0022-5347/00/1645-1686/0
THE JOURNAL OF UROLOGY®
Vol. 164, 1686–1690, November 2000
Printed in U.S.A.

BIOFEEDBACK TRAINING FOR DETRUSOR OVERACTIVITY IN CHILDREN

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ABSTRACT

Purpose: We evaluated biofeedback training for incontinence due to detrusor overactivity in children.

Materials and Methods: Included in our study were 22 boys and 17 girls with a mean age of 11.2 years. We noted nighttime incontinence in 3 patients, nighttime incontinence and daytime urinary symptoms in 26, and daytime incontinence in 10. All patients had detrusor overactivity and incontinence refractory to conventional treatment, including bladder training, tricyclic antidepressants, anticholinergics, desmopressin and/or conditioning therapy. Urodynamic study was performed using an 8Fr double lumen transurethral catheter for cystometry, a double balloon transrectal catheter for rectal pressure and external anal sphincter pressure measurement, and surface electrodes for sphincter electromyography. During biofeedback training patients were instructed to contract the anal sphincter without raising abdominal pressure to inhibit overactive bladder contractions. Biofeedback training was repeated monthly until cystometry revealed a stable bladder or lower urinary tract symptoms improved considerably.

Results: Four patients were lost to followup. Of the remaining 35 children urinary symptoms were cured in 23 and improved in 4. Urodynamic studies after 6 months of biofeedback training in 33 cases showed that bladder overactivity disappeared in 10 and improved in 18. Bladder capacity at the initial desire to void and maximum cystometric capacity increased significantly ($p = 0.0115$ and <0.0001, respectively). Detrusor-sphincter dyssynergia in 2 patients before biofeedback training resolved in each after therapy.

Conclusions: Biofeedback training for detrusor overactivity is effective even in pediatric cases refractory to conventional treatment.

KEY WORDS: bladder, urinary incontinence, biofeedback (psychology), urodynamics

Overactive bladder in children is the most common cause of nighttime wetting in association with daytime urinary symptoms, such as frequency, urgency and incontinence.[1] Bladder training and drug therapy with anticholinergics or tricyclic antidepressants have been indicated for overactive bladder but some cases are refractory to these therapies. Biofeedback training is reportedly effective for sensory urgency,[2] urge incontinence and enuresis due to detrusor overactivity,[3–7] urinary retention[8] and voiding dysfunction due to detrusor-sphincter dyssynergia[9] even in cases refractory to conventional therapy. Biofeedback training has been done during bladder filling with urodynamic testing (bladder biofeedback) or using electromyography of the perineal muscles during voiding (voiding biofeedback).[9] The latter technique of biofeedback training performed in a noninvasive manner using surface electrodes has often been used to treat dysfunctional voiding in children, that is pelvic floor hyperactivity during voiding.[10] Training to achieve pelvic floor relaxation during voiding in these cases may have a role when treating overactive bladder.[11] On the other hand, detrusor overactivity is reportedly inhibited by contracting the pelvic floor muscles through the perineal-detrusor inhibitory reflex.[12] Bladder biofeedback training using this technique has been effective for detrusor overactivity.[3, 4, 9, 13–15] We evaluated bladder biofeedback training clinically and on urodynamics in patients with daytime or nighttime wetting due to detrusor overactivity.

Accepted for publication June 16, 2000.
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MATERIALS AND METHODS

Included in our study were 22 boys and 17 girls 6 to15 years old (mean age 11.2) with urinary incontinence due to detrusor overactivity. Nighttime incontinence was noted in 3 patients (7.7%), nighttime incontinence and daytime urinary symptoms such as frequency, urgency or daytime incontinence in 26 (66.7%) and daytime incontinence in 10 (25.6%). Detrusor overactivity was defined as an involuntary detrusor contraction of more than 15 cm. water during the filling phase. Included in analysis were cases refractory to conventional therapy with bladder training, tricyclic antidepressants, anticholinergics, intranasal desmopressin and conditioning therapy. Because these medications were ineffective, they were withdrawn more than 1 month before study entry and were not given during or after training.

Neurological evaluation in all patients was performed with special attention to perineal sensation, anal sphincter tone, and the anal and bulbocavernosus reflexes, which are important for assessing sacral cord function. Spinal magnetic resonance imaging was done when plain x-ray showed a neurological or spinal abnormality. Children with neurological abnormalities or spina bifida were excluded from study. No patient had constipation or encopresis. Surgery had been done for vesicoureteral reflux in 1 child 3 years before study entry. Voiding cystourethrography before study entry revealed mild vesicoureteral reflux in 3 cases. Patients with

anatomical abnormalities of the urethra, such as posterior urethral valves or ring stricture of the bulbar urethra, were also excluded from study.[16] Urinalysis and urine culture before study entry yielded pyuria or bacteriuria in 8 patients, who were treated with antibiotics. No urinary tract infection developed during or after biofeedback training.

Urodynamics and biofeedback training were performed after the aforementioned conventional therapies had failed. After free uroflowmetry was done an 8Fr double lumen catheter was inserted transurethrally and post-void residual urine volume was measured. Using that indwelling catheter water cystometry was performed at an infusion rate of 30 ml. per minute with the patient supine or sitting. A double balloon catheter that we designed was also inserted transrectally to determine rectal pressure as a substitute for abdominal and external anal sphincter pressure (fig. 1, *A*). Simultaneously sphincter electromyography was performed with surface electrodes applied to the perianal skin (fig. 1, *B*).

Study participants were instructed to visualize urodynamic parameter monitoring and listen to the sounds of electromyography. Thus, detrusor activity was monitored by detrusor pressure calculated using the formula, bladder pressure − abdominal pressure, pelvic floor muscle activity by visualizing anal sphincter pressure and pelvic floor muscle activity by listening to the sounds of electromyography. We explained to patients how the bladder, abdominal and pelvic floor muscles activities were monitored. When detrusor overactivity was present at the initial urodynamic study, we explained that it caused incontinence (fig. 2, *A*). Participants were instructed to contract repeatedly the pelvic floor muscles for 10 seconds and relax for 5 with an empty bladder for 10 minutes without increasing abdominal pressure to inhibit the overactive detrusor contraction. Water was then infused again and they were instructed to inhibit detrusor overactivity by the described method (fig. 2, *B*). When electromyography showed detrusor-sphincter dyssynergia, patients were also told to relax the anal sphincter during voiding.

After biofeedback training patients were instructed to continue sphincter exercises by performing at least 30 contractions 3 times daily and bladder training at least once daily at home while imagining biofeedback training. Training was repeated monthly until cystometry revealed a stable bladder or lower urinary tract symptoms improved considerably. Patients or parents recorded the number and times of voiding, voided volume and the number of incontinence episodes. To assess the therapeutic outcome cure was defined as no urinary symptoms in 4 weeks and improvement as more than a 50% decrease in the number of incontinence episodes.

Methods, definitions and units conformed to the standards recommended by the International Children's Continence Society[10] except as specifically noted. All results are expressed as the mean plus or minus standard deviation. We performed the Wilcoxon signed ranks test for within group comparison, and Fisher's exact probability test to compare urodynamic effects and therapeutic results with $p < 0.05$ considered statistically significant.

RESULTS

Before biofeedback training all children had a normal urinary flow of more than 15 ml. per second and none had a post-void residual urine volume of more than 10 ml. All patients had detrusor overactivity, including 5 with bladder instability provoked by coughing or posture change to standing. Sphincter electromyography and anal sphincter pressure measurement during the filling phase showed low activity in 8 cases and periodic relaxation or an unstable urethra in 7, while during the voiding phase detrusor-sphincter dyssynergia was noted in 2.

Since 4 patients were lost to followup, we evaluated biofeedback training in 35. There was no effect in a girl with mental retardation and an IQ of 56 who was no longer compliant with training after 1 month. Another girl with mental retardation and an IQ of 48 had improvement on urodynamics but there was no improvement in nighttime incontinence after 14 months. A boy with bedwetting only and a girl with nighttime incontinence, frequency and urgency had no improvement at 6 months but each was cured by combined biofeedback training and electrostimulation 6 and 9 months thereafter, respectively. Biofeedback training was also ineffective in another 4 patients, in whom treatment was discontinued after 6 months. Of the remaining children incontinence or bedwetting was cured in 23 (65.7%) and improved in 4 (11.4%) (see table). The mean interval to cure or improvement was 8.96 months. Incontinence was cured in 2 of the 3 patients (67%) with nighttime incontinence only and in 2 with detrusor-sphincter dyssynergia. Recurrent incontinence in only 1 patient after 3 years was cured by repeat training. In 3 children vesicoureteral reflux noted before treatment resolved after biofeedback training and none had new onset vesicoureteral reflux during treatment.

During the initial biofeedback training session all except 3 participants achieved voluntary anal sphincter contraction, including 2 with mental retardation. Cystometry was repeated immediately after the initial biofeedback training session in 25 cases (fig. 2, *B*). Bladder overactivity disappeared in 4 patients (16%) and improved in 15 (60%) in whom cystometric capacity increased by greater than 50 ml. Mean bladder capacity at the initial desire to void increased significantly from 101.7 ± 69.2 to 118.3 ± 54.1 ml. ($p = 0.0119$). Mean maximum cystometric capacity also increased significantly from 180.0 ± 70.5 to 243.3 ± 69.9 ml. ($p < 0.0001$, fig. 3). In 2 children detrusor-sphincter dyssynergia resolved after biofeedback training.

We assessed the effect of biofeedback training on urodynamic parameters in 33 patients after 6 months (fig. 2, *C*).

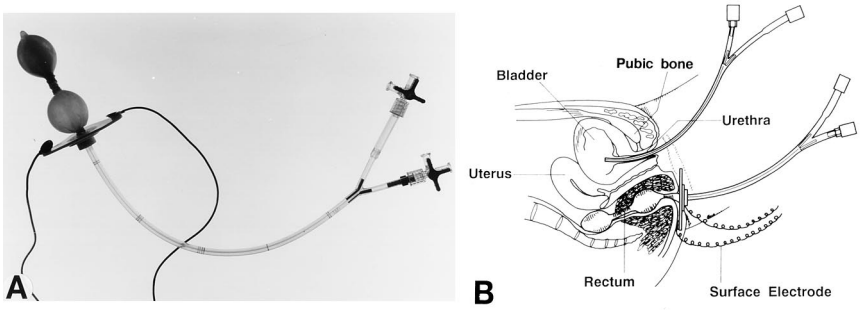

FIG. 1. *A*, double balloon catheter to measure rectal and external anal sphincter pressure, and surface electrode to measure electromyography in perianal region. *B*, urodynamic measurement during biofeedback training. For cystometry 8Fr double lumen catheter was inserted transurethrally and double balloon catheter transrectally for rectal and external anal sphincter pressure measurement. Sphincter electromyography was recorded simultaneously with surface electrodes applied to perianal skin.

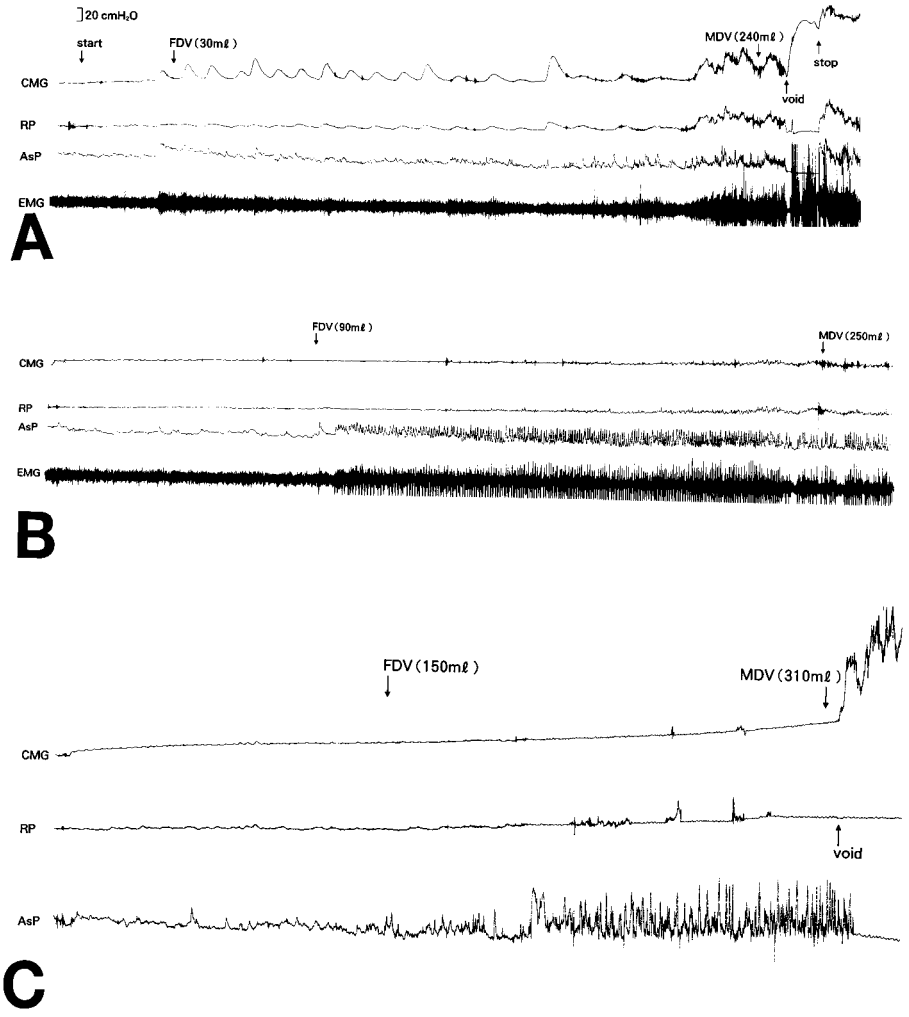

FIG. 2. Representative urodynamic study before treatment shows many overactive detrusor contractions. *A*, electromyography recording artifact during voiding phase was due to expelling of water but external anal sphincter pressure (*AsP*) was decreased to baseline. *B*, on repeat study during biofeedback training patient contracted pelvic floor muscles after initial desire to void and detrusor overactive contraction disappeared. *C*, after 6 months of biofeedback training maximum desire to void increased to 310 ml. with no detrusor overactivity. *FDV*, initial desire to void. *MDV*, maximum desire to void. *CMG*, cystometry. *RP*, rectal pressure. *EMG*, electromyography.

Bladder overactivity had resolved in 10 cases (30.3%) and improved in 18 (54.5%). After training mean bladder capacity at the initial desire to void significantly increased to 151.2 ± 57.3 ml. and mean maximum cystometric capacity to 288.9 ± 85.5 ml. ($p = 0.0115$ and <0.0001, respectively, fig. 3). After the 6 months of therapy detrusor-sphincter dyssynergia did not recur in 2 children. There was significantly more urodynamic improvement, consisting of a greater than 50 ml. increase in cystometric capacity, in cases considered clinically cured or improved than in those that were unchanged ($p = 0.0076$, see table).

DISCUSSION

In biofeedback training physiological activity is monitored, amplified and conveyed to patients as visual or acoustic signals, providing information on unconscious physiological processes.[4] This training is safe and effective, and avoids the side effects of drugs. For treating dysfunctional or dyscoordinated voiding in children the noninvasive technique of biofeedback training using sphincter electromyography with surface electrode is reportedly effective.[9,11] For bladder biofeedback training for detrusor overactivity a urodynamic catheter is necessary to diagnose detrusor overactivity, monitor detrusor pressure and evaluate the effects of training by urodynamics.[3,4,11,13–15] Thus, the biofeedback technique us-

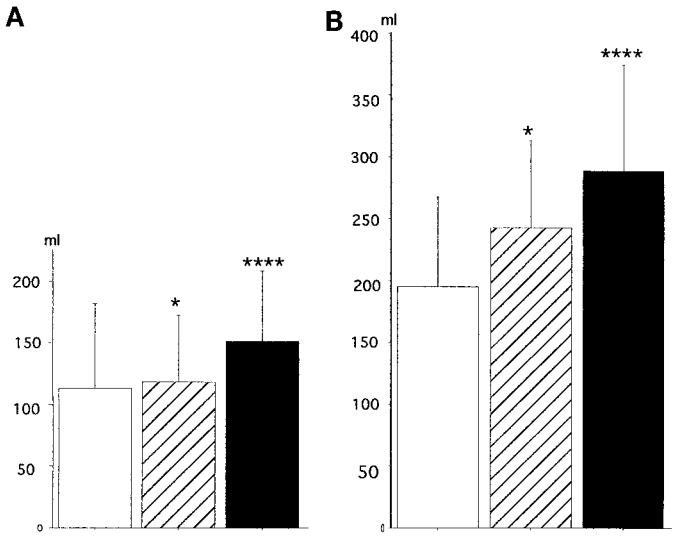

FIG. 3. Bladder capacity before biofeedback training in 39 patients (white bar), at repeat urodynamic study during biofeedback training in 25 (striped bar) and after 6 months of training in 33 (black bar). *A*, at initial desire to void. *B*, at maximum cystometric capacity. Asterisk indicates paired data $p < 0.05$. Asterisks indicate paired data $p < 0.0001$.

Association of clinical with urodynamic effects of biofeedback training on detrusor overactivity

Urodynamic Outcome	No. Cured	No. Improved	No. Unchanged	No. Unknown	Total No.
Cured	8	1	1	0	10
Improved	12	3	3	0	18
Unchanged	1	0	4	0	5
Unknown	2	0	0	4	6
Totals	23	4	8	4	39

ing a transurethral catheter has not been popular because it is somewhat invasive in children and requires much time and effort by physicians and patients.[7] It has been done as an adjunct to conventional or stage 2 treatment after conventional therapy fails.[3, 11, 17] It also helps by giving patients a better understanding of bladder function and their particular bladder problem.[6]

Biofeedback training was initially performed in the 1970s for detrusor overactivity.[5, 6] The earliest method of biofeedback training for detrusor overactivity was patient attempts to inhibit overactive detrusor contraction by concentrating, breathing deeply, clenching the fists, generally relaxing and so forth while watching the cystometric curves or listening to the auditory signal to which the increase in detrusor pressure is converted.[5–7] Cardozo et al reported cure in 11 of 27 patients (41%), although the beneficial effect was maintained in only 4 after 5 years of followup.[6] We think that it may be difficult for children to understand how to control overactive detrusor contractions using this method.

Recently patients were instructed to inhibit detrusor overactivity by contracting the pelvic floor muscles.[3, 4, 13–15] Kjølseth[4] and Hoekx[3] et al evaluated the effect of biofeedback training on detrusor instability and reported a cure rate of 60% and 70%, respectively, although unstable bladder contractions were not stabilized in either study. In our series the cure rate of daytime and nighttime incontinence was 66% and detrusor overactivity resolved in 30% of patients. Clinical results correlated with urodynamic improvement (see table). Although there may have been differences in patient characteristics as well as in the duration and method of conventional treatment before biofeedback training, the differences in urodynamic improvement in our study and that of Hoekx et al seem mainly to be due to different biofeedback training methods. We measured bladder, abdominal and anal sphincter pressure simultaneously by electromyography, whereas Hoekx et al only measured bladder pressure.

It is important during biofeedback training for patients to contract the pelvic floor muscle without contracting the abdominal muscle. Thus, we think that it is necessary to measure detrusor and pelvic floor muscle activity as well as abdominal muscle activity. For pelvic floor muscle measurement electromyography with a surface electrode is noninvasive and useful but it may record false electromyography activity of other muscles, such as the gluteus muscle and so forth. Using a triple balloon catheter to measure rectal (balloon 1) and anal sphincter (balloon 3) pressure Middaugh et al reported effective results of biofeedback training for incontinence in 4 men with stroke.[13] Using a double balloon catheter and surface electromyography recording our biofeedback training was done by sight using abdominal and anal sphincter pressure monitoring and by hearing using electromyography. External anal and urinary sphincters are innervated by the pudendal nerve and they commonly contract together. Since the external anal sphincter is by far the more accessible site, Middaugh et al used it effectively for biofeedback training to improve urinary sphincter control.[13] Repeat urodynamics during training verified that patients learned to inhibit overactive contractions effectively and rapidly.

For urodynamics we selected an infusion rate of 30 ml. per minute to save time. Although this filling rate was thought to represent nearly medium filling in patients older than 10 years, it is rapid and may provoke detrusor overactivity in young children. In other words, this filling rate may have helped to precipitate detrusor overactivity. Furthermore detrusor overactivity was also provoked by coughing or a posture change to standing in 5 cases. Interestingly sphincter electromyography and anal sphincter pressure during the filling phase showed low activity or unstable urethral relaxation in 15 children (38%), of whom most achieved voluntary anal sphincter contraction by biofeedback training. Nørgaard also reported the inactivated type of electromyography pattern in 58% of children with enuresis.[18] This low activity or unstable urethral relaxation may be due to hypoexcitability of the sphincter nuclei.[19]

It seems important to practice contraction and relaxation of the sphincters during biofeedback training because it is effective not only to avoid muscle fatigue, but also to recognize and make voluntary use of the pelvic floor muscles. This method may also be effective for detrusor-sphincter dyssynergia.[9, 11] In our study detrusor-sphincter dyssynergia was noted in 2 patients who immediately learned to relax the pelvic floor muscles during voiding. Dyscoordinated voiding was not noted after 6 months of biofeedback training.

As Hellström et al reported, biofeedback training and urodynamic studies are somewhat invasive in younger children, and the most important patient selection criteria are motivation and the ability to learn as well as the willingness to participate in training.[11] Therefore, most of our patients were older and only 3 were younger than 10 years (6, 7 and 8, respectively). Biofeedback training failed in 2 children who were mentally handicapped with an IQ of 48 and 56, respectively, although each was motivated. It is possible that detrusor overactivity is centrally controlled and this form of detrusor overactive contraction is less likely to be controlled by biofeedback. However, the lack of skills and difficulty in understanding the condition seemed to be major factors in the ineffectiveness of biofeedback training in these patients. Thus, intelligence should be considered when selecting patients. Another 2 children who were not cured by biofeedback training only were cured by combined biofeedback training and pelvic floor electrical stimulation. We consider electrical stimulation an effective adjunct for biofeedback training not only because of reflex inhibition of detrusor contractions, but also because of the awareness of pelvic floor muscle contractions.[20]

CONCLUSIONS

Biofeedback training was effective in children with urinary incontinence due to detrusor overactivity refractory to conventional treatment. Motivation, the ability to learn and willingness to participate in biofeedback training as well as intelligence are important patient selection criteria.

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EDITORIAL COMMENT

The authors report an approach to managing refractory incontinence secondary to detrusor overactivity using an invasive technique that was effective in the majority of patients studied. It is based on a long-standing belief that isolated contraction of the pelvic floor muscles may cause an inhibitory reflex that may result in the correction of detrusor overactivity with time (reference 12 in article). Furthermore, neuroplasticity secondary to persistent, low frequency stimulation of afferent neurons has an inhibitory effect on the dorsal horn and may explain why electrical stimulation and this treatment method are effective.[1]

In this study many children underwent invasive treatment. Some patients underwent 14 months of treatment. The importance of this series is not the technique used, but rather the information obtained using these techniques. It is unlikely that I would convince any patient with complete sensation to agree to these methods when simpler, less invasive alternatives are available.

The results obtained reinforce the movement to incorporate muscle retraining and isolation for treating children with voiding dysfunction. The majority of such children present with incontinence but those with recurrent urinary tract infection and vesicoureteral reflux with voiding dysfunction do not always have incontinence. It is important to evaluate and treat those patients as well. The authors treated the most refractory cases of low to normal bladder capacity, minimal pelvic floor dysfunction and detrusor overactivity. The other broad categories that we treat include clear pelvic floor hyperactivity, which is most common, pelvic floor laxity and low or staccato flow with minimal pelvic floor hyperactivity. We have not used the techniques presented but have had similar results with our methods.

The program that we use is based on certain principles.[2] We use the least invasive method to effect cure and escalate treatment until there is a cure. We seldom perform complete urodynamics when evaluating these patients. After excluding likely neurological causes we start with a conservative program that includes increased fluids, timed voiding and constipation correction. Depending on how much time parents concentrate on this program there is a 10% to 20% cure rate. If this initial program fails, children are evaluated radiologically, followed by a simultaneous noninvasive flow study, electromyography and ultrasound of post-void residual urine volume. They then undergo computer assisted pelvic muscle retraining directed toward correcting hyperactive muscle function or muscle laxity, or toward developing the inhibitory reflex method to correct bladder instability. In addition, we continue to encourage the medical program. This approach results in sustained improvement in 80% of patients, meaning that of those who present initially only 16% are not cured. In this remaining subgroup we initiate anticholinergics or an α-blocker while maintaining refresher muscle retraining. We also perform magnetic resonance imaging in select cases. This more conservative approach has resulted in almost completely successful treatment.

This report strengthens the argument for muscle isolation training even in patients without clear pelvic muscle laxity or hyperactivity as well as for longer treatment regimens in those with bladder instability. It is clear from our experience that complete urodynamics are only indicated in a minority of patients with voiding dysfunction in whom conservative treatment fails. This minority probably represents less than 5% of those who present with voiding dysfunction.

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REPLY BY AUTHORS

We agree that invasive urodynamics and our technique of biofeedback are not indicated in all children with urinary incontinence. As we have stated, our cases included incontinence refractory to conservative treatments, which accounted for 10% of the total incontinent series. We also excluded patients from study with suspected neurogenic bladder, recurrent urinary tract infection and suspected dysfunctional voiding with abnormal urinary flow. Invasive biofeedback has been indicated for only patients who are motivated and willing to participate in this therapy. Thus, most of our patients completed the biofeedback training therapy and only 4 were lost to followup.