Original Article

Electrophysiological assessment of sexual dysfunction in spinal cord injured patients

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Study design: Survey.

Objectives: To determine associations between sexual dysfunctions and electrophysiological examinations of the genital system in spinal cord injured patients.

Setting: Ege University Hospital, Izmir, Turkey.

Methods: In total, 25 patients (17 men, eight women) who were out of the spinal shock period were examined. Neurological levels were determined according to the American Spinal Injury Association (ASIA) impairment scale. Data about erection, ejaculation and vaginal lubrication were obtained via inquiry forms. Bulbocavernosus reflex (BCR), pudendal somatosensory evoked potentials (pSEP) and perineal sympathetic skin responses (pSSR) were recorded by an electromyographer unaware of the sexual state or neurological level of the patient.

Results: BCRs could be obtained from all patients with lesion levels above the sacral centre. A significant association was found between reflex erection and BCR positivity, while psychogenic erection was shown to have a significant association with the preservation of pSSR in men. Despite the lack of statistical significance due to the small sample size of the women examined, a similar association with lubrication was observed. Ejaculation and orgasm were not shown to be significantly associated with any electrophysiological examination. However, ejaculation was preserved in all men with a lesion level below T12 and with positive pSSR. There was no significant relationship between pSEP and sexual functions. The relationship between the existence of sacral sensation and pSEP positivity was statistically significant.

Conclusion: This study has proved that BCR and pSSR have an important role in the estimation of the remaining sexual function in spinal cord injured patients.

Statement on ethics: We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research. *Spinal Cord* (2007) 45, 298–303. doi:10.1038/sj.sc.3101949; published online 13 June 2006

Keywords: spinal cord injuries; sexual dysfunction; electrodiagnosis; bulbocavernosus reflex

Introduction

Spinal cord injury (SCI) causes deterioration in the sexual function in both sexes to a degree depending on the level and the extent of the injury. This impairment is mainly characterized by impotence and infertility as a result of erectile and ejaculatory dysfunction in men. Loss of vaginal lubrication and orgasmic disorders are frequently reported problems in spinal cord injured women. There are numerous studies regarding the sexuality of men with SCI in the literature; whereas the preserved fertility of these women has resulted in a lower level of interest in women's sexuality after the SCI.

Although there are many diagnostic means of evaluating sexual dysfunction, the exact standardization of these tests has not been established yet and, since they test only one of the components that may cause sexual dysfunction such as vascular, psychogenic or neurogenic, their diagnostic value is regarded as controversial.¹ Neurophysiological examinations which evaluate distinct divisions of the nervous system such as sympathetic, parasympathetic and somatic nerve fibres, are considered to be crucial especially if they also provide prognostic information.^{2,3} Electromyographic examination (EMG) of the pelvic floor muscles is valuable in the assessment of the involvement of the lower sacral segments. Pudendal somatosensory evoked potentials (pSEP) evaluate the afferent pathways arising

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from genital organs to upper centres,⁴ perineal sympathetic skin responses (pSSR) evaluate sympathetic fibres,^{5,6} and bulbocavernosus reflex (BCR) recordings evaluate the integrity of sacral reflex arc.⁷⁻⁹

The assessment of the sexual condition is of high importance for an effective problem-oriented treatment. Therefore, we aimed to evaluate the association between the sexual dysfunction, the neurological level of the lesion and electrophysiological examinations in the spinal cord injured patients including women to whom sufficient attention with regard to this had not previously been paid.

Methods

In total, 25 patients (17 men, eight women) who were out of the spinal shock period on admission to the hospital were enrolled in the study. Written informed consents were obtained from the patients and the local ethical committee of Ege University approved the study. Patients with a systemic illness that may interfere with sexual function were excluded. The mean age was 34.11 ± 10.09 years (range; 21–53 years) in men, and 36 ± 11.6 years (range; 22–56 years) in women. The average time interval after the SCI was 26.8 ± 29.2 months (range; 4–127 months).

The neurological level of each patient was determined according to the American Spinal Injury Association (ASIA) impairment scale.¹⁰ Neurological levels were classified according to the innervation of the genitals as follows; T10 and above, T11–L2 (thoracolumbar = TL), conus medullaris and cauda equina lesions. The sensory complete/incomplete distinction was made according to the examination of perianal sensation, whereas voluntary contraction of the anal sphincter was evaluated for motor complete/incomplete distinction. Of the 17 men, the lesion level was above T10 in nine, at T11–L2 in five, at conus medullaris in one and cauda equina in two. Of the eight women, the lesion level was above T10 in two, at T11–L2 in one, at conus medullaris in one and cauda equina in four.

Data regarding erection (presence, type), ejaculation (presence), orgasm (presence) and vaginal lubrication (presence, type) were obtained verbally from the patients by the use of standard questionnaires. Electrophysiological examinations of BCR, pSEP and pSSR were performed using a 2 channel Keypoint V 1.6 (Medtronic, Denmark) electromyography device by an experienced physiatrist (On AY) unaware of either the sexual state or the neurological level of the patient.

pSSR recordings were performed using 'Sympathetic Skin Response software package'. Pregelled self-adhesive disposable surface electrode pairs with a 15×20 mm recording area (Medtronic, Denmark) were used for recordings. The active electrode was placed on the perineal region in the midline behind the scrotum in men, and behind the vulva in women. The reference electrode was placed on the mons pubis, and the indifferent electrode over the medial aspect of the thigh in both sexes. The left median nerve was stimulated at

the wrist with a bipolar electrode consisting of two-disc electrodes 1 cm distant from each other. The electrical stimulation consisted of square waves given in single shocks with 20–30 mA intensity and 0.2 ms duration. Random stimuli were given paying attention to maintaining a minimum of 1 min pause between each stimulus. The frequency interval was 2 kHz to 0.5 Hz, and the analysis time after each stimulation was 5 s (500 msn/div). Amplifier gain was adjusted between 100 μ V and 0.5 mV per division. So that SSR might be obtained following three consecutive stimulations the response was noted as present, without taking latency or amplitude values into consideration.

BCR was obtained through the stimulation of the dorsal nerve of the penis or the clitoris by an active electrode placed over the dorsum of the penis or the clitoris with the reference electrodes being located proximally. The duration of the stimulation was 0.1–0.2 s, and the intensity was supramaximal. The recording was made by a concentric needle electrode inserted into the bulbocavernosus muscle in both sexes. The recording electrode was inserted behind the scrotum in the perineal region in men, and around the urethral meatus close to the vaginal aperture in women. The indifferent electrode was placed over the medial side of the thigh. About 10–20 responses were superimposed and the response of the earliest latency was selected. If no response could be obtained, or if the latency was longer than normal (above 45 ms), the response was considered negative.

pSEP examination was performed with 'Dantec Keypoint software'. The stimulation was given as rectangular waveforms of 0.2 ms duration and 3 Hz of frequency through bipolar surface electrodes placed over the dorsum of the penis or clitoris. The analysis time was 100 ms (10 ms/div), and the sensitivity was between 25 and 50 μ V. The stimulation intensity was 2–3 times the sensory threshold. In the case of sensory impairment, intensity generating minimal muscle contraction was given and if the nerve could not be stimulated, it was adjusted to 20–40 mA. Cortical recordings were made through needle electrodes inserted to the point 2 cm behind 'Cz'. The reference electrode was inserted at the forehead subcutaneously. In total, 500 stimulations were given, and all the responses obtained were averaged. The procedure was repeated and the two traces were superimposed. pSEP was considered to be present if reliable responses were obtained in both recordings without taking latency or amplitude into consideration.

As women in particular could not give reliable responses by verbal communication, written confidential questionnaires about their sexual functions were sent out to the patients 6 months after the completion of the study. By doing so, we attempted to take advantage of both the longer period, which had elapsed between the injury (range; 16–136 months) enabling the patients to better assess their surviving sexual function as well as the possibility of obtaining more information from the women in the study. Completed questionnaires were returned from 14 men and six women.

Statistical evaluation was made using the SPSS 10.0 software package. Frequency analyses were applied for all the data. The associations between the sexual functions and electrophysiological studies were analysed using Fisher's exact χ^2 test. An alpha level of $P < 0.05$ was used for significance.

Results

Clinical data regarding preserved sexual functions and their relationship with neurological level

Clinical data could be reliably obtained from all men by use of verbal questionnaires. Some type of erection was present in all men without regard to the neurological level. The responses to the written confidential questionnaire did not show significant differences except in one patient with TL lesion in whom reflex erection (RE) appeared. Table 1 shows the clinical data obtained by written questionnaire. RE was preserved in all nine men with lesion levels above T10, and five (three complete, two incomplete) of them also had psychogenic erection (PE). At the TL level (complete, incomplete) one patient had only PE, and four patients had both type of erections. In all conus/cauda level patients PE was preserved whereas RE was absent. All of the seven men with lesion levels below T12 had PE (not seen in the Table). Ejaculation was preserved in only nine men. Of these, the lesion level was above T10 in five, TL in two, and cauda in two. Orgasm was also present in seven men with preserved ejaculation.

Reliable information about lubrication could be obtained from only five women by use of a verbal

questionnaire. Only two women contributed data regarding orgasm. A confidential written questionnaire returned from six women provided more information (Table 2). Reflex lubrication (RL) was preserved in all two women with lesion levels above T10, and one of them also had psychogenic lubrication (PL). The woman with TL lesion and the one with conus lesion reported both type of lubrications. PL was preserved in all cauda patients except one. Only the woman with conus lesion reported the presence of orgasm.

BCR – neurological level – sexual function associations

BCR was obtained in all men and women with lesions above the sacral centre while there was no response in those with sacral lesions.

RE had been reported verbally in 13 of the 15 male patients with positive BCR. One of the remaining two men reported the return of RE over time via written questionnaire. In the two patients with negative BCR, RE was absent (Table 3). The association between BCR and RE was statistically significant ($P = 0.022$). None of the three women with positive BCR had nothing to contribute regarding their lubrication at the first verbal evaluation. All of them reported the presence of RL via written questionnaire. RL was absent in four of the five female patients with negative BCR (Table 3). The relationship between BCR and RL was not statistically significant ($P = 0.071$).

pSSR – neurological level – sexual function associations

pSSR were obtained in 16 of the 25 patients. pSSR were absent in seven out of 11 patients whose lesion levels

Table 1 Associations between sexual functions and neurological level in men

Level	Erection			Ejaculation (+) n (%)	Orgasm (+) n (%)	Total (n)
	Only RE	Only PE	Both RE&PE			
	n (%)	n (%)	n (%)			
Above T10	4 (44)	—	5 (56)	5 (56)	3 (30)	9
TL	1 (20)	—	4 (80)	2 (40)	2 (40)	5
Conus	—	1 (100)	—	—	—	1
Cauda	—	2 (100)	—	2 (100)	2 (100)	2

RE, reflex erection; PE, psychogenic erection

Table 2 Associations between sexual functions and neurological level in women

Level	Lubrication			Orgasm (+) n (%)	Total (n)
	Only RL	Only PL	Both RL&PL		
	n (%)	n (%)	n (%)		
Above T10	1 (50)	—	1 (50)	—	2
TL	—	—	1 (100)	—	1
Conus	—	—	1 (100)	1 (100)	1
Cauda	—	3 (75)	—	—	4

RL, reflex lubrication; PL, psychogenic lubrication

Table 3 The relationship of BCR with reflex erection and reflex lubrication

	Reflex erection ^a n (%)		Total (n)	Reflex lubrication n (%)		Total (n)
	(-)	(+)		(-)	(+)	
BCR (-)	2 (100)	—	2	4 (80)	1 (20)	5
BCR (+)	1 (7)	14 (93)	15	—	3 (100)	3

BCR: bulbocavernous reflex

^aSignificant association between RE and BCR**Table 4** The relationship of pSSR with psychogenic erection and psychogenic lubrication

	Psychogenic erection ^a n (%)		Total (n)	Psychogenic lubrication n (%)		Total (n)
	(-)	(+)		(-)	(+)	
pSSR (-)	5 (83)	1 (17)	6	2 (100)	—	2
pSSR (+)	—	11 (100)	11	1 (17)	5 (83)	6

pSSR: pudendal sympathetic skin responses

^aSignificant association between PE and pSSR

were above TL pathways, the lesions all being motor complete. pSSR were obtained in 12 of the 13 patients with lesion levels at or below T12 level. The only patient with negative pSSR at these levels was a woman with a complete cauda lesion.

In all of the 11 men with preserved pSSR, PE was preserved. In all men with preserved PE but one, pSSR were recorded (Table 4). The relationship between pSSR and PE was statistically significant ($P=0.001$). PL had been reported verbally in four of the five women with preserved pSSR. The remaining one woman reported the appearance of PL via written questionnaire. In five of the six women with preserved PL, pSSR were obtained (Table 3). The relationship between pSSR and PL was not statistically significant ($P=0.107$).

pSEP – preservation of sacral sensation – sexual function associations

All patients with preserved pSEP had incomplete lesions with preserved sacral sensation. pSEP could not be obtained from any of the patients with loss of sacral sensation. Instead, in 11 of the 14 patients with preserved sacral sensation pSEP could be obtained. The relationship between the preservation of sacral sensation and pSEP positivity was statistically significant ($P=0.000$). There was no significant relation between pSEP and sexual functions ($P>0.05$).

Electrophysiological studies were not significantly associated with ejaculation or orgasm ($P>0.05$). However, in all four men with lesion levels below T12 and positive pSSR, ejaculation was also preserved. No significant relationship was found between pSSR pSEP, and BCR ($P>0.05$).

Discussion

In this study, we obtained clinical data about the extent of preserved sexual functions and compared them with electrophysiological assessments in spinal cord injured patients. Confirming the previous studies, clinical evaluation showed the presence of some type of erection/lubrication in spinal cord injured patients, being largely related to the neurological level. BCR was found to be associated with the preservation of RE/lubrication; whereas pSSR was associated with PE/lubrication. Clinical data also confirmed the high occurrence of ejaculatory and orgasmic dysfunctions in spinal cord injured patients. No correlation between any reliably performed electrophysiological test and the preservation of ejaculation and orgasm is an important new finding of this study.

In men, data about sexual functions was easily obtainable by use of verbal questionnaires. We could not obtain reliable responses at the first assessment in women, possibly due to difficulties in the self-identification of their sexual states including their vaginal lubrication type and orgasm. This could probably be explained by the lack of a sexual intercourse in the majority of the patients. Another point to stress was the lack of sensation around the perineum, which resulted in hesitancy regardless of the type of lubrication. The sending out of written questionnaires after a long interval had elapsed after injury increased the awareness of the patients to their sexual state and more responses could be obtained.

A 100% ratio of RE in men with complete or incomplete lesions above TL pathways and 100% ratio of PE in those with lesions affecting the sacral centre are in complete accordance with the literature.^{2,11} Despite

the small sample size, the preservation of RL in women with lesion levels above T10, and the preservation of PL in women with cauda lesions suggests the existence of similar relationship in women.^{12–14}

In the present study, PE was also preserved in five of the nine men with a lesion level above TL pathways. It has been previously reported that PE might be preserved in incomplete lesions at this level.² In our study, however, PE was reported to be present even with complete lesions. This may be explained in two ways; (1) complete lesions assessed according to the ASIA scale may actually be incomplete, and some spared pathways could be mediating the connection. These patients may progress to incomplete state in the follow up. (2) As the erectile state was assessed according to the subjective information expressed by the patients, the erectile capacity may have been either over or underestimated. However, re-evaluation of the patients after a while confirmed the presence of PE in these patients. An assessment of erection by means of objective physiological tests is necessary for confirmation of these statements.

BCR examines sacral spinal segments and their afferent and efferent connections with the pelvic floor through the pudendal nerve. Thus, it provides the opportunity to presume the preservation of the sacral reflex arc.¹⁵ Data supporting this information was obtained in our study; for example, in all patients with a lesion level above the sacral centre BCR was obtained, whereas in those with sacral lesions it could not be obtained. Confirming the previous studies, we found a high relationship between BCR and RE.² As RE is associated with the integrity of the sacral reflex arc as well, this finding was expected. Furthermore, our study showed the appearance of RE over time in a patient with preserved BCR. To date, no report focusing on a similar relationship between BCR and RL exists. In our study, although statistically significant associations were not found due to the small sample size, the preservation of RL in all women with preserved BCR or absence of RL in most of women with absent BCR suggests the existence of this relationship.

SSR recording is a noninvasive method that assesses the function of nonmyelinated efferent postganglionic sympathetic nerve fibres. The sympathetic fibres controlling the perineal sudomotor activity are thought to originate from the TL (T10–L2) segments of the spinal cord. Therefore, the integrity of the pathway between brain centres and TL sympathetic intermediolateral column may be tested with pSSR.^{5,6} Curt *et al*¹⁶ have reported that pSSR could not be obtained in any of the patients with complete lesions above T9, in 60% of the patients with complete T10–L2 lesions, in 41% of the patients with incomplete T10–L2 lesions. In lesions below TL pathways, pSSR are expected to be preserved due to the preservation of the sympathetic outflow.¹⁶ In accordance with this information, we obtained pSSR in all patients with cauda/conus lesions. However, we obtained pSSR in three patients with complete lesions over TL pathways, which is inconsistent with the

previous reports. Indeed, it has been shown that the afferent pathway of SSR may be preserved in clinically complete SCI which might signify the preservation of some pathways and that this might be of prognostic value in motor recovery.¹⁷ Furthermore, the existence of SSR in patients with absent SEP shows that spinal afferents of SSR are different from those of SEP. The absence of a significant relationship between pSEP and pSSR in our study supports this data.

One of the important findings we obtained related to pSSR is the high association between pSSR and PE. This finding is expected and consistent with previous studies,² since the sympathetic fibres providing the sudomotor activity of the perineal skin and the sympathetic fibres that mediate PE share similar anatomic ways. Schmid *et al*² have determined that pSSR are integral in the estimation of PE capacity and that with the return of PE in the follow-up of pSSR negative patients, pSSR also turn out to be positive. They therefore indicated that, pSSR are crucial in the counselling of a patient's potential capacity for PE.² Another interesting finding is the preservation of PE in pSSR positive patients complete lesions above TL level. This finding is consistent with our previous statement about the existence of PE in high level complete lesions. The relation between pSSR and PL in spinal cord injured women has not been reported before. Despite the lack of statistical significance due to small sample size in our study, we found existence of pSSR in women with preserved PL. Furthermore, PL appeared in the follow-up of one woman with preserved pSSR. These findings suggest the value of pSSR in estimating PL capacity and encourage further researches.

As the TL centre where the sympathetic pathways are located is supposed to end at L2 level, the preservation of PE and pSSR in the patients with lesion levels at or below T12 was an interesting finding of this study. This finding may simply be attributed to the incompleteness of the lesion. However, even though it is difficult to reach a conclusion concerning the minority of the cases, this finding may also suggest that the pathways providing the sympathetic outflow might be located over the T12 level. It might be also assumed that the sympathetic outflow might have been compensated for by the upper sympathetic outflow. Neural plasticity mechanisms may play a role in this compensation. Further studies are necessary for the justification of this hypothesis.

Although electrophysiological studies were not found to be significantly associated either with ejaculation or with orgasm, the preservation of ejaculation in all cases with a lesion level below T12 and positive pSSR was striking. Although an absence of pSSR in 2 patients with ejaculatory failure of various origins was reported previously,¹⁸ such a relation has not been demonstrated for spinal cord injured patients so far. Although it is difficult to reach a conclusion with a small number of patients, this finding seems to further support our aforementioned hypothesis. No matter how complex ejaculation is, this might be attributed to the sympha-

thetic pathways, as the sympathetic fibres providing the sudomotor activity of the perineal skin and the sympathetic fibres that mediate ejaculation both use similar anatomic ways.

pSEP is the unique method that objectively assesses the somatosensory afferent fibres from the genitals to the brain. In our study, in accordance with previous studies, a significant relationship was observed between the preservation of sacral sensation and pSEP positivity.² However, there was no association between pSEP and sexual function. The evaluation of pSEP together with pSSR and BCR may provide a more detailed evaluation of all the pathways mediating sexual function.

Conclusion

This study has shown that the electrophysiological examinations related with the genital system, namely, BCR and pSSR play an important role in the estimation of the remaining sexual capacity in patients with SCI. Further research is necessary to investigate this relationship with the help of objective physiological tests.

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