studies are not recommended as routine diagnostic tools because of their invasiveness and the limited information gained from the tests [18]. To comprehensively evaluate children's symptoms associated with dysfunctional voiding, a validated questionnaire scale is needed to screen children in clinics, measure the severity of disease and monitor the response to treatment. Therefore, we have validated a Chinese version of the Dysfunctional Voiding Symptom Score (DVSS), originally developed by Farhat et al [19] in English. The DVSS consists of 10 items each with scores of 0 to 3 (Fig. 1). Seven items are related to voiding, two to defecation and one to stressful events. The chosen cut-off of 6.66 points for the total DVSS score had a sensitivity of 81.67%, and a specificity of 82.63%.

5. Late toilet training

The American Academy of Pediatrics suggests that toilet training be started after the age of two years [20]. However, there has been no consensus on the optimal timing or method for toilet training. Similarly, the definition of toilet trained is controversial among different studies. Since western countries have currently adopted child-oriented methods, toilet training is initiated after children exhibit signs of readiness for toilet training. During the past few decades, the timing of toilet training has been delayed in the western countries. Bakker et al reported that modern parents initiate toilet training at a later age than those 60 years ago [21]. The reasons for late toilet training may be busy parents and disposable diapers. Some evidence has shown that later toilet training may be associated with higher rates of urgency and urge incontinence than early training [22].

6. Constipation

Constipation is a common problem among children with prevalence rates ranging from 0.7% to 29.6% because of differences the definition of constipation, race, and geographic area [23]. The association between constipation and bladder dysfunction was first addressed in a study using the term dysfunctional elimination syndrome [24]. In one study, 89% of constipated children with urinary tract infections and incontinence had relief of bladder symptoms after their constipation was well managed. However, our recent study did not show a higher prevalence rate of urinary incontinence in community-dwelling children with constipation compared with those without constipation [25]. The discrepancy may be explained by the differences in study populations.

7. Giggle incontinence

Giggle incontinence is an uncommon condition in which there is complete emptying of the bladder when laughing. These patients usually have normal physical findings and urodynamic tests. Treatment should include timed voiding, anticholinergics and biofeedback therapy. The condition may be associated with cataplexy and some authors have proposed using methylphenidate to treat these patients. Biofeedback may also be of benefit in treating giggle incontinence [26].

8. Urinary tract infections

Urinary tract infection is thought to be associated with daytime incontinence, but the reason for the link remains elusive [27,28]. Theoretically, abnormal and inefficient voiding with turbulent flow may milk bacteria from the distal urethra back into the bladder resulting in infections. The rates of recurrent urinary tract infections in incontinent children are between 50% and 90% [27,28]. Bloom et al [29] found a higher prevalence of daytime enuresis in children with a history of urinary tract infection than those with no history. Therefore, managing urinary tract infections in incontinent children is an important issue.

CONCLUSIONS

Unlike incontinence in the adult population which is usually pathological, incontinence in children is more common and usually functional and does not require invasive diagnostic tools and intensive treatment. However, incontinence in children is bothersome and may be a clue to underlying pathology which may compromise renal function, leading to urinary tract infections and subsequent sequalae. To manage children with daytime incontinence, a detailed history and physical examination is paramount. Non-invasive diagnostic tools including a urinalysis, voiding diary, uroflowmetry with post-void residual test and/or electromyography, DVSS and ultrasound of the kidney and blad-

最近一個月中	從來沒有	少於一半的時候	約一半的時候	幾乎每次都如此	不知道
Q1. 白天時曾尿濕衣服或內褲。	0	1	2	3	NA
Q2. 當我白天尿濕褲子時，內褲非常濕。	0	1	2	3	NA
Q3. 我沒有天天大便。	0	1	2	3	NA
Q4. 大便時，我必須用力才能大的出來。	0	1	2	3	NA
Q5. 我每天只去廁所尿尿 1-2 次。	0	1	2	3	NA
Q6 尿急時我會用雙腳夾緊或交叉或蹲下來忍住小便，不去尿尿。	0	1	2	3	NA
Q7. 當我想尿尿時，非馬上去不可，無法稍等一下。	0	1	2	3	NA
Q8. 我必須用力才尿的出來。	0	1	2	3	NA
Q9. 我尿尿時會痛。	0	1	2	3	NA
Q10. 是否經歷下列事件：□否 (0) □是 (3) (可重複勾選) □新生兒 □搬新家 □換新學校 □學校問題 □虐待 (性 / 身體的) □家庭問題 (離婚 / 死亡) □特別事件 (生日) □意外事件 / 受傷 □其他					

Fig. 1. A Chinese version of the Dysfunctional Voiding Symptom Score (DVSS), translated by Stephen Yang, the copyright of Chinese version DVSS is reserved by Stephen Shei-Dei Yang.

der may be of benefit in improving diagnosis. Invasive complete urodynamic studies and voiding cystourethrography were usually reserved for children refractory to initial management or suspected of having a neurogenic bladder or anatomical anomaly.

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