

Pudendal Somatosensory Evoked Potentials in Normal Women

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ABSTRACT

Objective: Somatosensory evoked potential (SSEP) is an electrophysiological test used to evaluate sensory innervations in peripheral and central neuropathies. Pudendal SSEP has been studied in dysfunctions related to the lower urinary tract and pelvic floor. Although some authors have already described technical details pertaining to the method, the standardization and the influence of physiological variables in normative values have not yet been established, especially for women. The aim of the study was to describe normal values of the pudendal SSEP and to compare technical details with those described by other authors.

Materials and Methods: The clitoral sensory threshold and pudendal SSEP latency was accomplished in 38 normal volunteers. The results obtained from stimulation performed on each side of the clitoris were compared to ages, body mass index (BMI) and number of pregnancies.

Results: The values of clitoral sensory threshold and P1 latency with clitoral left stimulation were respectively, 3.64 ± 1.01 mA and 37.68 ± 2.60 ms. Results obtained with clitoral right stimulation were 3.84 ± 1.53 mA and 37.42 ± 3.12 ms, respectively. There were no correlations between clitoral sensory threshold and P1 latency with age, BMI or height of the volunteers. A significant difference was found in P1 latency between nulliparous women and volunteers who had been previously submitted to cesarean section.

Conclusions: The SSEP latency represents an accessible and reproducible method to investigate the afferent pathways from the genitourinary tract. These results could be used as normative values in studies involving genitourinary neuropathies in order to better clarify voiding and sexual dysfunctions in females.

Key words: neurophysiology; pelvic floor; evoked potentials; electrodiagnosis

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INTRODUCTION

The pudendal nerve is responsible for motor innervation of the urethral and anal sphincters as well as other muscles of the pelvic floor. Its sensory branch innervates the clitoris, distal urethra and vulvar labia (1). Electrical stimulation of sensory receptors generates action potentials, which travel through the pe-

ripheral nerve and spinal cord to the sensorimotor cortex (2). This influx of impulses evokes a cortical response, which can be recorded by surface electrodes placed above the scalp overlaying the somatosensory cortex.

The clinical use of evoked potentials has reported on its ability to demonstrate abnormalities in sensory function when the clinical history and physical or

neurological examination are insufficient for diagnosis, contributing to the definition of the anatomical distribution of the pathology and to the monitoring of alterations during the evolution of neurological diseases (3).

Measurement of somatosensory evoked potentials (SSEP) is the only technique currently available to investigate objectively the afferent pathways from the genitourinary tract to the brain. Its use represents an important tool for the evaluation of disorders affecting sensory innervations like peripheral neuropathies, spinal cord disorders and some supraspinal diseases. There are currently several indications for the use of SSEP to evaluate peripheral nerve disease: conduction measurements along normal or diseased nerves not easily accessible to standard electromyographic methods; to document axonal continuity when a sensory nerve action potential cannot be recorded; evaluation of radiculopathies, especially when sensory signs or symptoms predominate as well as plexopathies (4). Clinical studies using pudendal SSEP have been reported (5-7), but characteristics and normative values in normal women have been incorrectly described in short samples and not considering factors such as age, body mass and obstetric history.

The objective of this study was to establish reference latencies of clitoral sensory threshold and pudendal SSEP in normal women, observing physiologic factors, which could potentially influence the electrophysiological parameters.

MATERIALS AND METHODS

A prospective study was performed on 38 female volunteers without urogenital dysfunctions and

prolapses, urinary incontinence or previous pelvic or vaginal surgery (excepting cesarean section), after approval by the local Ethics Committee. Those with diabetes, renal insufficiency, alcoholism, previous or current neurological pathologies, interstitial cystitis, urinary infections in the last six months, voiding symptoms, pregnancy or using cardiac pacemaker were excluded from the study. Tests were performed in lithotomy position with a Neuropack sigma (Nihon-Kohden) evoked response unit. Volunteers' characteristics are described in Table-1.

Women rested comfortably on a bed with pillow to minimize electromyography interference from neck muscles. Stimulation was performed with the cathode placed adjacent to the clitoris on the left and on the right, respectively, at 3 and 9 o'clock positions. The anode was placed between the labia minora and labia majora on the same side. Clitoral sensory threshold was considered as the intensity necessary for the patient to first realize the stimulus. Volunteers received square wave pulses 0.2 milliseconds (ms) in duration, frequencies of 4.7 hertz (Hz) increasing the intensity until 2 to 3 times the sensory threshold.

The recording was done with surface electrodes placed in the midline of the scalp, 2 cm behind the vertex region. A reference electrode was placed in the midline of the forehead at the Fz region according to the 10-20 International System (8). A ground electrode was placed between these two electrodes. In some cases, the recordings were also obtained at P3 and P4 regions. Before the electrodes placement, the skin was gently scraped and prepared. Resistance was kept at less than 5.0 kOhms. A filter setting from 5-3000 hertz was used for all SSEP recordings. The first 100 ms after the stimulus were analyzed, consid-

Table 1 – Characteristics of volunteers in relation to age, body weight, height and deliveries.

	Age (years)	Weight (kg)	Height (cm)	Births	
				(VD)	(VD+CS)
Mean ± SD	39.08 ± 12.38	60.36 ± 8.6	158 ± 8	1.00 ± 1.47	1.68 ± 1.53
Range	20 - 74	45 - 76	140 - 178	0 - 4	0 - 4
Median	36	60.00	158	0	2
Sample (n)	38	38	38	38	64

VD = number of vaginal delivery; CS = number of cesarean section.

ering for study at least 250 to 500 responses. The P1 latency or first positive deflections in the waveform (also referred as P40) was measured using electronic cursors on the screen of the machine. Only SSEP latency have been taken into account because amplitude values depend on a variety of technical and biological factors and are therefore less reliable than latencies.

The results are demonstrated as average \pm standard deviation (SD). The *t* test was used to compare sensory thresholds and the pudendal SSEP latency with stimulation of both sides. The Pearson correlation coefficient was used to investigate the correlation between sensory threshold and pudendal SSEP of each side to age, body mass index [BMI = weight

/(height)²] and height. The variance analysis was used to compare the sensory threshold and the pudendal SSEP latency of both sides between nulliparous and vaginal or cesarean groups with age and parity matched. In all statistical tests results were considered significant at 5% ($\alpha = 0.05$) level.

RESULTS

Stimulus intensity between 2 and 3 times the perception threshold was well tolerated by the subjects. The cortical responses appeared as identifiable W-shaped waveforms (Figure-1). The mean clitoral sensory threshold obtained was 3.64 ± 1.01 mA ($n =$

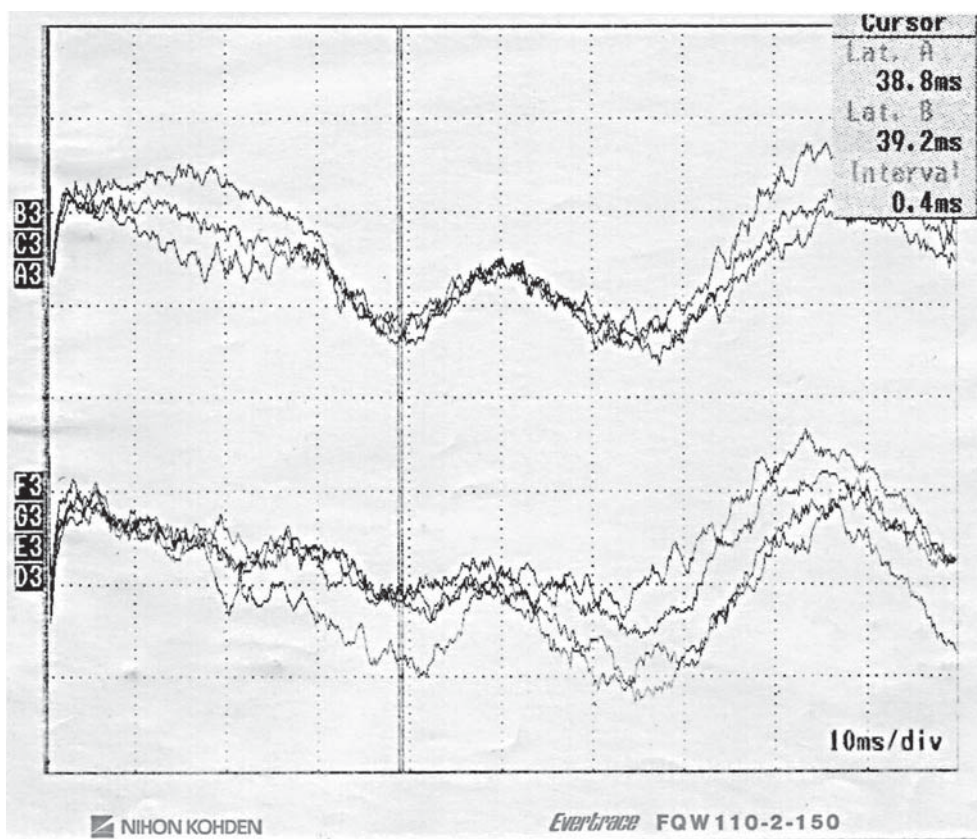


Figure 1 – Recordings of the pudendal somatosensory evoked potential obtained by left (up) and right (down) clitoral stimulation. The vertical line demonstrates the latency (P1 latency).

Table 2 – Correlation of clitoral sensory threshold and P1 latency to age, body mass index and height.

	Age		BMI		Height	
	r	p	r	p	r	p
Left sensory threshold	-0.11	0.53	0.33	0.06	0.02	0.86
Right sensory threshold	-0.30	0.08	0.26	0.14	-0.01	0.95
Left stimulus SSEP	0.002	0.98	0.08	0.63	0.13	0.42
Right stimulus SSEP	0.11	0.49	0.04	0.80	0.22	0.19

r = Pearson correlation coefficient; SSEP = somatosensory evoked potential.

34) on the left side and 3.84 ± 1.53 mA (n = 33) on the right. There were no differences for the sensory thresholds obtained on both sides (p = 0.43). The mean P1 latency obtained after left and right clitoral stimulation were 37.68 ± 2.60 ms (n = 36) and 37.42 ± 3.12 ms (n = 35) respectively. There were no significant differences in latency between the sides (p = 0.86). There were no correlations between sensory thresholds and SSEP latencies according to age, BMI and height of volunteers (Table-2). The sensory threshold and P1 latency in relation to obstetric history are demonstrated in Table-3. A significant difference of the P1 latency between nulliparous women and volunteers submitted to cesarean section was detected. There was no difference in the sensory threshold among the groups. There was also no difference in SSEP latency between nulliparous and volunteers who had vaginal deliveries or between vaginal delivery group and cesarean section group (Table-3).

COMMENTS

Evoked potentials are used clinically to provide assessment of functional abnormality in nerve conductions and to monitor its progression mainly in patients whose neurological disorders are diagnosed or suspected by suggestive clinical history or physical examination. The pudendal SSEP have been used in pelvic dysfunctions and showed responses with prolonged latencies or not recordable in subjects with multiple sclerosis and bladder or sexual dysfunctions (5,7,9,10). However, this method has been rarely studied on healthy women. Haldeman et al. (11) and Guerit et al. (12) published their observations made on only 5 volunteers and other studies were done in a maximum of 14 women (1,13,14). Only recent studies have described reference latencies in a large sample, which included 77 healthy women (15). Normative values are necessary to discuss technical aspects of the

Table 3 – Results of clitoral sensory threshold and pudendal somatosensory evoked potential latency according to pregnancies and deliveries.

	Nulliparous (n = 11)	Vaginal* (n = 11)	Cesarean Section* (n = 11)	p Value
Sensory threshold (mA)	3.9 ± 1.0	3.6 ± 1.1	4.1 ± 1.2	0.58
P1 latency (ms)	35.7 ± 2.4	37.1 ± 2.2	38.8 ± 2.7	0.018 nulliparous x cesarean section
Age (years)	39.0	41.9	36.0	0.57
Height (meters)	1.55	1.57	1.59	0.51
Delivery events	0	2.45	2.0	0.86

* Only volunteers who referred to one type of delivery in their obstetric history were considered.

methodology before its use in research or clinical practice, in a similar way described before for pudendo-anal reflex latency (16). In the present study, this method was applied to a significant number of volunteers, furthermore considering the influences of age, height, BMI and obstetric history.

Haldeman et al. (10) demonstrated that the amplitude of the pudendal SSEP was maximal over the sensory cortex in the midline (Cz^{-2cm}) for both men and women; they also showed that the latencies and waveform were similar to those obtained following tibial nerve stimulation at the ankle.

Vodusek et al. (13) emphasized that the awkwardness of stimulation may be a major obstacle in applying this diagnostic procedure to females. The clitoral stimulation accomplished with a conventional bipolar stimulator was well tolerated by the volunteers, being easily performed. The placement of the anode on the labia majora / minora instead of the pubis, as described by other authors (14) has the advantage of not obtaining the SSEP by addition of stimulation of other peripheral nerves of the region such as the ilioinguinal.

The stimulus frequency of 4.7 Hz was used in order to reduce the noise caused by 60 Hz frequency, which was used in previous study (11). The W waveforms as well as the central recording site are similar as previously described (1,9,11,13). Despite the short distance between the stimulus sites, only some volunteers presented mild discrepancy between both sides in P1 latency, not reaching average difference. This could represent only physiological differences. The laterality of pudendal nerve stimulation cannot be ascertained according to the closeness of the cathode sites of stimulation and to the existence of only one dorsal nerve of the clitoris. This could reflect identical P1 latencies for the both sides of stimulation in some cases. Besides unilateral stimulation, medial or bilateral clitoral stimulations have been performed for eliciting pudendal SSEP in women (15).

The recordings obtained between P3 and P4 were not always as clear as those observed from the midline of the scalp. However, in cases when the response in Cz'-Fz demonstrated low signal to noise ratio, the responses obtained in the parietal area were used to define the P1 latency.

There was no difference in the sensory threshold and P1 latency obtained from each side and there was no correlation between these parameters and age, BMI or height of the volunteers. The influence of height on the SSEP is described especially when studying peripheral nerves of the lower limbs (e.g. the posterior tibial nerve). Some authors observed a positive correlation of pudendal SSEP latency with height in men (5). Although we have not found this correlation, it is reasonable to suppose its existence, nevertheless minimized if compared to the posterior tibial nerve. Since the height's difference of our volunteers was relatively small, this effect may not have been significant to be detected. According to this assumption, we can explain the fact that the mean latency obtained in this study is lower than in other studies accomplished in European and American women (11,13,14). Comparative studies with different pelvic floor pathologies in shorter women must be interpreted carefully. Similar differences in varied ethnic groups are also demonstrated in P40 component obtained after stimulation of the posterior tibial nerve (17).

A longer P1 latency was observed in the cesarean section group when compared to the nulliparous women group. This result contradicts the expectation that neurological lesions of the pelvic floor occur after vaginal delivery and cesarean section has a protective factor to the pelvic floor structure (18). The reasons for this discovery are speculative at this moment. Evidence of lesion in women's pudendal motor innervation submitted to salvage cesarean section has already been described (19). An explanation for this would be the time spent waiting for vaginal delivery to occur before opting for cesarean section. Groutz et al. found that elective cesarean section was associated with a significantly lower prevalence of postpartum urinary dysfunction than those who had spontaneous vaginal delivery or cesarean section performed for obstructed labor (20). However, other studies are necessary to clarify if this result is a clinically relevant finding. The study of SSEP in women should be carefully analyzed in those with a history of cesarean section. There was no difference between women who have been submitted to vaginal delivery and nulliparous. However, there was a tendency for longer

latencies in vaginal delivery group that could reach significance if larger sample had been studied.

A critical reading of the literature reports suggests that the sensitivity of the test is low in assessment of axonal lesions. Some authors admit that the presence of an abnormal pudendal SSEP in an individual patient is, as a rule, accompanied by other neurological deficits and that the necessity to measure the latency may be questioned (21). However, according to other reports, the ability to demonstrate and document a dysfunction of the nervous system could be fundamental in validating clinical symptoms and signs (2,6).

In conclusion, the SSEP represents a reproducible and accessible method of evaluating the afferent pathways of the pudendal nerve in women. The SSEP latencies obtained in these healthy women are within the ranges currently reported in literature. We found that there is a statistically significant difference in the latencies when comparing nulliparous women to those with Cesarean section, but its clinical significance is unknown. These results could be used as normative values in studies involving genitourinary neuropathies in order to better understand voiding and sexual dysfunctions in females.

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CONFLICT OF INTEREST

None declared.

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