

Pudendal Somatosensory Evoked Potential and Bulbocavernosus Reflex Testing in Erectile Dysfunction

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Pudendal somatosensory evoked potential (PSEP) and bulbocavernosus reflex (BCR) testing have been reported to be useful in the evaluation of erectile dysfunction and neurogenic bladder. 461 patients with sexual dysfunction were studied to determine the usefulness of the above tests. Abnormality of PSEP was found significantly in upper motor neuron (UMN) type spinal cord patients and average prolonged P1 latency was 47.4 ± 9.8 msec. Lower motor neuron (LMN) type spinal cord patients revealed great abnormality in BCR latency with an average value of 44.9 ± 14.5 msec on the right and 44.2 ± 15.6 msec on the left. Additionally significant differences were obtained in patients with diabetes mellitus, pelvic trauma and spinal cord lesion of the UMN type in the study of PSEP. There was also a significant difference in the patients with diabetes mellitus, pelvic trauma and spinal cord lesion of the LMN type in the BCR study. The findings of our study suggest that PSEP together with BCR study is useful in assessing the integrity of the sacral reflex arc and the central afferent pathway, in differentiating the lesion site and in providing basic data for the management plan in sexual rehabilitation. Furthermore, because erection is under the influence of both the somatic and autonomic nervous system, BCR study and PSEP combined with currently studied electrical activity of the corpus cavernosum would provide a more accurate evaluation of the neurogenic erectile dysfunction patients.

Key Words: Bulbocavernosus reflex latency, pudendal somatosensory evoked potential, erectile dysfunction

The main causes of erectile dysfunction are classified as neurological, psychological, vascular, and endocrine origin. Some objective tools have been used in order to differentiate the nature of erectile dysfunction. In the evaluation of patients for neurological sexual dysfunction, several methods are being used. Among these, penile biothesiometry, bulbocavernosus reflex (BCR) study and pudendal somatosensory evoked potential (PSEP) are used in the assessment of the somatic nervous system. Until

quite recently, the autonomic system could be evaluated only indirectly, utilizing the results of nocturnal penile tumescence testing and the erectile response to intracavernosal pharmacotherapy (Haldemman *et al.* 1982).

As early as 1959, Bors and Blinn reported that BCR could be recorded by electromyography and, in 1967, Rushworth stressed the diagnostic value of BCR and reported briefly an electrophysiological method in which electrical shock was applied to the glans. Thereafter, BCR has been used in evaluating neurogenic bladder disorder as well as neurogenic sexual dysfunction.

In 1947, Dawson reported that the averaged evoked potential could be recorded over the scalp produced by stimulation of peripheral nerves. Since then, SEP proved to be a useful diagnostic tool in evaluating the abnormality

Received July 7, 1992

Accepted August 25, 1992

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along the pathway from the point of peripheral stimulation to the cerebral cortex. PSEP is scalp recorded SEP from stimulation of the penile shaft, and may be used to detect any lesion between the dorsal nerve and the brain (Kaneko *et al.* 1983; Spudis *et al.* 1989).

BCR study is useful in assessing the integrity of the sacral spinal cord segments at S2-4 and also their afferent and efferent connections. PSEP is an objective neurophysiologic assessment method in evaluating the entire pudendal nerve afferent pathway. A neurological lesion above the sacral cord would show intact BCR with abnormal PSEP. As a consequence, both BCR study and PSEP are useful in assessing the neurological integrity of an erectile dysfunction patient.

In this study, normal data were assessed from healthy male volunteers as well as data from sexual dysfunction patients. Classifications were made according to the etiological origin and were compared to the normal value with the purpose of providing a future guide for assessment and treatment plan in patients with erectile dysfunction.

SUBJECTS AND METHOD

Subject

Thirty eight healthy males and 461 patients with erectile dysfunction were investigated. The ages of normal subjects ranged between 20 and 50 years with a mean age of 38.4 years (Table 1). The age distribution of the patient

group is illustrated in table 1, and the normal control group and the patients in this study were grouped according to the following criteria: 1) Normal control group: Normal male volunteers who were normopotent, neurologically normal on examination, and had no systemic disease. 2) Erectile dysfunction only: Patient group having erectile dysfunction with no history of any disease, neurologically normal on examination. 3) Spinal cord lesion: Patient group with spinal cord lesions which were caused by trauma, spinal tumor, myelitis, or congenital lesion. (UMN type: patient with clinically evident upper motor neuron type, LMN type: patient with clinically evident lower motor neuron type) 4) Diabetic mellitus: Diabetic patient group with erectile dysfunction. 5) Pelvic trauma: Patient group with erectile dysfunction after pelvic trauma. 6) Herniated disc: Patient group with erectile dysfunction without any other medical or neurological disorder except for underlying herniated disc. 7) Miscellaneous: A heterogeneous group of patients complaining of erectile dysfunction.

Method

Two electrodes were wrapped circumferentially around the glans penis, perpendicular to the long axis of the penis. The proximal stimulation electrode was always connected to the cathode of the stimulator. A monopolar needle electrode was placed percutaneously into the body of the bulbocavernosus muscle and connected to the input of the TECA TD 20 electromyography unit. A reference skin electrode was placed at the upper medial thigh level, and a ground was placed on the opposite thigh. The needle electrode was adjusted until consistent responses were obtained from a supramaximal stimulus. In most cases stimuli were delivered with a frequency of 1 per second and a pulse duration of 0.1 msec, using a nerve stimulator.

PSEP study

The stimulus was applied through the same ring electrodes used for the BCR study. The stimulus intensity was increased gradually to the point at which minimal contraction occurred. The active electrode was placed in the midline of the scalp 2 cm behind the Cz and the reference electrode at the Fz, according to the 10~20 EEG recording system.

Table 1. Age distribution of normal and patient group

Age (years)	No. of cases	
	Normal Group	Patient Group
10~19		6
20~29	10	106
30~39	18	181
40~49	8	108
50~59	2	49
60~69		11
Total	38	461

The statistical analysis was carried out using t-test with level of significance of $p < 0.05$.

RESULTS

The distribution of patients is illustrated in table 3. In the healthy normal Korean, the average short latency P1 SEP latency stimulating pudendal nerve was 38.2 ± 2.2 msec and the average bulbocavernosus reflex latencies were 32.4 ± 3.6 msec on the right, and 32.5 ± 3.5 msec on the left (Table 2).

Great abnormality in PSEP was found in the patient group of spinal cord lesion with clinically evident upper motor neuron involvement and the average prolonged P1 latency of the available PSEP was 47.4 ± 9.8 msec (Table 4, 6). The patient group of spinal cord lesion with clinically evident LMN type revealed great abnormality in the BCR study. And the average

latency of the available BCR was 44.9 ± 14.5 msec on the right, and 44.2 ± 15.6 msec on the left (Table 3, 6).

In the patient group of diabetes mellitus, pelvic trauma, and UMN type spinal cord lesion, there was significant difference in the study of PSEP compared to the normal value (Table 6).

Table 2. PSEP* and BCR study of normal control group (n=38)**

	Mean (msec) \pm SD	Range (msec)
PSEP	38.2 ± 2.2	33.8~42.6
BCR Study Rt.	32.4 ± 3.6	25.2~39.6
Lt.	32.5 ± 3.5	25.5~39.5

Values are the mean \pm SD

PSEP*: Pudendal Somatosensory Evoked Potential

BCR**: Bulbocavernosus Reflex Latency

Table 3. Number and percentage of abnormal response of BCR study

Group	No. of cases	Prolonged response	Absence of response	Abnormal BCRL (%)
Erectile dysfunction only	283	9	0	9(3.2)
Spinal cord lesion				
UMN type	41	2	0	2(4.9)
LMN type	35	5	24	29(82.9)
Diabetes mellitus	30	3	3	6(20.0)
Pelvic trauma	43	8	6	14(32.6)
Herniated disc	18	1	0	1(5.6)
Miscellaneous**	11	1	0	1(9.1)

Miscellaneous*: Tuberculous meningitis (2), Cerebral palsy (1), Cerebrovascular accident (2), Multiple sclerosis (1), Arachnoiditis (1), Mile's operation (3), Poliomyelitis (1)

Table 4. Number and percentage of abnormal response of PSEP

Group	No. of cases	Prolonged response	Absence of response	Abnormal PSEP (%)
Erectile dysfunction only	283	13	0	13(4.6)
Spinal cord lesion				
UMN type	41	11	23	34(82.9)
LMN type	35	4	24	28(80.0)
Diabetes mellitus	30	6	3	9(30.0)
Pelvic trauma	43	13	7	20(46.5)
Herniated disc	18	2	0	2(11.1)
Miscellaneous**	11	2	0	2(18.2)

Table 5. Comparison of abnormality in each group

Group	No. of cases	Abnormal Pudendal SEP	Abnormal BCRL	Abnormal in any one test (%)
Erectile dysfunction only	283	13	9	22(7.8)
Spinal cord lesion				
UMN type	41	34	2	34(82.9)
LMN type	35	28	29	30(85.7)
Diabetes mellitus	30	9	6	10(33.3)
Pelvic trauma	43	20	14	21(48.8)
Herniated disc	18	2	1	3(16.7)
Miscellaneous**	11	2	1	3(27.3)

Table 6. Results of PSEP and BCR study

Group	PSEP	Rt. BCRL	Lt. BCRL
Normal control	38.2±2.2	32.4± 3.6	32.5± 3.5
Erectile dysfunction only	39.1±2.9	32.8± 4.3	32.8± 4.0
Spinal cord lesion			
UMN type	47.4±9.8*	32.0± 4.5	31.9± 4.6
LMN type	41.6±5.3	44.9±14.5*	44.2±15.6*
Diabetes mellitus	42.9±8.8*	35.7± 5.0*	35.8± 4.8*
Pelvic trauma	42.3±7.4*	36.0± 8.7*	38.4±11.9*
Herniated disc	40.5±5.4	32.6± 5.7	33.0± 6.4
Miscellaneous	40.8±5.8	33.5± 3.1	34.1± 3.6

Values are the mean ±SD

*p<0.05

And also in the BCR study, compared to the normal value, a significant difference was found in the patient group with diabetes mellitus, pelvic trauma and LMN type spinal cord lesion (Table 6).

DISCUSSION

Human penile erection is primarily an involuntary or reflex phenomenon that can be elicited by a variety of stimuli and by at least two distinct central mechanism, either "psychogenic" or "reflexogenic", the former being initiated by the auditory, visual, tactile, olfactory and imaginative stimuli which may arouse the erotic centers in the brain, and the latter by exteroceptive stimulation of the genital region or vague interoceptive stimuli in the bladder or

rectum (Bors and Comarr 1960). The erection control center in the spinal cord are situated in the thoracolumbar (around T12-L1) and sacral segments (S2-4). the thoracolumbar erection center can mediated psychogenic erection in the state of intact communication with the higher center by controlling the sympathetic outflow. Therefore in the patients who suffer complete LMN lesions of the sacral cord erection after psychogenic stimuli is possible. In the sacral erection center, the pudendal nerve carries the afferent impulses necessary for reflexogenic erection and the efferent neural impulses are conducted through the pelvic nerve from the sacral cord segment. In addition, the sacral stimuli originating from the higher centers of the central nervous system as well as the local reflexogenic stimuli (Weiss 1972; deGroat and Booth 1980). This has been proven in a previous experimental study in which the

psychogenic erection was maintained after bilateral sympathectomy (Root and Bard 1947). As a result in patients with complete spinal cord injury above the sacral cord level who are able to erect only by reflexogenic stimuli, bilateral pudendal nerve destruction should result in complete impotence, since the afferent limb of the reflex arc is eliminated (Bors and Comarr 1954).

As mentioned above, both the autonomic nervous system and somatic nervous system contribute to the penile erection mechanism, but the penile erection is primarily an autonomic reflex. The autonomic nervous system has been assessed indirectly by several methods including nocturnal penile tumescence testing. Only recently some reports on the autonomic nervous function in controlling the erection by recording the electrical activities of the corpus cavernosum have been published. The somatic nervous system is examined by BCR and PSEP, both of which are objective methods of evaluating peripheral and central afferent pudendal pathways and also the sacral arc (Harin 1988).

Since the micturation center and one of the spinal sexual reflex center contributing to penile erection are located in the S2-4 spinal cord segment, BCR is widely used to evaluate the lesions of the sacral cord, sacral roots, and pudendal nerve in patients with sexual dysfunction or voiding problems (Erkein and Reel 1976; Siroky *et al.* 1979; Blaivas *et al.* 1981). PSEP produced by stimulation of the dorsal nerve of the pudendal nerve provides a useful diagnostic index of conduction in the somatosensory pathway to the cortex. But in patients with neurological disease, the PSEP may be affected by disorders not only of the central nervous system but also of the peripheral nervous system (Hume and Cant 1978). In the case of BCR study, BCR latency may be normal if the lesion is above the sacral cord, but the abnormal BCR study can not differentiate whether the lesion is located in the afferent limb, sacral cord or efferent limb of the reflex arc. Therefore the combined use of BCR and PSEP can compensate for the limitation of each study, and facilitate the documentation of the presence, location and completeness of the neurological lesion (Krane and Siroky 1980; Haldemann *et al.* 1982; Erkein *et al.* 1985).

Siroky *et al.* (1979) reported that the BCR study may be clinically useful in evaluating pa-

tients suspected of having sacral cord lesions or pudendal neuropathy and can provide an objective and quantifiable method to evaluate the neural integrity of the sacral cord and cauda equina. In 1981, Blaivas *et al.* reported that in the case of LMN lesions, the BCR was absent or prolonged and the BCR was demonstrated by electromyography in patients with UMN lesion.

In the study of PSEP, Haldemann *et al.* (1982) reported that, together with BCR study, the results may facilitate the diagnostic evaluation of neurologic disease affecting bowel, bladder, and sexual function. In their report, they stated that intact BCR latency with delayed PSEP suggest a disturbance in the spinal cord, brain stem, or cortical pathway. On the other hand, the intact PSEP with absent or delayed BCR may indicate a peripheral motor or ventral conus medullaris lesion.

Erkein *et al.* (1985) reported that the PSEP was a useful diagnostic method in the evaluation of patients with UMN type spinal cord injury, multiple sclerosis, and parkinsonism, and that the BCR study was found to be superior in patients having diabetic impotence and in patients with cauda equina lesions. In addition, in 1983, Bilkey *et al.* reported that the mean BCR latency in patients with UMN lesions was significantly shorter than that of the normal control group. They explained that such a decreased latency may be the result from the loss of the inhibitory influence of the higher neural centers on the BCR and from increased excitability of the motor neurons at the level of S2 through S4.

Our results show that the abnormal rate of BCR study is highest in the patient group of LMN type spinal cord lesion and that PSEP is highest in the UMN type. These data are in agreement with those of Siroky, Blavis, and Erkein and their associates (Siroky *et al.* 1979; Blaivas *et al.* 1981; Erkein *et al.* 1985). In addition, though there was no significant difference, the mean latency of BCR in the patient group of UMN type spinal cord lesion was shorter than that of the normal control group. These results are consistent with previous reports (Bilkey *et al.* 1983).

In the case of injury confined to the vascular system, good results were obtained through the revascularization of the corpora cavernosa alone whereas the penile prosthesis or intracavernosus pharmacotherapy were needed in

patients with neurologic injury (Montague 1988). In the group of erectile dysfunction after pelvic trauma, 48.8% of the patients revealed an abnormal response in any one test of BCR or PSEP in our study. These results should be helpful in establishing the future management plan for erectile dysfunction.

Although Ellenberg (1971) reported that erectile dysfunction in diabetic patients was caused by peripheral neuropathy in 82% of the cases, its etiology may well be of another origin such as vascular, endocrine or psychological (Lehman and Jacobs 1983). Melman and Frye (1983) suggested that the BCR study was incompatible in the evaluation of diabetic erectile dysfunction because diabetic erectile failure is primarily of an autonomic reflex, whereas the BCR is a test of somatic nerve function. In contrast to this opinion, Siroky *et al.* (1979) believed that an isolated autonomic neuropathy leading to impotence would be rare. In our study, the PSEP was abnormal in 30.0% of the diabetic patient group, and 20.0% in the BCR study. These results were inconsistent with those of Siroky *et al.* (1979) who demonstrated prolongation of BCR latency in 85% of impotent diabetics, but approached the value of Jevitch *et al.* (1982) who reported a 34.2% BCR abnormality.

As previously stated, some authors reported that the BCR study and PSEP, which are tests for somatic nerve function, are not suitable for the evaluation of erectile dysfunction because the penile erection is primarily of an autonomic reflex. And Lavoisier *et al.* (1989) stated that damage to the afferent components of the sacral pathway could result in an abnormal BCR but still allow erection via other efferent fibers synapsing with the efferent fibers. Currently the direct assessment method for autonomic nervous system is under study (Gerstenberg *et al.* 1989; Wanger *et al.* 1989). There was a report stating that it seems unlikely that an isolated autonomic neuropathy by itself would cause impotence, so the PSEP and the BCR study continue to be widely used clinically.

Though some authors (Melman and Frye 1983; Arsdalen and Wein 1983; Lavoisier *et al.* 1989) have doubts on the validity of the PSEP and BCR study, others (Erkein and Reel 1976; Siroky *et al.* 1979; Blaivas *et al.* 1981; Haldeman *et al.* 1982; Erkein *et al.* 1985) stress their value and the practical application of those studies in differential diagnosis of erectile dys-

function. Wabrek (1985) reported that BCR study needed to be done in patients with sexual dysfunction where penile revascularization, or sex therapy, or both, were being considered, because abnormal latency would contraindicate revascularization and should limit outcome expectations of sex therapy.

Therefore, PSEP together with BCR study seems to be useful in assessing the integrity of the sacral reflex arc and central afferent pathway, in differentiating the lesion site, and in providing basic data for the management plan in sexual rehabilitation. Furthermore, because erection is under the influence of both the somatic and autonomic nervous system, BCR study and PSEP combined with currently studied electrical activity of the corpus cavernosum would provide a more accurate evaluation of the neurogenic erectile dysfunction patient (Gerstenberg *et al.* 1989; Wanger *et al.* 1989).

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