0022-5347/86/1365-1026$02.00/0
THE JOURNAL OF UROLOGY
Vol. 136, November

Printed in U.S.A.

EVALUATION OF ERECTILE DYSFUNCTION WITH CONTINUOUS MONITORING OF PENILE RIGIDITY

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ABSTRACT

Measurement of nocturnal penile tumescence or circumferential expansion is a valuable method for the diagnosis of erectile impotence. However, only a few investigations have been made of penile rigidity during tumescence with a single isolated measurement. A new method of continuous and simultaneous recording of nocturnal penile rigidity and circumferential expansion (tumescence) was used in 105 patients with erectile impotence. The method provided several findings concerning nocturnal penile erection. Circumferential expansion was not always accompanied by penile rigidity. A dissociation of rigidity between the tip and base of the penis was observed in some patients. Shortened episodes and low amplitude of rigidity also were seen. Of 11 patients with psychogenic impotence diagnosed by conventional methods 3 (27.3 per cent) showed abnormal nocturnal rigidity and 8 of 94 (8.5 per cent) with organic impotence diagnosed by conventional methods showed normal nocturnal rigidity. Because of its ambulatory character the continuous measurement of nocturnal penile rigidity is of value in defining features of nocturnal penile erection and differentiating psychogenic from organic impotence.

After the documentation of nocturnal penile erection by Halverson,[1] and Ohlmeyer and associates,[2] many investigations have been performed using penile tumescence during sleep. Karacan and associates recorded nocturnal penile tumescence and demonstrated that this event was a general phenomenon in healthy male subjects 3 to 79 years old, and could be used to distinguish psychogenic from organic impotence.[3] However, Fisher and associates found varying degrees of impairment of nocturnal penile tumescence without apparent organic disease in 15 to 20 per cent of the subjects.[4] Since tumescence only expresses penile erection as circumferential expansion and does not measure penile rigidity, it subsequently has been appreciated that penile rigidity would be the more appropriate measurement. We report the clinical results of a new method for continuous monitoring of penile rigidity and circumferential expansion during sleep.

MATERIALS AND METHODS

The study was done on 105 patients with erectile impotence admitted to our medical center between September 1984 and May 1985. All patients were evaluated by careful general physical and neurological history and examination. Psychological examination also was performed by a neuropsychologist. The patients underwent tests to measure the nerve conduction velocity of the posterior tibial nerve, sural nerve and dorsal nerve of the penis, and the latency of the bulbocavernosus reflex. In the nerve conduction velocity test of the dorsal nerve of the penis conduction velocity was calculated at the take-off and first negative peak of the potential. Cortical and spinal evoked potentials also were recorded with stimulation of the posterior tibial nerve and dorsal nerve of the penis. The penile blood pressure was measured at one of the dorsal arteries and at the bilateral deep arteries of the penis. The penile brachial index was calculated by dividing an average value of the 3 penile blood pressures by the brachial arterial pressure.

The subjects were classified carefully into those with no apparent disorders or psychogenic impotence (11) and those with organic impotence (94). The organic impotence group was subdivided into patients with noninsulin-dependent diabetes mellitus (21), insulin-dependent diabetes mellitus (14), cardiovascular disorders (29), neurological diseases (15), Peyronie's disease (3), alcoholism (5) and malignant tumors (7). Cardiovascular disorders included hypertension, arteriosclerosis and ischemic heart disease. The neurological diseases consisted of Parkinson's disease (4 patients), epilepsy (3), cerebrovascular disease (3), sleep apnea (2), multiple sclerosis (2) and progressive ataxia (1).

A commercially available system* was used for continuous and simultaneous monitoring of penile rigidity and circumferential expansion of the penis. The device consisted of an ambulatory data recording unit and a microcomputer system. The ambulatory unit had 2 recording loops that were applied at the base and tip (or 5 to 10 mm. proximal to the corona) of the penis, respectively, similar to nocturnal penile tumescence measurement. The loops were fitted automatically with a minimum force by initial operation of the unit. Each loop was connected to a sensor in the body of the ambulatory unit, which was able to measure and to record rigidity and circumferential change of the penis for as long as 10 hours on a memory chip. The device was fixed firmly to the thigh or abdomen by a large self-adhesive band. By tightening with a 12 ounce force the sensor measured linear displacement of the loop and calculated the rigidity. The rigidity was expressed as a percentage, with 100 per cent indicating a solid rod that showed no linear displacement of the loop. The circumferential expansion or tumescence was expressed in cm. The test was performed during 3 consecutive nights. The analysis of the results was limited to the test of the system.

RESULTS

Among several episodes of rigidity and circumferential expansion in 3 consecutive days, a maximum rigidity and circumferential expansion lasting more than 10 minutes were selected arbitrarily as an index of individual rigidity and circumferential expansion for quantitative analysis. Careful observation of rigidity and circumferential expansion in the subjects revealed several things. A normal finding, consisting of high amplitude of rigidity in the tip and base of the penis (fig. 1), was seen in

Accepted for publication May 2, 1986.

* Rigiscan, Dacomed Corp., Minneapolis, Minnesota.

16 patients (15.2 per cent). These patients usually showed several episodes of augmentation of penile rigidity and circumferential expansion with the frequency and duration of the episodes dependent upon the night of the test. Circumferential expansion was observed simultaneously with an increase of rigidity. However, the degree of circumferential expansion was not always in proportion to the degree of rigidity. There were 5 abnormal findings: 1) dissociation of rigidity between the tip and base of the penis, in which case rigidity at 1 of 2 loops on the penis showed low amplitude even though rigidity at another loop was of high amplitude (fig. 2, *A*), 2) uncoupling between rigidity and circumferential expansion in which rigidity showed low amplitude when circumferential expansion was of high amplitude (fig. 2, *B*), 3) shortened episodes of rigidity with augmentation of rigidity lasting less than 10 minutes despite high amplitude (fig. 3, *A*), 4) low amplitude of rigidity (fig. 3, *B*), and 5) no episodes of rigidity and circumferential expansion (fig. 4). Abnormal findings were noted in 89 patients (84.8 per cent) (tables 1 and 2).

Some patients complained of sleep disturbance during the first night of the test. This problem became minimal during days 2 and 3 of the test.

Psychogenic impotence diagnosed by conventional methods. Abnormal findings were observed with use of the device in 3 of 11 patients (27.3 per cent) with psychogenic impotence diagnosed by conventional methods. Two patients had shortened episodes and low amplitude of rigidity, and 1 had dissociation of rigidity between the tip and base of the penis, and shortened episodes of rigidity.

Organic impotence diagnosed by conventional methods. Of 94 subjects with organic impotence diagnosed by conventional methods 8 (8.5 per cent) had normal rigidity and circumferential expansion. Of these 8 patients 7 were diagnosed finally as having psychogenic impotence. In 1 patient with Peyronie's disease, a normal nerve conduction velocity of the dorsal nerve

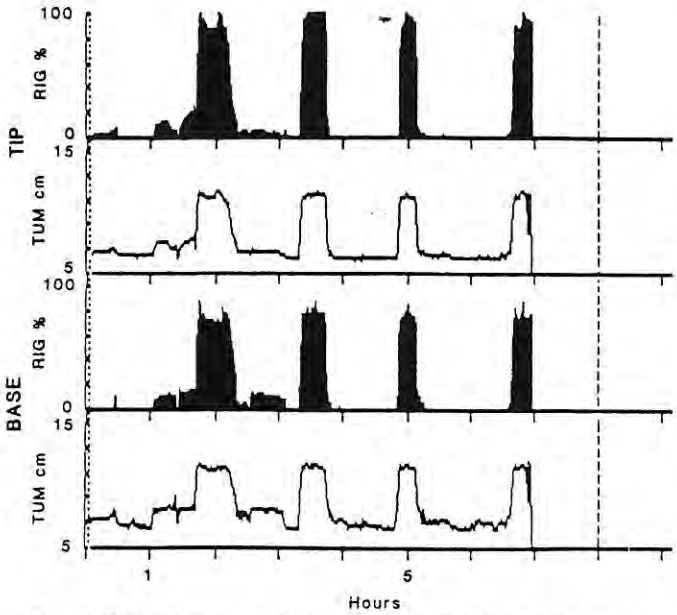

FIG. 1. Normal trace of rigidity (*RIG*) and circumferential expansion (*TUM*).

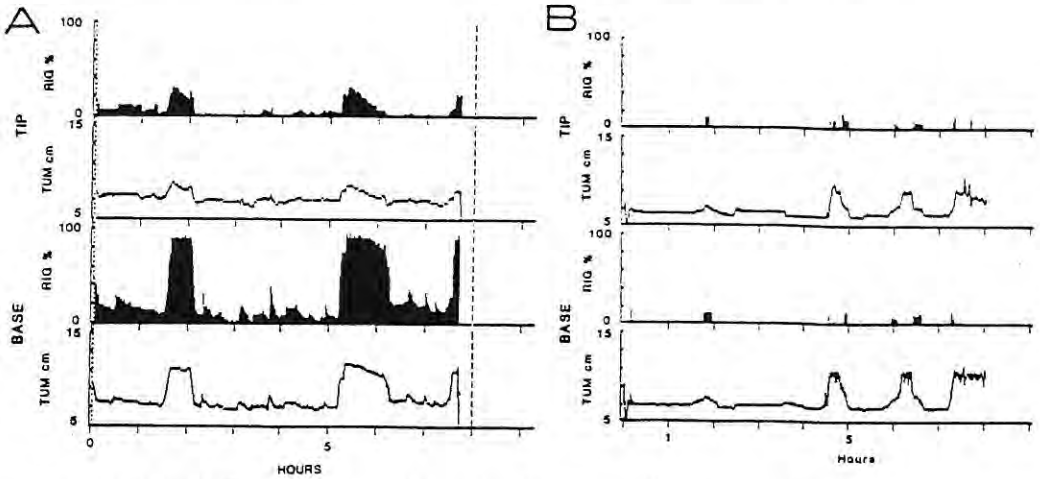

FIG. 2. *A*, dissociation of rigidity (*RIG*) between tip and base of penis. *B*, uncoupling between rigidity (*RIG*) and circumferential expansion (*TUM*).

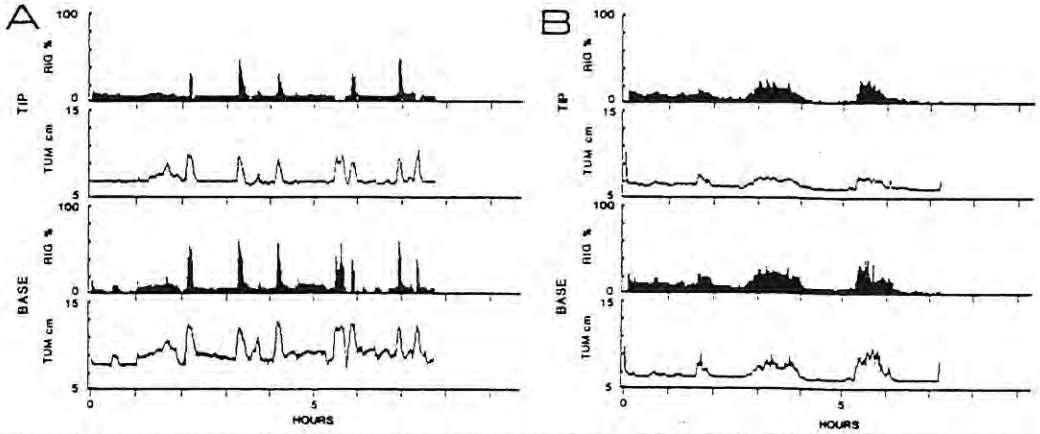

FIG. 3. *A*, shortened episodes of rigidity (*RIG*). *B*, low amplitude of rigidity (*RIG*). *TUM*, circumferential expansion

of the penis and a normal penile brachial index the impotence was owing to distortion of the penis during erection. The other 2 patients with Peyronie's disease had a slow nerve conduction velocity of the dorsal nerve of the penis and one had a low penile brachial index. Abnormal findings of the device were seen in 86 patients (91.5 per cent) with organic impotence diagnosed by conventional methods. Dissociation of rigidity between the tip and base was observed in 32 patients, uncoupling between rigidity and circumferential expansion was noted in 3, shortened episodes of rigidity occurred in 32, low amplitude of rigidity was seen in 36, and no episodes of rigidity and circumferential expansion were noted in 34.

Quantitative analysis of the system. A quantitative analysis was done on 4 factors: circumferential expansion at the base and tip of the penis (41 ± 13 and 28 ± 7 mm., respectively, in the normal group), and rigidity at the base and tip of the penis (76 ± 17 per cent and 63 ± 16 per cent, respectively, in the normal group). All of these values were significantly different from those of the abnormal group (table 2).

DISCUSSION

Evaluation of nocturnal penile erection has been valuable for the differentiation of organic from psychogenic impotence.[5] Many investigations have been made by measuring tumescence or circumferential expansion of the penis instead of evaluating rigidity, which previously has been difficult to measure. However, the use of the snap-gauge band illustrated that circumferential expansion was not a reliable indication of penile erection.[6] The uncoupling between rigidity and circumferential expansion in this study has indicated clearly that circumferential expansion is not always associated with an increase in rigidity.

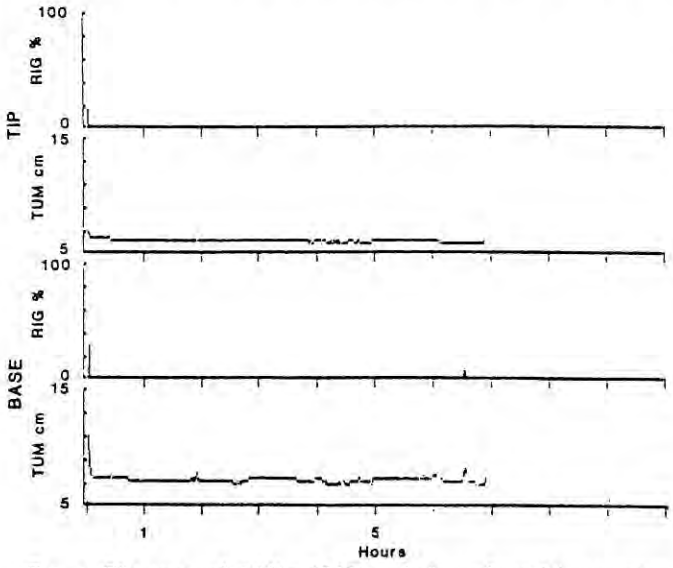

FIG. 4. Flat trace of rigidity (*RIG*) and circumferential expansion (*TUM*).

Nocturnal circumferential expansion of the penis has a wide range of normal values.[3,4] Normal values of circumferential expansion of the penis may not mean full erection for some men and circumferential expansion below normal values may be enough for full erection in others. Furthermore, rigidity increases greatly after circumferential expansion almost attains the maximum value. Therefore, measurement of rigidity is necessary to understand impotence. Because of the ambulatory character and capability of the monitoring system of continuous recording during sleep patients and examiners are freed of troublesome direct observation of penile rigidity.

Continuous monitoring of nocturnal penile rigidity and circumferential expansion enabled correction of the initial diagnosis from psychogenic to organic impotence in 3 of 11 patients (27.3 per cent) and from organic to psychogenic impotence in 7 of 94 (7.4 per cent). A high rate of abnormal rigidity in the patients with psychogenic impotence diagnosed by conventional methods has proved the crucial importance of this method to differentiate organic impotence from so-called psychogenic impotence, in which case no abnormality is detected by a series of conventional examinations.

Since nocturnal penile tumescence is affected by aging penile rigidity also is expected to vary depending on age. The frequency, duration and amplitude of rigid episodes may vary after the patient is 50 years old. The continuous and simultaneous monitoring of penile rigidity and circumferential expansion is expected to have great benefit in clarification of normal features of erection associated with age and in differentiation of psychogenic from organic impotence.

The etiology of impotence frequently is multiple. Some of the causes include penile neuropathy,[7] penile vascular disease,[8] neurological disease,[9,10] Peyronie's disease and pharmacological effects.[11] Whether these etiologies produce significant erectile impairment can be assessed only by continuous monitoring of penile rigidity.

TABLE 2. *Analysis of rigidity and circumferential expansion*

	Normal	Abnormal	P Value
No. pts.	16	89	—
Circumferential expansion (mm.):			
Base	41 ± 13	18 ± 13	<0.001
Tip	28 ± 7	12 ± 10	<0.001
Rigidity (%):			
Base	76 ± 17	29 ± 17	<0.001
Tip	63 ± 16	24 ± 13	<0.001

Calculated with values at maximum amplitude lasting more than 10 minutes (mean ± standard deviation).

TABLE 1. *Results of tests*

Conventional Diagnosis	Age (mean ± standard deviation)	Device Results (No. pts.)						
		Normal	Abnormal	Abnormal Findings*				
				A	B	C	D	E
Psychogenic impotence	58 ± 10	8	3	1	0	3	2	0
Organic impotence:	60 ± 7	8	86	32	3	32	36	34
Noninsulin-dependent diabetes mellitus	60 ± 5	0	21	9	0	8	10	8
Insulin-dependent diabetes mellitus	55 ± 9	0	14	1	0	3	3	10
Cardiovascular disorders	62 ± 7	3	26	11	2	7	12	10
Neurological diseases	58 ± 8	3	12	7	1	9	7	1
Peyronie's disease	61 ± 4	1	2	1	0	0	0	1
Alcoholism	56 ± 9	1	4	1	0	1	1	1
Malignant tumors	62 ± 3	0	7	2	0	4	3	3
Totals	59 ± 7	16	89	33	3	35	38	34

* A—dissociation between tip and base, B—uncoupling between rigidity and circumferential expansion, C—shortened episodes of rigidity, D—low amplitude of rigidity and E—no episode of rigidity and circumferential expansion.

Sue Reininger provided technical assistance in this investigation.

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EDITORIAL COMMENT

This method of continuous penile monitoring represents a "high-tech" addition to the diagnostic evaluation of impotence. Compared to conventional nocturnal penile tumescence monitoring the most significant feature of the method is the ability to record rigidity and circumference. The subgroup B in figure 4 (uncoupling between rigidity and circumferential expansion) would represent this added value. However, I can see only 3 of the 105 patients who showed "uncoupling".

In these days of dollar consciousness most of the practitioners will ask whether it is an indispensible investment. After all, even if all the data are perfect the test can only determine whether the patient has organic or psychogenic impotence. Additional tests still are required to make further differentiation between the various types of organic impotence.

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REPLY BY AUTHORS

The most significant feature of continuous penile rigidity monitoring is the capability of differentiating between organic and psychogenic impotence when organic impotence is manifested by penile softening. If this is the only positive feature of this method it is an important one, since psychogenic disability frequently accompanies organic impotence. However, an additional advantage of this methodology includes the capacity to define different forms of erectile abnormality in different diseases. The most significant of these are dissociation with distal softening in the penile shaft and reduction in maximum penile rigidity in all areas of the penile shaft. Any further evaluation of etiology rests upon the validity of the initial determination of impairment of erectile function.