Biofeedback treatment uses electronic or mechanical instruments to relay visual and/or auditory evidence to assist a person in gaining control over a physiologic process or function. In pediatric urology patients, biofeedback treatment is used to promote retraining of pelvic muscles. Figure 1 depicts the pathophysiology of dysfunctional voiding. In the figure, increased pelvic floor tension or overtraining is part of a vicious cycle that leads to pelvic floor and bladder dysfunction. Biofeedback methods are used to interrupt the cycle and promote pelvic floor relaxation and improve bladder function. With the use of biofeedback methods, the child learns about an unconscious physiologic process through visual, auditory, and/or tactile signals so that the unconscious physiologic process can be recognized and then changed or influenced (Hoebeke et al., 1996).

Historical Review

Biofeedback techniques to manage external sphincter-detrusor dyssynergia were initially described in the late 1970s. Interest has recently returned for biofeedback utilized as a treatment modality for children with dysfunctional voiding, recurrent urinary tract infections, or diurnal enuresis. The concept that pelvic floor musculature affects bladder function is not new. DePaepe and colleagues (2002) assert the pelvic floor is under voluntary control and plays an important role in the pathophysiology of lower urinary tract dysfunctions in children, especially of non-neuropathic bladder sphincter dysfunction. Allen and Bright (1975) reported on the relationship between dysfunctional voiding symptoms and objective pathology using urodynamics in the pediatric urological population. It was their idea that dysfunctional voiding represented a transitional stage between infant reflex voiding and mature voiding with cognitive reflex guarding. Cardozo, Stanton, and Hafner (1978) initially reported the use of biofeedback in a highly selected population of women with detrusor instability.

Controversy exists in the literature in regard to the validity of objective versus subjective improvement of symptoms of voiding dysfunction in children (McKenna, Herndon, Connery, & Ferrer, 1999). Some believe that patients with voiding dysfunction should initially be treated with behavioral therapy for its long-term efficacy and biofeedback used only if this therapy fails (Weiner et al., 2000). Others, however, attest that biofeedback achieves perineal synergy, cures symptoms in children with detrusor-sphincter dyssynergia, and that it guarantees long-term clinical and functional recovery (Porena, Costantini, Rociola, & Mearini, 2000). Attainment of daytime dryness is an important milestone for children and has been noted to improve self-esteem dramatically (Hagglof, Andren, & Bergstrom, 1997).

The earliest method of biofeedback training for detrusor overactivity focused on patient attempts to inhibit overactive detrusor contraction by concentrating, breathing deeply, clenching the fists, and generally relaxing while watching the cystometric curves or listening to the auditory signal to which the increase in detrusor pressure is converted. Maizels, King, and Firlit (1979) introduced urodynamic biofeedback as a new approach to treat vesical sphinc-
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Figure 1. Pathophysiology of Dysfunctional Voiding

Often patients have daytime and/or nighttime enuresis. For children with urinary incontinence and bladder overactivity, the goal is dryness. For children with vesicoureteral reflux and recurrent urinary tract infections, the goal of biofeedback is to establish low pressure cycling of the bladder. For children with severe voiding dysfunction, significant improvement of symptoms, rather than elimination of symptoms, is the targeted outcome goal (management versus cure). The common goal of biofeedback is to make children aware of their pelvic floor musculature and to teach them functional ways of using these muscles with voiding.

Biofeedback Methods

To grasp the basis of voiding dysfunction and the mechanics of biofeedback, it is important to understand the relationship between the nervous system (brain and spinal cord) and the urinary system. The brain and spinal cord coordinate the functions of the body’s organ systems, including the kidneys and the bladder. The kidneys filter waste from the blood and dispose of this waste in the urine. The ureters carry the urine down to the bladder where it is stored until time for emptying or voiding. The bladder stretches and relaxes as it fills and then squeezes or contracts as it empties. When the bladder is full, a signal is sent to the brain. The brain makes us aware of the need to urinate. As the bladder muscle contracts, a band of muscles at the bladder opening, called the external or urethral sphincter, relaxes to let the urine out. This muscular band is also responsible for tightening to keep urine in as the bladder fills. The surrounding muscles (lower pelvic muscles) hold the pelvic organs in place. Tightening of the pelvic muscles also tightens the urinary sphincter. Voiding dysfunction occurs when one or several physiological mechanisms do not work in a coordinated fashion. These include the inability to sense when the bladder is full, relax the sphincter, tighten the sphincter, and determine when the bladder is empty.

Teaching children the dynamics of voiding can be challenging. The success of biofeedback therapy depends greatly on patient and parent compliance, motivation to learn, and a willingness to participate. The procedure must be discussed clearly with the patient and family. The child’s session must be individualized and be developmentally appropriate for that child. Each child is taught to identify differences in relaxation, contraction, and straining. Children observe changes in the electromyography tracing on the monitor and wait for cues by the nurse to elicit a contraction or relaxation. Under guidance the child is taught to optimize pelvic floor relaxation with a stool placed beneath the feet or with knees spread which helps to relax the perineum.

Biofeedback involves use of electromyography and uroflowmetry. Electromyography patches are placed perianally at the 3 and 9

Goals of Treatment

The goals of biofeedback vary with the etiology of the problem. Children with bladder sphincter dysfunction (defined as contraction of the pelvic floor muscles during voiding in the absence of obstruction) may present with urgency, frequency, and occasional recurrent urinary tract infections and vesicoureteral reflux (McKenna et al., 1999).
A sensor patch is placed on the abdomen to monitor accessory muscle activity (see Figure 2). Leads are connected to an external unit that interprets and analyzes the electrical impulses received from the pelvic floor muscles. The external unit is attached to a computer, which relays the image to a monitor (see Figure 3).

At the beginning of all sessions, a provider obtains a voiding history and assesses if the child is a potential candidate for biofeedback. The provider then discusses the accomplishments of the previous treatment session, patient progress at home, incidence of breakthrough infection, compliance with home exercises, and addresses any questions the family has concerning the pelvic floor muscle retraining program. After all questions and/or concerns are addressed, the biofeedback session commences with placement of perianal leads. Patients are completely dressed and reclined in an adjustable chair during the session.

The session schedule involves the patient first relaxing and the nurse obtaining a baseline relaxation reading. Patients then perform Kegel exercises and short bursts of pelvic floor contractions, called quick flicks. When patients are not able to isolate the pelvic floor muscles, immediate instruction is given on how to isolate them (focusing on squeezing the leads on the buttocks). The patient is then instructed to perform four, 5-second repetitions of quick flicks, that is, short contractions and relaxations with the nurse and patient watching electromyography-generated activity patterns on the television screen. This is followed by a 30-second relaxation interval. The patient then performs a series of eight, 10-second alternating contractions and relaxations. This interval is then followed by a 30-second rest period.

Screening uroflowmetry and bladder scan for post-void residual urine are performed. The child is asked if there is residual urine in the bladder. This sequence is repeated until the bladder is empty or the child is unable to void any more. Over time, the child becomes increasingly aware of the difference between poor bladder emptying and an empty bladder.

An initial biofeedback session lasts approximately 90 minutes and a followup session lasts 60 minutes, depending on how well the child grasps the concept and practices at home. Three sessions, 4 to 6 weeks apart, is a usual starting point; however, timing of sessions is not well-documented in the literature. Other treatment plans include biweekly sessions or biofeedback until detrusor-sphincter dyssnergia is resolved (Porena et al., 2000). Timing between sessions essentially depends on progress and retention of concepts taught previously.

It is generally accepted that biofeedback is the treatment of choice for children with dysfunctional voiding in the form of staccato (fail to empty or store urine) or fractionated (further hyperactivity of the pelvic floor which stops flow with voiding occurring in several portions).
Pediatric urologic nurses must be aware of the significant psychosocial impact of urinary incontinence beyond the typical age of toilet training.

(Schulman, Von Zuben, Plachter, & Kodman-Jones, 2001). To date, however, there has been no agreement as to the optimal form of biofeedback. Some biofeedback programs attempt to funnel the attention of children through intensive inpatient programs (McKenna et al., 1999). At The Children’s Hospital of Philadelphia (CHOP), the current outpatient biofeedback program focuses on what is interpreted as the underlying pathologic condition.

The key to successful biofeedback is both patient and parent participation and motivation. Computer games in biofeedback serve as a mechanism to engage the child and maintain interest in the program. It is a reproducible technique and is advocated by others (Pfister et al., 1999). The games provide visual biofeedback as well as positive reinforcement. Game action is controlled by patient pelvic floor muscle activity.

Outcomes

In biofeedback therapy, children learn during voiding to sustain concentration and maintain a relaxed pelvic floor and voluntary urethral sphincter (Porena et al., 2000). The accurate monitoring of this physiological response by electromyography and the immediate recognition by feedback of the changes provide the basis for therapeutic retraining. Outcome variables include improved urinary continence, fewer urinary tract infections, and less vesicoureteral reflux. Improvement with continence may lead to improved self-esteem for the child as an added outcome.

Nursing Implications

For children with voiding dysfunction, establishing and maintaining good bladder habits takes a lot of work. A lot of “homework” is given outside of clinic. This includes comprehensive voiding and stooling diaries to track voiding habits and accidents. Maintaining the child’s motivation to work vigilantly on developing healthy voiding skills and to adhere to the treatment recommendations over time is a big challenge. For many children, a reward system is needed to help them focus on establishing bladder routines. Behavior therapy interventions such as modeling healthy urinary habits are often needed to alter maladaptive child behaviors that interfere with treatment progress. Success can only be achieved if the child is an active participant in treatment and if the child believes there are benefits to obtaining proper voiding habits.

Pediatric urologic nurses must be aware of the significant psychosocial impact of urinary incontinence beyond the typical age of toilet training. School, peer, and family relationships are often affected, and can result in damage to the child’s developing self-esteem. Problems related to self-esteem may require additional referrals to appropriate health care providers as needed. Pediatric nurses are in key positions to identify children with voiding problems. Once the problem has been acknowledged, nurses can assess the problem and its impact on the family; educate parents, children, and others regarding causes; discuss management options; and refer children for medical intervention when necessary.

Research Implications

Noninvasive urodynamic techniques, including biofeedback, have facilitated the diagnosis and management of detrusor-sphincter dyssynergia, which has been identified as a major cause of voiding disturbance in children who are uro-anatomically and neurologically normal (Porena et al., 2000). The etiology of dysfunctional voiding is controversial. The clinical presentation varies and the precipitating event in autonomic somatic dyssynergia usually remains obscure. Jayanthi, Khoury, and McLorie (1997) suggested that there may be a subgroup of children in whom voiding dysfunction is congenital rather than acquired. This hypothesis is difficult to confirm. Some authors have suggested that the beneficial results of biofeedback may be due to intensive one-on-one education rather than physiologic changes induced by biofeedback (Wein, 1982). Hence, further study is needed.

Cost Effectiveness

Urinary incontinence and voiding dysfunction are common problems, estimated to affect 13 million adults and children in the United States, and to account for costs exceeding $15 billion per year (Fantz et al., 1996). It is associated with a high burden of illnesses, high costs, and substantial negative effect on quality of life. Many medical and psychological insurance plans now cover biofeedback for various conditions. Some require co-payments. Other plans have annual caps. A prescription for the training, along with a diagnosis, may be required from a provider under the medical part of the plan. Intangible benefits from biofeedback therapy include increased patient satisfaction and better patient compliance. Although not stated in the literature, one can imagine how biofeedback therapy can provide a number of benefits that can be measured and put into dollar terms. These include reduced...
incidence of urinary tract infections and vesicoureteral reflux, fewer visits to the physician, fewer hospitalizations, and decreased use of medications. By treating the underlying cause, costs are greatly reduced, patients are less burdened, and families can enjoy a better quality of life.

Reimbursement for the evaluation and treatment of patients with voiding dysfunction varies from practice to practice, but most often involves a combination of the different codes (see Table 1). The initial evaluation involves a consultation code, usual detail (99253) or comprehensive (99254) level. If screening radiologic studies are performed, this is usually done through the radiology office and there is usually not a billable service for the urologist involved in that evaluation. If the patient proceeds with further noninvasive urodynamic studies, he or she would receive a simultaneous uroflow study, an EMG, and bladder ultrasound for PVR (codes 51741, 51784, 51798). The patient who proceeds with biofeedback treatment would be coded as 90911 for each session. Most patients are re-evaluated at the end of the biofeedback sessions by repeating the simultaneous urine flow, EMG, and PVR to be certain the treatment did not result in increased hyperactivity of the pelvic floor, and to be certain that the flow pattern and EMG pattern are in line with the patient improvement.

**Conclusion**

Biofeedback can be a successful modality for dysfunctional voiding in children associated with recurrent urinary incontinence, urinary tract infections, and vesicoureteral reflux. Many treatment programs typically utilize formal urodynamic studies to develop an inpatient treatment program. At CHOP, however, the initial evaluation and treatment of children with voiding dysfunction is on an outpatient basis, focusing on correcting pelvic floor voiding immaturity.

Although this approach is time consuming and labor intensive for the patient and the nurse practitioner, the advantages are that it is noninvasive and makes the patient more responsible and less passive regarding the condition. It provides positive results in most patients in a short duration of time. Biofeedback can be readily performed using the resources available in most pediatric urologic practices on an outpatient basis. Given the excellent results in the CHOP outpatient clinic, this strategy is recommended as adjunctive therapy in pediatric patients recalitrant to standard behavior modification.

**References**


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**Table 1. CPT Codes for Reimbursement**

- Biofeedback therapy – 90911
- Complex uroflow – 51741
- Pelvic floor EMG – 51784
- Bladder scan residual – 51798