

ABDOMINAL WALL ELECTROMYOGRAPHY: A NONINVASIVE TECHNIQUE TO IMPROVE PEDIATRIC URODYNAMIC ACCURACY

STEPHEN A. KOFF AND EVAN J. KASS*

From the Section of Urology, Department of Surgery, University of Michigan Medical Center and C. S. Mott Children's Hospital, Ann Arbor, Michigan

ABSTRACT

Abdominal wall electromyography, using sticky surface patch electrodes placed on the rectus abdominus muscles, was used during noninvasive urodynamic studies in 60 children to detect straining. Straining, which usually was imperceptible to the examiner, occurred in 64 per cent of neurologically normal children. Urodynamics identified detrusor-sphincter dyssynergia during straining to void but reverted to normal when the same children voided without straining. Because the urodynamic findings that characterize detrusor-sphincter dyssynergia are mimicked by straining and other common urologic entities, the potential for misdiagnosis is great unless some assessment of intra-abdominal pressure is made during neuourologic testing.

With the proliferation of noninvasive pediatric oriented urodynamic techniques has come the suspicion that detrusor-sphincter incoordination is a major cause of urologic dysfunction in children. However, because dyssynergia can be mimicked by other conditions, such as straining and uninhibited detrusor contractions, these conditions must be detected to ensure urodynamic accuracy. The usual approach in adults to identify straining during voiding and to confirm uninhibited bladder contractions during cystometry involves a rectal balloon to measure intra-abdominal pressure. However, in children this technique is often incompatible with normal and natural micturition, especially when studies are performed while the patient is awake. Herein we describe a totally noninvasive method for assessing abdominal wall muscular activity using electromyography and present our experience with this technique in the urodynamic study of 60 children with voiding disturbances.

MATERIALS AND METHODS

Urodynamic testing was done in 39 girls and 21 boys between 6 months and 20 years old (mean age 9.3 years). All patients had symptoms of voiding dysfunction, including diurnal enuresis, precipitate micturition, incontinence and weak or interrupted streams, and/or recurrent urinary tract infections. Vesicoureteral reflux was present in 16 children and 5 had either congenital (myelodysplasia) or acquired spinal cord injury.

A standard urodynamic protocol was adopted to test separately bladder filling and emptying. Urotropic drugs were stopped 24 hours before investigations and premedication was not used. Two disposable infant electrocardiogram electrodes, which are pre-jelled and self-adhering, are placed perianally in approximately the 10 and 2 o'clock positions.¹ Two similar adult electrocardiogram electrodes are placed on the anterior abdominal wall over the lower rectus abdominis muscles, and a third reference electrode is placed on the lateral abdominal wall. In some older patients hair must be removed to afford better electrode adherence. The patient is then asked to cough, strain down and squeeze the perineum to confirm satisfactory electrode placement and recording. In addition to recording abdominal wall muscular activity, the abdominal electrodes also monitor electrocardiogram activity, which is easily distinguished from the electromyographic tracing. Next, the child is in-

structed to void into the uroflowmeter,[†] either standing or sitting, with simultaneous recording of electromyographic activity of the abdominal and perineal muscles as well as the uroflow rate on a TECA TE4 multichannel recording electromyograph.[‡] If straining, evidenced by increased abdominal wall electromyographic activity, is noted during voiding, the child is asked to stop voiding and to try again to void without straining (fig. 1).

Upon completion of the voiding study the patient is transferred with electrodes in place to an examining table and a 10F urethral catheter is inserted in the bladder. With a carbon dioxide cystometer[§] and the recording electromyograph, combined cystometry, and perineal and abdominal wall electromyography is performed. To test for uninhibited contractions the patient is specifically instructed not to void during bladder filling. After completing the cystometric studies, those patients in whom the voiding examination was either incomplete or associated with straining are restudied by uroflowmetry and electromyography after filling the bladder with saline. At the conclusion of urodynamic testing each patient is anesthetized for cystoscopy.

To assess the significance of increased abdominal wall electromyographic activity 7 children were studied simultaneously with a rectal balloon to monitor intra-abdominal pressures during urodynamic testing.

RESULTS

The surface patch electrodes were applied successfully in all cases and, in each instance, voluntary contraction of the perineal and abdominal wall muscles confirmed electrode position and produced an increase in the respective electromyographic activities. Differences in the pattern of muscular activation were observed during Valsalva type maneuvers (such as coughing and bearing down), which usually produced a simultaneous increase in perineal and abdominal wall electromyographic activity compared to perineal tightening, which typically caused only a response in perineal electromyography. In children studied simultaneously with rectal balloon pressure measurements elevation in rectal pressure was observed in all cases whenever abdominal electromyography indicated activation of the abdominal wall musculature (fig. 2).

In tests of bladder emptying 56 of 60 children (93 per cent) voided successfully into the uroflowmeter on ≥ 1 occasions. Of 23 children who voided to completion (residual urine <25 cc)

[†] American Medical Systems Model N7520B, Minneapolis, Minnesota.

[‡] TECA Corp., White Plains, New York.

[§] Modern Controls, Inc., Minneapolis, Minnesota.

Accepted for publication July 1, 1981.

Read at annual meeting of American Urological Association, Boston, Massachusetts, May 10-14, 1981.

* Current address: Children's Hospital National Medical Center, 111 Michigan Ave., N. W., Washington, D. C. 20010.



FIG. 1. Location of electrodes with patient sitting on uroflowmeter

without straining 20 demonstrated normal detrusor-sphincter coordination with silencing of perineal muscle electromyographic activity (fig. 3). The remaining 33 children (59 per cent) demonstrated straining with increased abdominal wall electromyographic activity during voiding (fig. 4). In 32 cases the perineal electromyographic activity increased simultaneously with voiding and defined detrusor-sphincter incoordination or dyssynergia. If the pattern of straining and sphincter constriction was continuous low uroflow rates generally were observed, whereas if the straining and sphincter constriction were intermittent a stuttering urinary stream occurred. Of the 33 children who voided by straining 26 (79 per cent) were coaxed to void without straining whereupon they demonstrated completely normal detrusor-sphincter coordination with silent perineal electromyography and a normal stream (fig. 4). In total 47 children ultimately voided with normal detrusor-sphincter synergy, while 9 demonstrated persistent dyssynergia. Of these 9 patients with bladder-sphincter incoordination 4 had neurogenic bladder disease and were uncoordinated without straining, 3 were <4 years old and 2 had severe uninhibited bladder dysfunction. In no neurologically normal child in this series did detrusor-sphincter dyssynergia occur during voiding without straining.

Assessment of bladder and sphincter function during bladder filling was performed successfully in 59 children using combined cystometry, and perineal and abdominal surface patch electro-

myography. The results are recorded in the table. In each of 15 children with uninhibited bladders detrusor-sphincter dyssynergia occurred whenever the child voluntarily constricted the perineal sphincter muscles during bladder contraction in an attempt to maintain continence. Simultaneous abdominal and perineal electromyography confirmed the voluntary nature of the sphincteric constriction in these patients and proved that the uninhibited contractions occurred without straining (fig. 5).

Whenever straining during voiding was detected by electromyography we attempted to identify any visible clue (such as breath holding, bearing down or flushing) that would suggest straining. Each child appeared to strain in his own peculiar manner which, except in patients with myelodysplasia, was rarely if ever perceptible to the examiner.

In no patient was evidence of bladder outflow or urethral obstruction observed at endoscopy.

DISCUSSION

The trend in pediatric urodynamics is toward noninvasive techniques that permit a more physiologic assessment of the way children actually void, while still faithfully reproducing important neurourologic relationships. In pursuing this goal Firlit and others have popularized the technique of combined uroflowmetry and surface patch perineal electromyography, and have identified a variety of apparent abnormalities of bladder and sphincter coordination in children.²⁻⁴ While this methodology represents a significant advance, one must be cautious with interpretation because uroflowmetry merely records the end result of urinary propulsive forces and does not differentiate detrusor contraction from straining to void with increased intra-abdominal pressure as the voiding mechanism. Likewise, constriction of the urinary sphincter during voiding is truly a pathologic process (detrusor-sphincter dyssynergia,

NORMAL CHILD

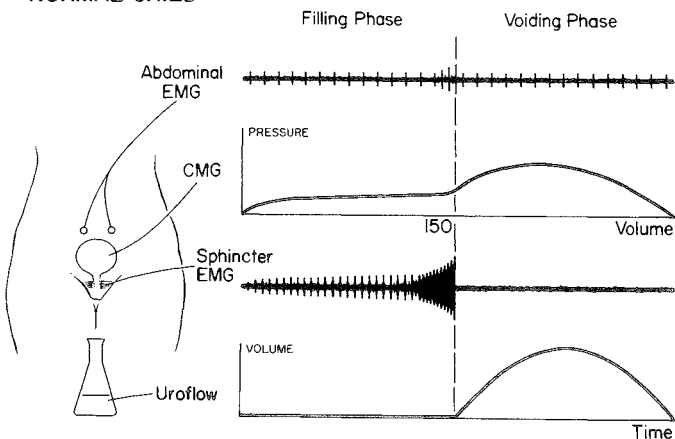


FIG. 3. Urodynamic findings of normal child during bladder filling and emptying.

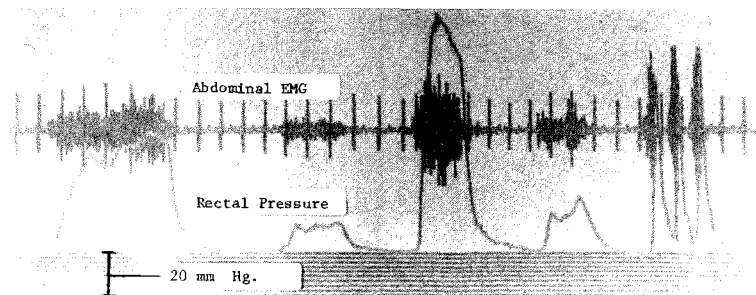


FIG. 2. Simultaneous tracing of abdominal wall electromyography and rectal pressure demonstrates concordant response with varying degrees of straining.

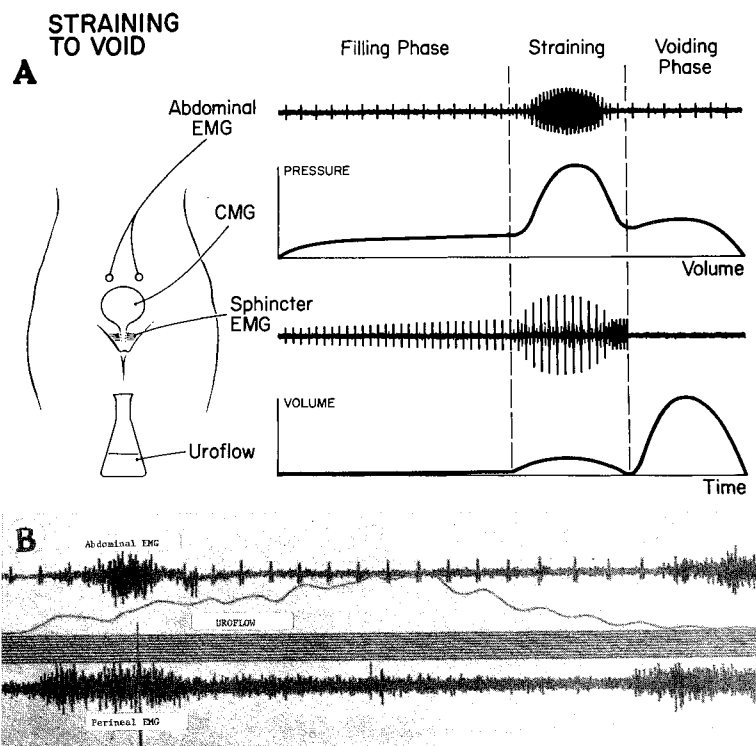


FIG. 4. A, urodynamic findings during straining to void demonstrate increased abdominal and perineal electromyographic activity with weak stream. Without straining voiding proceeds normally. B, actual tracing of child who initially strains and is asked to stop straining during voiding. Note simultaneous activation of abdominal and perineal electromyographs, and low uroflow rate during straining. Without assessment of abdominal wall activity, tracing would be indistinguishable from detrusor-sphincter dyssynergia.

Urodynamic results during bladder filling

Diagnosis	No. Pts.
Normal	33
Uninhibited bladder with voluntary sphincter constriction	15
Large capacity bladder	5
Neurogenic bladder	5
Decompensated bladder	1

UNINHIBITED BLADDER SPHINCTER CONTROL

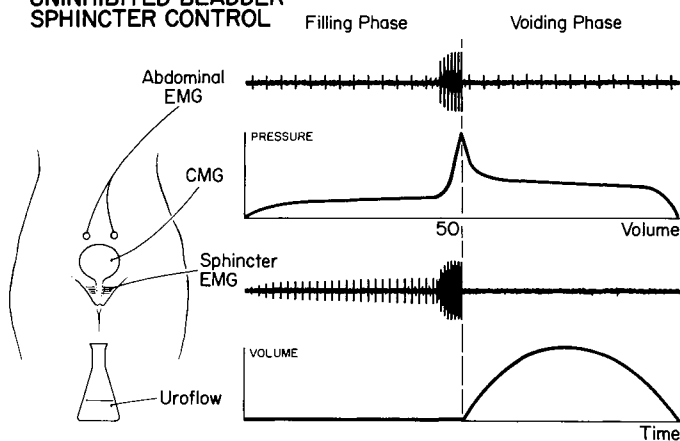


FIG. 5. Urodynamic findings with uninhibited contraction and voluntary sphincter constriction.

fig. 6) but sphincter constriction during straining is normal and simply reflects reflex activation of the periurethral muscles in response to increased intra-abdominal pressure. Therefore, the detection of straining during voiding is important in pediatric urodynamics because if it is not recognized the activity of the urinary sphincter and the coordination between bladder and sphincter may be misinterpreted.

In an attempt to detect straining noninvasively during pediatric urodynamic studies we have developed the technique of abdominal wall surface patch electromyography. The method uses sticky skin electrodes placed over the lower rectus abdominis muscles to monitor abdominal wall contraction (fig. 1). When added to simultaneous uroflowmetry and perineal patch electromyography, it permits a totally noninvasive evaluation of the relationship of abdominal wall muscular activity to the events of micturition and detects straining.

Initially, our impressions were that straining to void was rather uncommon in children and could easily be detected by observing the child. During the course of the study these impressions were proved false as several interesting features of straining during micturition emerged. When neurologically normal children were instructed to strain before voiding, contraction of the abdominal and perineal muscles was observed. Straining during voiding was common in children undergoing urodynamic testing, since they appeared to try to please the examiner by hurrying to initiate and complete voiding. When instructed to void 75 per cent strained to initiate voiding and 64 per cent strained during voiding. Simultaneous contraction of the perineal muscles was demonstrated and associated with low uroflow rates and/or stuttering urinary streams (fig. 4, A). Eventually, almost all children who strained could be coaxed into voiding without straining, whereupon normal coordination between bladder contraction and sphincter relaxation occurred. We observed also that in children straining to void does not involve deep breathing, breath holding, visible bearing down or turning scarlet, and generally is imperceptible even to the trained examiner. Clearly, if abdominal wall electromyography or some other assessment of intra-abdominal pressure had not been performed, the urodynamic findings during straining would have been interpreted as detrusor-sphincter dyssynergia, which obviously would have been an error.

In addition to assessing perineal muscle function during micturition, complete study of the child with suspected vesicourethral dysfunction requires similar examination during bladder

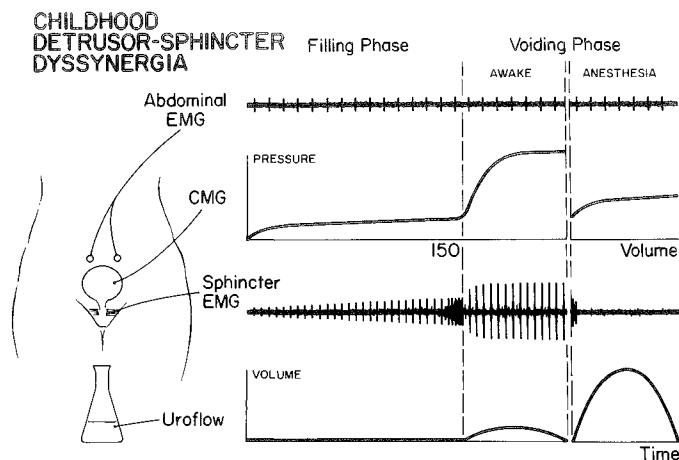


FIG. 6. Urodynamic findings with voluntary detrusor-sphincter dyssynergia. Anesthesia may be used to prove that sphincter constriction is voluntary.

filling. This will identify uncontrolled or uninhibited bladder contractions and will monitor the simultaneous activity and coordination of the periurethral striated muscles. The technique of surface electrode electromyography of the rectus and perineal muscles combined with carbon dioxide cystometry proved useful in studying awake children, and allowed easy identification of uninhibited contractions, documentation of voluntary sphincter constriction during such contractions and separation of both of these events from straining during urodynamic testing (fig. 5). The documentation of voluntary sphincter constriction during uninhibited contractions is important because of associated uropathology⁵ and also because the urodynamic findings are identical to those for the diagnosis of detrusor-sphincter dyssynergia. Therefore, if the conduct of the urodynamic session is not carefully monitored and the involuntary nature of the uninhibited contraction is not appreciated, misdiagnosis can occur.

With the development and widespread use of pediatric oriented urodynamic techniques to assess voiding disturbances in neurologically normal children, a variety of pathologic diagnoses have been proposed (such as internal sphincter dyssynergia,⁶ external sphincter dyssynergia,^{2,7} hyperactive sphincter,³ spastic sphincter^{8,9} and so forth), almost all of which define bladder-sphincter incoordination and require therapies that are at times not harmless. Our experience is contrary and suggests

that the majority of these urodynamic findings are not pathologic and merely reflect the peculiar but normal ways in which children eventually develop urinary control. Having observed apparent detrusor-sphincter dyssynergia in 64 per cent of children, we found that the dyssynergia was actually due to straining and, in fact, did not occur in any neurologically normal child in the absence of straining. This suggests that detrusor-sphincter dyssynergia is a rare occurrence in neurologically normal children and that its diagnosis may be made too often on the basis of incomplete urodynamic data collection or by misdiagnosis of more common urodynamic conditions. Therefore, we contend that the apparent incoordination previously described to exist between the bladder and sphincter in many children who either fail to relax the sphincter during bladder contraction or who have paradoxical sphincter contractions during voiding is artifactual and most often due to unrecognized straining or uninhibited bladder contractions. Since these latter conditions can now be identified and accurately distinguished noninvasively from true dyssynergia, the diagnostic difficulties surrounding these entities in the pediatric patient will, hopefully, lessen.

REFERENCES

1. Barrett, D. M.: Disposable (infant) surface electrocardiogram electrodes in urodynamics: a simultaneous comparative study of electrodes. *J. Urol.*, **124**: 663, 1980.
2. Cook, W. A., Firlit, C. F., Stephens, F. D. and King, L. R.: Techniques and results of urodynamic evaluation of children. *J. Urol.*, **117**: 346, 1977.
3. Firlit, C. F., Smey, P. and King, L. R.: Micturition urodynamic flow studies in children. *J. Urol.*, **119**: 250, 1978.
4. Maizels, M. and Firlit, C. F.: Pediatric urodynamics: a clinical comparison of surface versus needle pelvic floor/external sphincter electromyography. *J. Urol.*, **122**: 518, 1979.
5. Koff, S. A., Lapides, J. and Piazza, D. H.: Association of urinary tract infection and reflux with uninhibited bladder contractions and voluntary sphincteric obstruction. *J. Urol.*, **122**: 373, 1979.
6. Smey, P., King, L. R. and Firlit, C. F.: Dysfunctional voiding in children secondary to internal sphincter dyssynergia: treatment with phenoxybenzamine. *Urol. Clin. N. Amer.*, **7**: 337, 1980.
7. Maizels, M., King, L. R. and Firlit, C. F.: Urodynamic biofeedback: a new approach to treat vesical sphincter dyssynergia. *J. Urol.*, **122**: 205, 1979.
8. Tanagho, E. A., Miller, E. R., Lyon, R. P. and Fisher, R.: Spastic striated external sphincter and urinary tract infection in girls. *Brit. J. Urol.*, **43**: 69, 1971.
9. Tanagho, E. A. and Miller, E. R.: Abnormal voiding and urinary tract infection. *Int. Urol. Nephrol.*, **4**: 165, 1972.