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CORRELATION AMONG CYSTOMETRY, URETHRAL PRESSURE PROFILOMETRY AND PELVIC FLOOR ELECTROMYOGRAPHY IN THE EVALUATION OF FEMALE PATIENTS WITH VOIDING DYSFUNCTION SYMPTOMS

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ABSTRACT

We herein evaluate the correlation among cystometry, urethral pressure profilometry and pelvic floor electromyography in 137 female patients. The predominant symptom was frequency in 40 patients, urge incontinence in 31 and stress incontinence in 66. There appeared to be a correlation between urge incontinence and a hyperreflexic cystometrogram but no correlation was noted between either frequency or stress incontinence and the cystometrogram profile. The urethral pressure profile showed a correlation between stress incontinence and the lowest profile measurements. Frequency and urge incontinence had similar profile measurements except for maximum urethral planimetry. Electromyography showed that the external urethral sphincter had a different finding than the levator ani or the external anal sphincters in all 3 groups of female patients. The external urethral sphincter had a higher percentage of denervation than the other 2 muscles, especially in the stress incontinence group.

The value and relative importance of cystometry, urethral pressure profilometry and pelvic floor electromyography in the evaluation of female patients presenting with frequency, or urge or stress incontinence have yet to be determined. While cystometry is well accepted there is no agreement on the best method nor the value in making a definite diagnosis with urethral pressure profile measurements and with electromyography of the pelvic floor muscles.

We herein compare the results of cystometry, urethral pressure profilometry and pelvic floor electromyography in female patients presenting with frequency, or urge or stress incontinence.

MATERIAL AND METHOD

Of 137 female patients studied the predominate symptom was frequency in 40 patients, urge incontinence in 31 and stress incontinence in 66 patients (table 1). A cystometrogram was done with the patient in the supine and standing positions via a 16F Foley catheter using a Merrill air cystometer. Cystometrograms were repeated at different rates of fill.

For vesical and urethral pressure profile measurements 2, 5F Millar PC 350 Mikro-Tip catheters were used and the distance from the tip of the catheter was marked in centimeters. At first both catheters were passed into the bladder and 1 was fixed in the bladder while the other catheter was withdrawn through the bladder neck, and a urethral pressure profile was obtained with constant withdrawal at 1 mm. per second by mechanical means.

Urethral planimetry was defined as the measurement of the area under the urethral profile extending from the point where the urethral pressure exceeds the bladder pressure and including the area down to the zero base line.

Electromyography of the levator ani, and the external anal and external urethral sphincters was done using Disa coaxial needles. For the levator ani the needle was inserted in the perineum 1 cm. from the midline and 3 to 5 cm. deep (depending on the subcutaneous tissue of the patient). For the external urethral sphincter the second needle was inserted 1.5 cm. deep between the clitoris and the external meatus; previous insertion of the Foley catheter made this placement easier. The third electromyography needle was inserted in the external anal sphincter 1 cm. from the mucocutaneous line and 1 cm. deep. In all 3 insertions the audible recording of active motor neuron firing was used to confirm the correct positioning of the electromyography needle in the required muscle. When the needles were in proper position, reflexly provoked electromyographic activity was registered by pulling on an indwelling Foley catheter, which provided sensory input for pelvic floor muscle contraction. The method of recording the electromyography was 2-fold: 1) visually on a storage oscilloscope with Polaroid camera reproduction of the tracing and 2) acoustically with the loudspeaker. Both modalities gave approximately an equal amount of information and both were taken into consideration in determining the degree of innervation of the muscle studied. The grading of innervation (activity) was classified as normal or slight, moderate or severe degrees of denervation (reduced activity).

RESULTS

The average age of the patients presenting predominately with frequency was 47 years, in patients presenting with urge incontinence it was 47 years and in patients presenting with stress incontinence it was 51 years. The differences were not significant ($p > 0.1$). Student's t distribution test was used for statistical evaluation in this study.

Normal and hyperreflexic profiles were found in equal percentages in the frequency and stress incontinence groups but a hyperreflexic profile was more predominate in the urge incontinence group (table 2 and fig. 1). Postural changes did not affect the cystometric curves of bladder function that were hyperreflexic, flaccid or secondary to bladder wall changes (fibrosis or inflammation). Postural changes did affect normal curves in some patients with a history of micturition disorders and resulted in detrusor instability with the patients in the standing or walking positions (fig. 2).[1]

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The urethral pressure profile measurements are noted in table 3 with the statistical difference between the stress incontinence group and the other 2 groups. Table 4 lists the electromyography findings (fig. 3). There was some denervation of the external urethral sphincter in two-thirds of the patients in each group, while there was some denervation of the levator ani and of the external anal sphincter in only a third of the patients in each group. External urethral sphincter denervation was most marked (88 per cent) in the stress incontinence group. Levator ani denervation was similar in all 3 groups. External anal sphincter denervation was more pronounced in the frequency group.

TABLE 1. *Associated diagnoses*

	Frequency No.	Stress Incontinence No.	Urge Incontinence No.
Postop. (hysterectomy, bladder/urethral suspension)	5	12	0
Central nervous system disease	5	3	6
Spinal cord injury	3	2	3
None	27	49	22
Totals	40	66	31

TABLE 2. *Cystometrogram findings*

	Frequency No. (%)	Stress Incontinence No. (%)	Urge Incontinence No. (%)
Normal	19 (47.5)	29 (44.0)	9 (29.0)
Hyperreflexic	19 (47.5)	28 (42.5)	19 (61.0)
Secondary bladder wall changes	1 (2.5)	2 (3.0)	0
Flaccid	0	6 (9.0)	3 (10.0)
Not done	1 (2.5)	1 (1.5)	0
Totals	40 (100.0)	66 (100.0)	31 (100.0)

DISCUSSION

Cystometry. Gleason and associates compared cystometrograms and urethral profiles with gas and water media techniques in 25 female patients.[2] The cystometrogram data showed a high correlation between gas and water techniques with gas values consistently lower than water values. Urethral profile data with gas were difficult to interpret in terms of water generated data and correlations were tenuous at best.

When a gas cystometer was used in our study there appeared to be a correlation between urge incontinence and a hyperreflexic cystometrogram but no correlation was noted between either frequency or stress incontinence and cystometrogram profile. There was the same percentage of normal and hyperreflexic bladder function in these latter 2 groups.

Our stress incontinent group comprised female patients in whom stress incontinence was the predominant symptom but frequency and/or urge incontinence may have been present to a lesser extent. This fact would account for the 43 per cent incidence of detrusor hyperreflexia in our stress incontinent group, which did not solely consist of simple stress incontinence. The patients with detrusor hyperreflexia should be treated with anticholinergic drugs and the treatment should differ from simple stress incontinent patients with a normal cystometrogram who are candidates for operative correlation.

Techniques of urethral pressure profilometry. Meunier and Mollard compared perfused catheters and microtip transducers in 46 children and found significant differences in the readings obtained by each method.[3] Asmussen compared an open end catheter system with a microtip transducer catheter system in

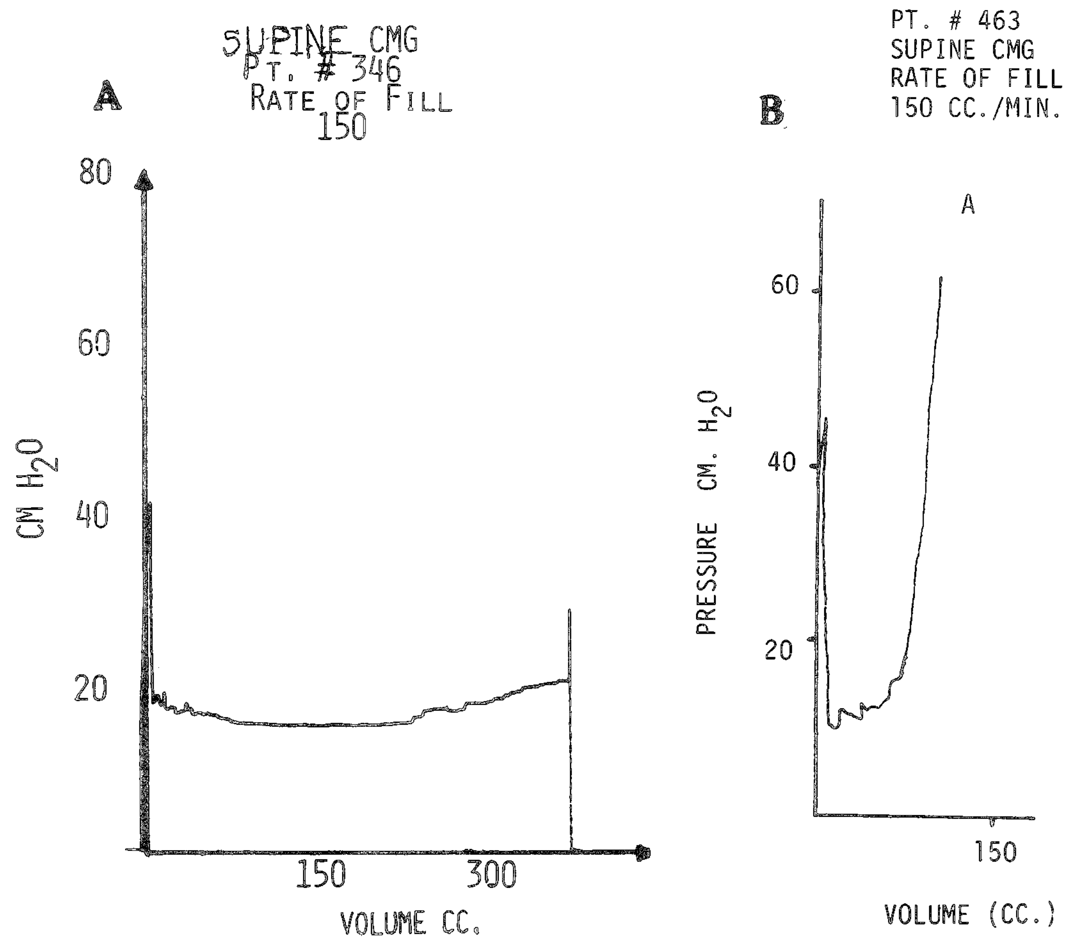

FIG. 1. Cystometrogram tracings. *A*, normal curve. *B*, hyperreflexic curve.

vivo and in vitro under dynamic and static conditions and found the microtip transducer catheter system superior for clinical practice and research.[4] Tscholl and associates found urethral pressure profilometry measurements by carbon dioxide perfusion and by liquid to be similar and recommended the carbon dioxide perfusion method since it is simple, rapid to perform, less expensive and easy to handle.[5] Schmidt and associates compared carbon dioxide perfusion, constant water perfusion and membrane catheter techniques for evaluating in vivo and in vitro urethral pressure profile studies and found the membrane catheter technique to be the best, carbon dioxide to be the worst and water perfusion in between them.[6] Teague and Merrill compared air infusion, water infusion, membrane catheter and transducer tip catheter techniques in a canine model.[7]

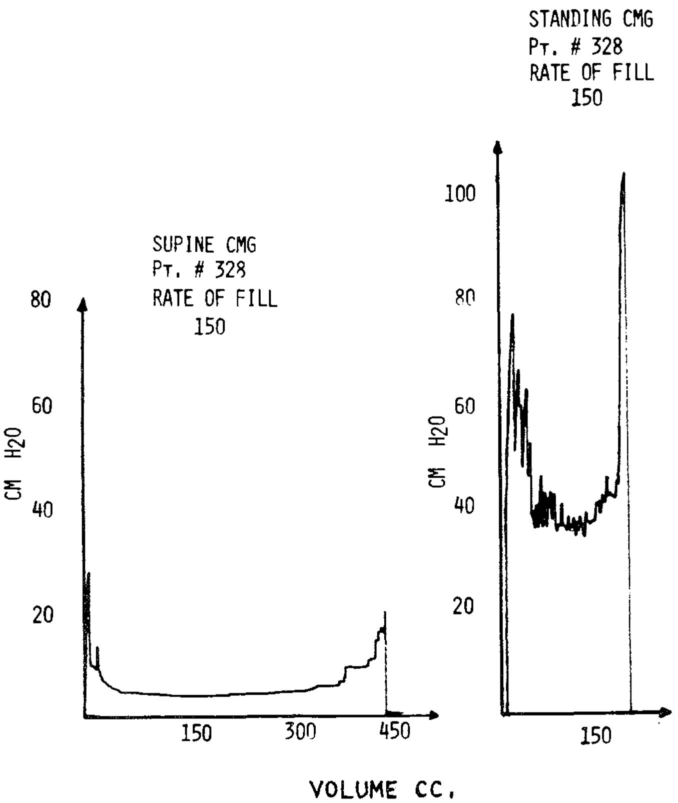

FIG. 2. Cystometrogram in patient 328 shows normal curve with patient in supine position and hyperreflexic curve with patient standing.

They concluded that none of the methods tested will give accurate recordings of urethral pressure in all clinical situations.

Value of urethral pressure profilometry. Meunier and Mollard found urethral pressure profilometry not sufficient to diagnose bladder outlet obstruction.[3] Also, urethral pressure profilometry was of little use in children with low urethral resistance and was not indispensable in routine pediatric urodynamics. Urethral pressure profilometry did have value in preoperative and postoperative urethrotomy or artificial sphincter implantation.[3] Edwards and Malvern evaluated 69 normal women, 55 women with detrusor dysfunction and 103 women with sphincter weakness.[8] These investigators found no significant difference in urethral length between the groups. After surgical repair for incontinence 15 patients were improved symptomatically but only 10 of these were improved visibly in the urethral pressure profilometry.

Harrison reviewed the use of urethral pressure profilometry and concluded that the profile had perhaps fallen short of its expectations as a diagnostic tool.[9] In the investigation of incontinence he believed that the differentiation of detrusor instability from defects of urethral closure remained a fundamental principle. The diagnostic value of the profile in incontinence was blurred by the wide scatter of normal values but a low value, relative to the age of the patient, was strongly suggestive of sphincter deficiency, particularly if there was no detrusor instability. Detrusor instability and sphincter weakness may coexist, and then the profile may provide the only objective evidence of the sphincter weakness.

McGuire studied urethral sphincter function in 56 patients with radiography urethral pressure profilometry and electromyography evaluations, and found that normal urethral closure pressures do not necessarily correlate with perfect urinary control nor do low urethral pressures preclude continence.[10] Højsgaard recorded urethral pressure profilometry in 70 female patients before and after meatotomy.[11] This study did not reveal any significant difference in the amplitude or contour and the urethral pressure profilometry was not a diagnostic aid in deciding whether meatal stenosis is of pathogenic importance in the development of lower urinary tract symptoms in women.

Henriksson and Ulmsten evaluated urethral pressure profilometry in 30 women with stress incontinence before and after surgical repair.[12] While all 30 patients reported continence after the operations minimal changes had occurred in the profile pressures and in the functional length of the urethra (within 3 and 2 mm. Hg). Awad and associates studied the urethral pressure profilometry in 20 women with stress incontinence and 10 controls and concluded that the most useful measurement for diagnostic purposes was the maximum closure pressure with

TABLE 3. *Urethral pressure profile measurements with statistical difference between stress incontinence group and the other 2 groups*

	Frequency (mean ± standard deviation)		Stress Incontinence (mean ± standard deviation)		Urge Incontinence (mean ± standard deviation)
Max. urethral pressure (cm. water)	60.0 ± 24	p >0.1	54.0 ± 28	0.05> p >0.01	67.0 ± 28
Bladder pressure (cm. water)	8.0 ± 6	p <0.01	12.0 ± 6	p >0.1	11.0 ± 7
Max. urethral closure pressure (cm. water)	52.0 ± 30	0.1> p >0.05	42.0 ± 27	0.05> p >0.01	56.0 ± 27
Functional profile length of urethra (mm.)	28.0 ± 6	p <0.01	25.0 ± 7	p >0.1	27.0 ± 7
Max. urethral planimetry (cm.^{2})	7.4 ± 4.0	p >0.1	6.7 ± 4.3	0.05> p >0.01	8.9 ± 4.4

TABLE 4. *Electromyography findings*

	Frequency			Stress Incontinence			Urge Incontinence		
	Levator Ani No. (%)	Urethral Sphincter No. (%)	Ext. Anal Sphincter No. (%)	Levator Ani No. (%)	Ext. Urethral Sphincter No. (%)	Ext. Anal Sphincter No. (%)	Levator Ani No. (%)	Ext. Urethral Sphincter No. (%)	Ext. Anal Sphincter No. (%)
Normal	20 (62)	9 (28)	17 (53)	41 (67.0)	7 (12)	44 (72)	16 (61.5)	9 (35)	17 (65)
Slight denervation	6 (19)	7 (22)	6 (19)	10 (16.5)	5 (8)	9 (15)	7 (27.0)	5 (19)	6 (23)
Moderate denervation	6 (19)	13 (41)	9 (28)	10 (16.5)	43 (70)	8 (13)	3 (11.5)	11 (42)	2 (8)
Severe denervation	0	3 (9)	0	0	6 (10)	0	0	1 (4)	1 (4)
All muscles not done	8	8	8	5	5	5	5	5	5
Totals	40 (100)	40 (100)	40 (100)	66 (100.0)	66 (100)	66 (100)	31 (100.0)	31 (100)	31 (100)

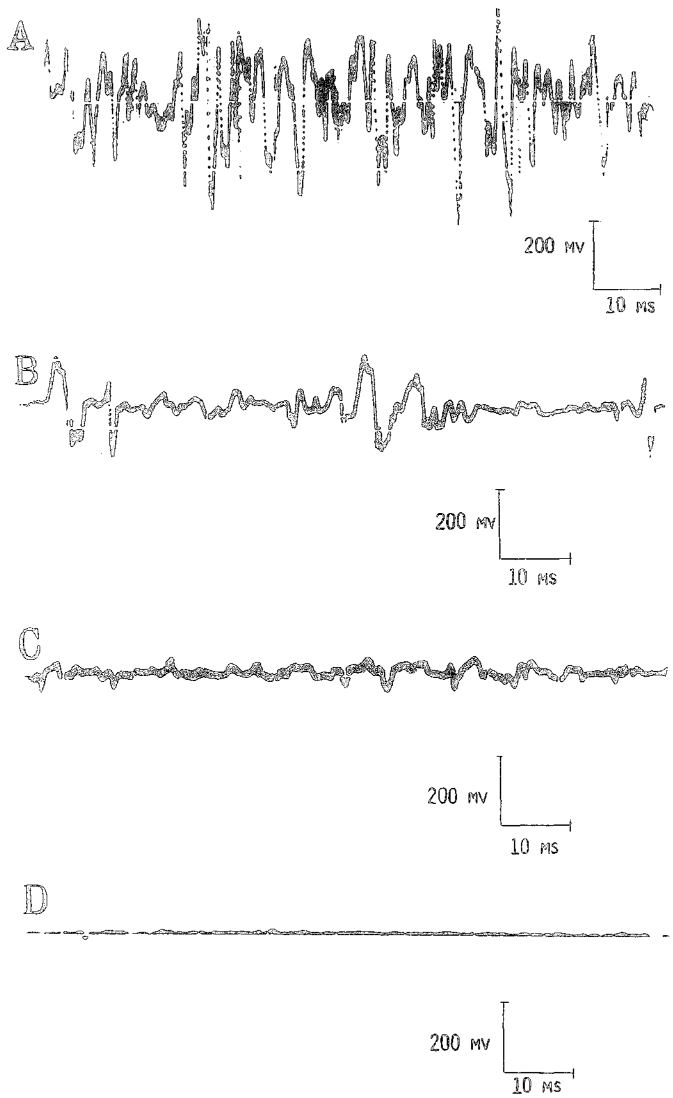

FIG. 3. Reflexly provoked electromyographic activity of external urethral sphincter. *A*, normal innervation. *B*, slight denervation. *C*, moderate denervation. *D*, severe denervation.

a full bladder and the patient standing.[13] The second most useful measurement was the maximum closure pressure with a full bladder and the patient supine.

In our study using terminal microtip transducers the urethral pressure profile showed a correlation between stress incontinence and the lowest profile measurements. This correlation would be expected when the stress incontinence was owing to pelvic floor muscle weakness. The frequency and urge incontinence groups had similar profile measurements except for maximum urethral planimetry, which was increased in the urge incontinence group.

If denervation of the external urethral sphincter is responsible for the reduced urethral pressure profile measurements (others have reported minimal changes in profile pressures in women with stress incontinence after a successful surgical repair), then urethral profilometry is of doubtful value as a preoperative test in stress incontinence.

Anal electromyography has been used as an expression of the activity in the urethral sphincter as the anal and urethral sphincters contract and relax synchronously.[14, 15] However, Vereecken and Verduyn have shown that there is desynchronization and even dyssynergic activity of the various pelvic floor muscles.[16]

Electromyography showed that the external urethral sphincter had a different finding than the levator ani or the external anal sphincter in all groups. Therefore, it cannot be interpreted that the findings in these muscles are interchangeable.

The needle electromyography evaluation is a semiquantitative method and its reading is, to some extent, arbitrary based on the experience of the investigator. The severe degree of denervation is significant clinically, usually is well defined and was found in 10 patients in the external urethral sphincter, in 1 patient in the external anal sphincter and in no patient group levator ani. The slight and moderate degrees of denervation are prone to subjective interpretation.

The external urethral sphincter had a higher percentage of denervation than the levator ani or external anal sphincter. A local operation in the area of the external urethral sphincter, for example hysterectomy, or bladder or urethral suspension, could account for this finding.

External urethral sphincter denervation was more evident in female patients who had had a previous bladder or urethral operation than in those who did not. In the stress incontinent group moderate or severe denervation of the external urethral sphincter was present in 92 per cent of the female patients who had had a previous bladder or urethral operation compared to being present in 78 per cent of those who did not. In the frequency group moderate or severe denervation of the external urethral sphincter was present in 80 per cent of the female patients who had had a previous bladder or urethral operation compared to being present in 44 per cent of those who did not.

The external urethral sphincter denervation was most marked (88 per cent) in the stress incontinence group, which could account for the lowest urethral profile measurements in this group.

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REFERENCES

1. Godec, C. J. and Cass, A. S.: Cystometric variations during postural changes and functional electrical stimulation of the pelvic floor muscles. J. Urol., **123**: 722, 1980.
2. Gleason, D. M., Bottaccini, M. R. and Reilly, R. J.: Comparison of cystometrograms and urethral profiles with gas and water media. Urology, **9**: 155, 1977.
3. Meunier, P. and Mollard, P.: Urethral pressure profile in children: a comparison between perfused catheters and micro-transducers, and a study of the usefulness of urethral pressure profile measurements in children. J. Urol., **120**: 207, 1978.
4. Asmussen, M.: Intraurethral pressure recording. A comparison between tip-transducer catheters and open-end catheters with constant flow. Scand. J. Urol. Nephrol., **10**: 1, 1976.
5. Tscholl, R., Tettamanti, F. and Wörsdörfer, O.: The urethral pressure profile recorded by means of CO_2-perfusion at high flow rates. Brit. J. Urol., **48**: 337, 1976.
6. Schmidt, R. R., Witherow, R. and Tanagho, E. A.: Recording urethral pressure profile: comparison of methods and clinical implications. Urology, **10**: 390, 1977.
7. Teague, C. T. and Merrill, D. C.: Laboratory comparison of urethral profilometry techniques. Urology, **13**: 221, 1978.
8. Edwards, L. and Malvern, J.: Proceedings: studies of intra-urethral pressures in normal and incontinent women. Urol. Int., **29**: 205, 1974.
9. Harrison, N. W.: The urethral pressure profile. Urol. Res., **4**: 95, 1976.
10. McGuire, E. J.: Combined radiographic and manometric assessment of urethral sphincter function. J. Urol., **118**: 632, 1977.
11. Højsgaard, A.: The urethral pressure profile in female patients with meatal stenosis. Scand. J. Urol. Nephrol., **10**: 97, 1976.
12. Henriksson, L. and Ulmsten, U.: A urodynamic evaluation of the effects of abdominal urethrocystopexy and vaginal sling urethroplasty in women with stress incontinence. Amer. J. Obst. Gynec., **131**: 77, 1978.
13. Awad, S. A., Bryniak, S. R., Lowe, P. J., Bruce, A. W. and Twiddy, D. A. S.: Urethral pressure profile in female stress incontinence. J. Urol., **120**: 475, 1978.
14. Bradley, W. E., Timm, G. W. and Scott, F. B.: Sphincter electromyography. Urol. Clin. N. Amer., **1**: 69, 1974.

15. Scott, F. B., Quesada, E. M. and Cardus, D.: The use of combined uroflowmetry, cystometry and electromyography in evaluation of neurogenic bladder dysfunction. In: The Neurogenic Bladder. Edited by S. Boyarsky. Baltimore: The Williams & Wilkins Co., p. 106, 1967.
16. Vereecken, R. L. and Verduyn, H.: The electrical activity of the paraurethral and perineal muscles in normal and pathological conditions. Brit. J. Urol., **42:** 457, 1970.

EDITORIAL COMMENT

In this extensive clinical study the authors compared cystometry, urethral pressure profilometry and pelvic floor electromyography in female subjects who presented with frequency, and urge and stress incontinence. Of the patients who primarily complained of symptoms suggesting stress incontinence 42 per cent were found to have detrusor hyperreflexia and, thus, were candidates for anticholinergic medication rather than surgical therapy. This observation shows the diagnostic value of cystometry in incontinent female patients who present with symptoms suggesting active as well as passive incontinence. The authors do not propose and I do not believe that cystometry or urethral pressure profilometry is of value in female subjects who have straightforward stress incontinence uncomplicated by previous surgical intervention or symptoms suggesting detrusor hyperreflexia.

The data from this study suggest that there is a much higher incidence of pelvic floor denervation in female subjects with urinary incontinence than was suspected previously. Also noteworthy is the observation that denervation was more common in the external urethral sphincter than it was in the other pelvic floor skeletal muscles tested. Although the incidence of denervation was highest (92 per cent) in patients who had had a bladder or urethral operation it also was found commonly (44 per cent) in patients who had not had a regional operation. Possibly, child birth is responsible for denervation in the non-surgically treated patients. In any case, to evaluate the merits of this intriguing clinical observation the incidence of denervation (real or artifactual) in nulliparous women and in postpartum patients who are not incontinent must be determined.

Since there was little correlation among the electromyography recordings of the pelvic floor muscles tested the authors conclude that the electromyographic activity from the external urethral, external anal and levator ani muscles is not interchangeable. This conclusion seems to be justified in the patient population studied. We also have found that the electromyography recordings vary in patients with multiple sclerosis. However, the electromyography recordings from the various pelvic floor muscles in the normal male subjects we have studied have been similar in appearance. Thus, I concluded that the variations in electromyographic activity recorded in incontinent female subjects and multiple sclerotic patients represent changes induced by disease rather than a difference in the floor muscular innervation.

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