

Urinary Incontinence

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Urinary incontinence is the involuntary loss of urine. Incontinence may occur only during the daytime (diurnal) or after the child goes to sleep for a nap during the day or at night (nocturnal). Incontinence is categorized as primary if the child has never been dry for an interval of greater than 6 months. Secondary incontinence occurs after the child has remained continent for 6 months. This differentiation is important and directs evaluation and therapy. Primary incontinence rarely has an organic cause and usually relates to an arrested developmental state, whereas secondary incontinence may be associated with an etiology such as stress, sexual abuse, constipation, or bladder or occult spinal cord lesions [1–10]. Urinary incontinence is a common problem often brought to the attention of a primary care physician [11–16]. With the proper understanding of normal and abnormal bladder function, a pediatrician can create a protocol that will benefit most children seen with this condition. This article focuses on the child who has daytime incontinence and provides a foundation for evaluation and treatment.

Epidemiology

Gaining urinary control is a sequential process. The infant bladder functions as a reservoir for urinary storage and elimination. Babies who have normal bladder function void by reflex; the bladder contracts when full and when stimulated by touch and temperature. The toddler (aged 2–3.5 years) progresses through a transitional phase of urinary development that ends with a mature, volitional, voiding pattern present after age 3 years. The age at which a child gains urinary

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control often follows a familial pattern. Urinary incontinence occurs in 10% to 15% of 4- to 6-year-old children, with resolution at an approximate rate of 15% per year. At the age of 12 years, 4% of the population is incontinent at least once a week; at the age of 15, 2%. Incontinence has been reported to occur more often in girls than in boys but is not of clinical significance [17].

Bladder physiology

A basic understanding of normal bladder physiology and urologic anatomy is required to know when incontinence may be pathologic and when evaluation and treatment are necessary. Bladder function comprises two distinct phases, passive storage and active voiding. Incontinence occurs in both phases. The storage phase of bladder function is crudely mediated by the thoracolumbar sympathetic system, nerves T10 through L2, and the voiding phase is governed by the parasympathetic system, nerves S2 through S4 (Figs. 1 and 2) [18].

Storage

During the passive storage phase, the bladder is simply a reservoir—urine is held without leaking and low pressure necessary to protect the kidneys is maintained. When incontinence occurs during this phase, it might be secondary to anatomic abnormalities such as an ectopic ureter, a deficient bladder neck, or physiologic irritability stimulating an overactive bladder. Normal urinary storage

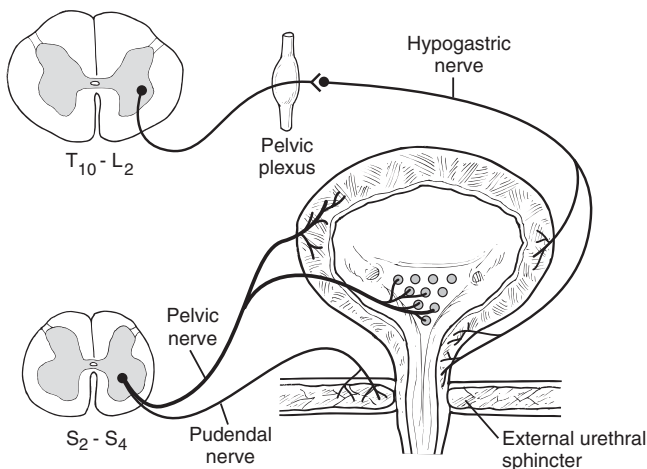


Fig. 1. Parasympathetic pathway responsible for bladder emptying.

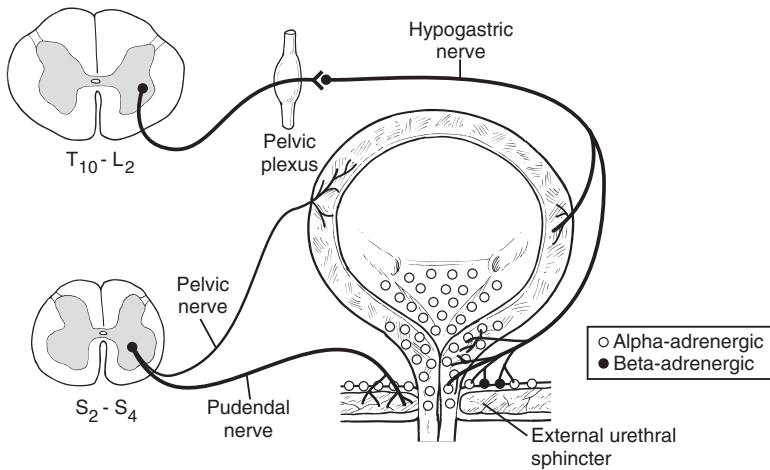


Fig. 2. Sympathetic pathway responsible for bladder storage.

requires that a reservoir hold an appropriate volume of urine for a given age. Age-based urinary capacity can be roughly estimated using the following formula: volume (in milliliters) = $30 \times (\text{age [in years]} + 2)$ [19]. During storage, the bladder must also have the characteristic of high compliance and be able to accommodate an increase in urine volume without a corresponding increase in bladder pressure. Multiple factors adversely affect bladder size and elasticity, such as bladder thickening, fibrosis, and collagen deposition. These characteristics can be caused by recurrent urinary tract infections, dysfunctional voiding, anatomic obstruction, and neurologic impairment [20]. Urinary continence during storage also requires a closed urinary sphincter mechanism, which comprises the bladder neck and external urinary sphincter.

Voiding

Under normal conditions, the active phase of voiding occurs by a reflex mechanism that results in a bladder contraction. A reflexive bladder contraction is initiated by conscious relaxation of pelvic floor muscles. Descent of the bladder neck into the deep pelvis is followed by reflexive opening of the bladder neck and sequential relaxation of the external urinary sphincter. The bladder then contracts and urine is expelled without resistance under low pressure. This synchronous, synergistic voiding pattern leads to balanced voiding and complete elimination of urine. Urinary tract infections, obstruction, and neurogenic dysfunction can cause physiologic changes that prevent coordinated function of the bladder, bladder neck, and external sphincter. When voiding is asynchronous, it usually occurs at the expense of high pressure and significant postvoid residual. This pattern is described as detrusor-sphincter dyssnergia [21,22].

Differential diagnosis

Neurogenic

The differential cause of urinary incontinence can be broadly categorized as neurogenic or non-neurogenic. Neurogenic causes are due to a defect in neural tube formation or traumatic injury to the spinal cord. Non-neurogenic causes are more common and include anatomic abnormalities and bladder overactivity. The neural tube begins to form in the third week of gestation, before most women even recognize that they are pregnant. Abnormalities in neural development at this time result in disorders classified as dysraphic defects and include a spectrum of midline problems from skin level to the vertebral bodies. Spinal dysraphism can have an important influence on a child's ability to gain bladder and bowel control and indirectly affect the long-term development of the kidney.

Spinal bifida is the most common dystrophic defect and occurs in approximately 1 out of 1000 births. Spina bifida includes children who have a meningocele, a myelomeningocele, and occult defects. A child who has a meningocele has a vertebral defect and protruding meningeal sac but the spinal cord remains intact. A myelomeningocele is a more extensive defect, with protrusion of the spinal cord within the meningeal sac. Occult defects include lipomeningocele, tethered spinal cord, and diastematomyelia. Occult defects are often associated with a dorsal midline nevi, hemangioma, hairy patch, or buttock deviation. All spinal defects require close urologic evaluation and support because of the potential for urinary incontinence and functional renal compromise. These complications occur less often in a child who has a meningocele or diastematomyelia.

The fact that a baby who has spina bifida has a wet diaper does not equate with normal synergistic voiding. A wet diaper may occur from passive urine flow and a weak external sphincter or at the expense of high pressure from overflow due to a thick and fibrotic denervated external sphincter. It is important to know whether voiding occurs synergistically, with relaxation of the external urinary sphincter while the bladder contracts (bladder-sphincter-synergy) or whether abnormally high voiding pressure is generated due to bladder-sphincter dys-synergy. Bladder storage pressure may also be compromised and elevated due to thickened fibrotic changes from a denervated neurogenic bladder.

All children who have a suspicious midline spinal defect should undergo investigation. Screening for a neurologic problem with spinal sonography can easily be performed within the first 6 months of life.

Non-neurogenic

Non-neurogenic urinary incontinence due to an anatomic abnormality is limited to a few specific conditions. Children who have an anatomic abnormality have a classic history of never gaining urinary control, day or night. Often, a family reports that their daughter voids normally but always has wet underwear. In this situation, a high level of suspicion should be given to an ectopic ureter.

Developmentally, the terminal portion of the ureter in boys may insert abnormally within the bladder neck or posterior urethra but never implants distal to the external urinary sphincter and, therefore, boys do not suffer from incontinence caused by an ectopic ureter. Girls can have an ectopic ureter implant along the full extent of the urethra or within the vagina. Usually, an ectopic ureter terminates within the distal third of the vaginal introitus. Ectopic ureters are frequently associated with a duplicated renal collecting system and traditionally drain the upper segment or a small, poorly functioning, dysplastic ectopic kidney.

Bladder neck deficiency is a patulous opening with poor coaptation of epithelial surfaces and results in minimal resistance to the outflow of urine. This condition is particularly problematic when there is an increase in abdominal pressure due to coughing, sneezing, and laughing. This defect can occur in boys and girls due to bilateral ectopic ureters or epispadias.

A girl who has a labial adhesion may present with intermittent urinary incontinence due to obstruction of the vaginal outlet and trapping of urine within the vagina. Classically, the girl has postvoid dribbling of urine when ambulating immediately after voiding. Chronic colonization with urine may lead to urinary tract infections.

Many children are taken to a physician for evaluation of urinary incontinence simply because the family does not understand the developmental milestones for gaining bladder control. Children reported to be toilet trained at age 18 months do not manifest the mental capacity to appreciate normal voiding behavior. These children can regress after age 3 years when traditional volitional control is usually obtained. Some children have incontinence secondary to an overactive bladder. The child who has an overactive bladder may follow a familial pattern for urinary incontinence. Social stress, sexual abuse, environment, and dietary factors also play a primary role in bladder irritability [1–10]. Recently, it was noted that children who have attention-deficit disorder demonstrate up to a ninefold-higher incidence of voiding dysfunction, which may be partly due to the child's heightened level of activity and distractibility [23].

Dysfunctional elimination syndrome describes the association between abnormal bladder and bowel behavior. Constipation plays a major role in perpetuating symptoms of voiding dysfunction [10,24,25]. When a neurogenic etiology is eliminated, general developmental and social problems must be considered.

History

The age of the child at presentation is relevant to the differential diagnosis, potential evaluation, and possible treatment options. As previously mentioned, the family must have an understanding of the normal developmental voiding phases to gain an appropriate perspective on the problem. A thorough family history helps to identify familial symptoms in parents or siblings. It is not unusual for a parent to have had similar problems treated with urethral dilation, which is

no longer first-line therapy for urinary incontinence. The age at which other family members achieved continence helps determine the expected duration of the existing incontinence.

Specific characteristics of incontinence are important, such as primary or secondary and continuous or intermittent. When intermittent, the time of the incontinent event should be noted as occurring immediately after voiding or randomly throughout the day. A history of prior urinary tract infections supports the need to evaluate the urinary system with imaging. Determining the characteristics of the urinary stream is helpful in directing management: Is the stream is complete or staccato? Does the child strain or relax when initiating the urinary stream? Is the child preoccupied with other activities when it is time to void? Does the child seem rushed and, therefore, incompletely empty the bladder? Other major medical illnesses, surgical procedures, and instrumentation of the urethra should be reported.

The diet history is crucial and frequently inaccurate. The volume and quality of beverage consumed plays a direct role in incontinent behavior. The child and parent should independently contribute this information. Some parents are unaware of what their child is consuming, and caffeinated products are particularly problematic. Often, parents do not have an understanding of what products contain caffeine. Parents may also not appreciate that caffeine is a diuretic, a potent stimulant, and a bladder irritant—all of which can contribute to a child's incontinent episodes. Other products such as orange juice, tomato products, and allergens should be eliminated from the diet. When constipation is a concern, fiber consumption should be reviewed.

Physical examination

The physical examination begins with visualization of a child's spine for any midline markings such as a central skin lesion, a hairy patch, deviation of the gluteal crease, a deep sacral dimple, flat buttocks, or an absent sacrum. Identification of any of these defects should generate further evaluation. The abdominal examination helps to identify masses that could represent a palpable bladder or stool within the colon. The genital examination in boys should include evaluation of the foreskin and penile glans for irritation, the location and size of the urethral meatus, and any cutaneous lesions around the external genitalia and rectum. Girls should have the appearance of the labia and clitoris documented. The labia may appear fused and thus trap urine, particularly in the overweight girl. A split or bifid appearance of the labia and clitoris is consistent with the female epispadias complex. An open bladder neck can be visualized in some girls who have this defect (Fig. 3). The hymenal ring, perineum, and perianal region should be evaluated for unusual drainage or lesions associated with potential sexual abuse. When an ectopic ureter is considered in the girl who has chronic total incontinence, the child should be positioned supine and "frog legged." The



Fig. 3. A bifid clitoris and patulous bladder neck typical of female epispadias.

vaginal introitus is dried and inspected after 15 minutes. Reaccumulation of urine suggests an ectopic ureter and warrants further evaluation.

Evaluation

The diagnostic evaluation for most incontinent children can be limited to a routine urinalysis with dipstick and microscopic interpretation. A specific gravity greater than 1.005 excludes the diagnosis of diabetes insipidus; significant glucosuria can justify investigation for diabetes mellitus. Proteinuria could represent renal insufficiency and the urinalysis should be repeated. The microscopic evaluation of the urine helps determine which urine specimen should be sent for culture. In select cases, hypercalciuria/hyperuricosuria leads to voiding dysfunction, although the exact mechanism is not understood [26,27]. A spot urine for a calcium/creatinine ratio can help identify the children at risk.

It is helpful to know whether a child is effectively emptying his or her bladder. A postvoid residual can be easily checked with a noninvasive bladder scan or formal pelvic ultrasound. A child who has frequency may be eliminating only 50% of his or her predicted bladder capacity after each void. These children are best served by improving their voiding efficiency. The frequent voider who demonstrates no postvoid residual volume, however, benefits from therapy directed at increasing the functional bladder capacity or reducing bladder overactivity. The uroflow assessment is another noninvasive modality that assesses voiding dynamics. This test helps determine whether a child is straining or relaxed when voiding. When a perineal patch electromyogram electrode is used during a uroflow study, children who contract their pelvic floor while voiding can be identified (bladder-sphincter dyssynergy) [28,29]. Behavioral and medical therapy can be instituted to reverse this abnormal voiding pattern.

A renal/bladder ultrasound is an ideal screening tool for evaluating incontinence. It is noninvasive and provides information regarding the kidneys and

bladder. An ultrasound should be obtained in all children who have a previous history of a urinary tract infection and in children presenting with secondary incontinence. It can be very helpful in the older child when reassurance is needed to rule out a structural problem. Bladder wall thickness greater than 5 mm is an indicator of outlet obstruction due to significant bladder-sphincter dyssynergy or a posterior urethral valve in a boy (Fig. 4) [30–33]. The upper urinary tract, kidney, and ureter are assessed for possible renal duplication, an indication that an ectopic ureter may be present in girls. A renal/bladder ultrasound may show rectal distention indicative of unrecognized constipation [10]; however, a kidney, ureter, and bladder x-ray gives better appreciation for the significance of constipation and also allows for inspection of the spine in the assessment of a potential dysraphic abnormality. It must be remembered that 5% of the population has a bony defect without symptomatic consequences.

The invasive voiding cystourethrogram should be restricted to children who have a history of urinary infections, gross hematuria, a family history of reflux, or an abnormal finding on the renal/bladder ultrasound (Fig. 5). A very low threshold should be set when managing boys who have urinary incontinence. A history of straining or a weak urinary stream in a boy should prompt consideration for a voiding cystourethrogram to clear the lower urinary tract of an obstructive process (Fig. 6).

When a neurogenic defect is suspected, a thorough investigation of the physiologic status of bladder function is required. Urodynamic evaluation provides reproducible results in infants and toddlers, but the procedure is invasive and requires meticulous attention to detail [20,30–32]. The use of sophisticated, computerized equipment allows for recording of multiple parameters related to bladder function (ie, capacity, compliance, contractility, and effective emptying) and to external urinary sphincter activity (synergy/dyssynergy and sphincter length). Baseline assessment of the kidneys should also be established with a renal sonogram. Blood work (serum creatinine) may be required to assess kidney

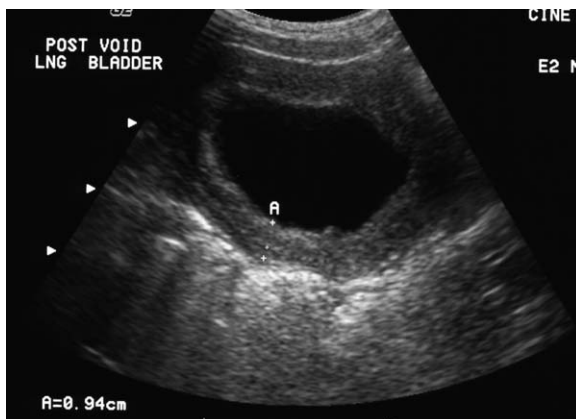


Fig. 4. A renal/bladder ultrasound in an 8-year-old boy.



Fig. 5. This voiding cystourethrogram demonstrates the classic spinning-top deformity that is created with dssynergic contraction of the pelvic floor during voiding. Note that a left grade 2 vesico-ureteral reflux is present, a finding that may be present in up to one third of patients who have voiding dysfunction.

function, particularly in children who have abnormal kidney changes. Urodynamic studies do not play a role in the initial evaluation of a child who has voiding dysfunction unless there is suspicion of true neurogenic dysfunction [29].

Lumbosacral MRI is indicated for the child who has a suspected neurogenic problem. This approach allows a high level of anatomic detail and for the identification of a tethered cord or fatty filum. This study, however, usually requires sedation. Spinal ultrasonography is an excellent alternative to evaluate for cord tethering in infants younger than age 6 months.

Cystoscopy does not play a role in the initial evaluation or management of an incontinent child, and urethral dilation is not the primary treatment of urinary

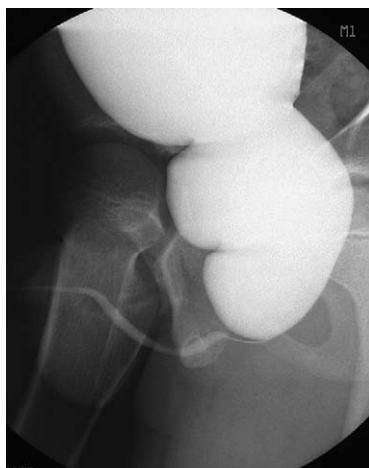


Fig. 6. This voiding cystourethrogram demonstrates a dilated posterior urethra secondary to posterior urethral valves in an 8-year-old boy who was screened with a renal/bladder ultrasound.

incontinence. These procedures should be undertaken only after the initial assessment is suggestive of a structural abnormality.

Treatment

The management of urinary incontinence in a child who has a normal urinalysis and physical examination begins with a conservative program that concentrates on diet modification, treatment of constipation, maintenance of hygiene, and timed voiding.

Diet modification includes the absolute elimination of caffeine from the diet. The family should be instructed that caffeine acts as a stimulant (which results in an overactive bladder) and as a diuretic (which increases urinary output). Some families require a dietary list that shows which beverages and products contain caffeine. Other dietary products that can increase bladder activity include orange juice (the result of potassium irritation), tomato products, and spicy foods. Dietary supplements that improve bladder “wellness” include 100% cranberry juice or cranberry extract and active yogurt cultures, which have a probiotic effect. These supplements decrease the risk of urinary tract colonization of bacteria by preventing adherence and the subsequent irritative response [34]. School-aged children should be instructed to drink primarily water. Providing children with their own water bottle along with a permission slip allowing them to drink liberally is required.

Aggressive management of constipation is needed for any treatment to be successful. A large bulk of stool within the rectal vault places the child at an increased risk for urinary infections and voiding dysfunction. The simple mechanics of a large stool impaction can cause deviation of the floor of the bladder and bladder neck, making complete bladder emptying difficult. In addition, stool holding increases pelvic floor activity, preventing the needed relaxation required for normal low-pressure voiding. Finally, a large bulk of stool within the rectum initiates a neuronal mechanism that tightens the rectal sphincter and prevents a bowel contracture to minimize encopresis. This neuronal activity simultaneously influences bladder function, tightening the external urinary sphincter and decreasing bladder contractility.

Constipation is very difficult to assess subjectively by the parent or primary care provider. The imaging studies previously reviewed assist with the diagnosis. The goal for treatment is a soft bowel movement every day or every other day. The child who has severe constipation requires an initial clean out from below and above. After the stool is evacuated, a motility agent such as polyethylene glycol 3350 and a high-fiber diet should be instituted. The following is a simple formula for the recommended dose of fiber: fiber (in grams) = age (in years) + 5. **Box 1** lists commercially available fiber supplements. Motility agents are tapered after an appropriate balance has been achieved (**Table 1**). When constipation is refractory to these simple measures, consultation with a gastroenterologist may be required.

Box 1. Fiber supplements available to manage constipation

Metamucil (psyllium hydrophilic mucilloid; wafers, capsule, powder)
 Benefiber (powder, chewable tablet, candy drops)
 FiberCon (calcium polycarbophil; caplet)
 Citrucel (caplet)
 FiberChoice (chewable tablet)

Poor hygiene increases perineal and genital irritation in boy and girls. Younger girls frequently have a difficult time balancing on the toilet and wiping from front to back, which often introduces stool and small tissue particles into the vaginal introitus. The small, thin girl may position herself on the toilet with her legs together and buttocks angled down. This can cause a small amount of urine to flow retrograde into the vagina and become trapped by the normal hymenal ring. These children usually complain of immediate postvoid dribbling when they stand and may develop the habit of excessive wiping. Having the child lean forward with legs spread (or sitting reversed on the toilet) cures this problem.

The urethra in boys and girls is easily irritated with soaps or prolonged exposure to bath water, resulting in urethritis. Using a mild soap and limiting bath time can be helpful.

A voiding program should be developed, beginning with documentation of the voiding process in a diary. Recorded parameters include the number of times voiding is initiated, the time between voids, the volume voided, number and time of incontinent episodes, and the number of bowel movements. The diary provides concrete data that are useful in further management and helps the child focus on the problem. The voiding diary can also be used as part of a positive reinforcement program when it is apparent that inattentive voiding is a factor in the incontinence. Instructing the child to void on time (2 to 4 hours depending on age) and providing a simple reward system has great merit. A rigid voiding program is an integral component in the treatment of a child who has attention-deficit hyperactivity disorder. It is unfortunate that success is limited, even when combined with dietary restrictions and pharmacotherapy.

Table 1
 Colonic motility agents available to manage constipation

Colonic motility agent	Dose
Polyethylene glycol 3350 (MiraLax)	>5 y, 17 g; <5 y, 8.5 g
Lactulose	15 mL po qd
Mineral oil	1–2 Tbsp prn
Docusate sodium (Colace)	>12 y, 50–200 mg qd; 6–12 y, 40–120 mg qd; 3–6 y, 2 mL tid
Glycerin suppository	2–5 y, 1 g; >6 y, 2–3 g
Senna	6–11 y, 5–7.5 mL qh; 2–5 y, 2.5–3.75 mL qh

When conservative management fails, pharmacotherapy or biofeedback may be instituted. There are several different pharmacologic agents that can be of benefit after the particular voiding problem has been elucidated, such as anticholinergic medication for bladder overactivity [35–37] or α -blockers for the inability to relax the external urinary sphincter (Table 2) [38–41]. The specific medication is determined by the results of the voiding diary, abnormalities found on ultrasound imaging, and the assessment of the postvoid residual. Anticholinergic therapy can be effective in the child who has an overactive bladder, decreasing contractions during the filling phase and increasing the duration between voiding episodes [35–37]. The benefits of the medication must be balanced with the child's age, the child's ability to take medication, and the potential side effects. Often, there is a tradeoff: treating the incontinence at the expense of developing secondary heat intolerance, dry mouth, constipation, scratchy eyes, and moody behavior. Introduction of some of the newer long-acting agents has maintained efficacy while improving the side effect profile.

Children who demonstrate an elevated postvoid residual urine volume may benefit from relaxation of α -adrenergic nerve fibers located within the bladder neck and posterior urethra (α -blockers) [38–41]. Postural hypotension can occur and blood pressure measurements should be obtained when using this medication.

Behavior modification (retraining pelvic floor muscle activity) can improve voiding function in children who do not respond to conservative voiding programs or pharmacotherapy [29,42–51]. Therapy is time intensive and requires cooperation and interest from the child and his or her family.

Rarely, a child presents with severe voiding dysfunction and significant adverse upper urinary tract changes (Hinman syndrome, non-neurogenic neurogenic bladder). This condition requires aggressive management and includes a combination of pharmacotherapy, behavior modification, and clean intermittent catheterization [21,52–55].

Table 2

Anticholinergic and α -adrenergic antagonist medication available for the treatment of voiding dysfunction

Medication	Dose	Maximum dose
Anticholinergics		
Oxybutynin chloride (Ditropan)	0.2 mg/kg per dose	0.6 mg/kg/d
Ditropan XL (oxybutynin chloride)	5 mg qd	15 mg qd
Hyoscyamine sulfate (Levsin)	0.03 mg/kg bid	0.1 mg/kg bid
Methantheline bromide (Pro-Banthine)	0.5 mg/kg bid	0.5 mg/kg qid
Tolterodine tartrate (Detrol)	0.02 mg/kg bid	2 mg bid
Detrol LA (tolterodine tartrate)	2 mg qd	4 mg qd
α-Adrenergic blockers		
Tamsulosin	0.4 mg qhs	0.4 mg qh
Afluzosin	10 mg qhs	10 mg qh
Doxazosin	0.5 mg qhs	1–2 mg qhs
Terazosin	1 mg qhs	2–4 mg qhs

Surgical intervention rarely has a role as the primary treatment of voiding dysfunction [56].

Children who have a known neurogenic deficit require investigation with urodynamics followed by a combination of pharmacotherapy, clean intermittent catheterization, and often, surgical reconstruction [57–62].

Summary

Urinary incontinence is a common primary care problem. With an understanding of normal voiding dynamics and an appreciation for the differential diagnosis, a systematic protocol can be established that allows the pediatrician to effectively treat most children. Emphasis should be placed on primary therapy: establishing healthy dietary habits, treating constipation, maintaining appropriate hygiene, and developing a regular voiding pattern. When the initial evaluation identifies an anatomic abnormality or when primary therapy fails, referral to a pediatric urologist is warranted.

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