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정상인의 교감신경 피부반응에 관한 전기생리학적 연구

김대식, 우종균[1], 김병원[2]
동남보건대학 임상병리과, [1]국민건강보험공단 일산병원, [2]김천대학교 임상병리학과

Electrophysiological Study on SSR in Normal Healthy Subjects

Kim, Dae Sik · Yoo, Jong Kyun[1] · Kim, Byung Weon[2]
Department of Biomedical Laboratory Science, Dongnam Health College, Suwon; [1]Department of Neurology, National Health Insurance Corp. Iilsan Hospital, Ilsan; [2]Department of Biomedical Laboratory Science, Gimcheon University, Gimcheon, Korea

ABSTRACT : Sympathetic skin response (SSR) is defined as a minute change of skin potential after electrical stimulation. This test measures the change in voltage that originates from the surface of the skin and is attributed to sudomotor activity. The aim of this study was to define the criteria for validation of the responses. 40 normal subjects (20-73 yr of age) with non-sympathetic dysfunction were tested and SSR was generated from all subjects. The SSR latency was 1,331.22±177.51 ms in the right palm, 1,331.74±156.42 ms in the left palm, 1,851.79±220.99 ms in the right sole, and 1,874.10±215.01 ms in the left sole. Also, the SSR amplitude was 595.83±221.16 μV in the right palm, 605.33±226.45 μV in the left palm, 291.76±133.36 μV in the right sole, and 288.77±129.70 μV in the left sole. The SSR latency and amplitude had no significant difference between the right and left sides. The SSR latency was consistently shorter ($p<0.001$) and the SSR amplitude was higher ($p<0.001$) in the feet than in the hands. P-type (32 subjects, 75%) was more than N-type (8 subjects, 25%) in the SSR wave forms. The SSR latency and amplitude in palms/soles were closely correlated with age ($p<0.05$) and height ($p<0.05$). The SSR test is one method for assessing impairment of sympathetic fibers in peripheral neuropathy as well as a disorder of sympathetic system in other diseases and so our results from normal healthy subjects can be used as clinical criteria for the SSR test.

KEY WORDS : *Sympathetic skin response, SSR, Sole, Palm, SSR latency, SSR amplitude*

INTRODUCTION

To evaluate the function of the automatic nervous system, there are several methods like as a deep breathing, Valsalva's maneuver, the measurement of heartbeat changes on a electrocardiography or blood pressure changes by a hand grip, and sympathetic skin response (SSR) test by a electromyography.

SSR is defined as a minute change of skin potential after electrical stimulation. This test measures the change in voltage that originates from the surface of the skin (Sibanc et al., 2008). SSR using surface electrodes is very simple and a useful electrophysiological test (Shahani et al., 1984). SSR is introduced by Tarchanoff in 19th century and it is known to be related with an sudomotor function of the sympathetic nerve (Lin et al., 1995). SSR is generated from skin potential changes by various internal and external alerting stimuli like as an algesia, a cough, a deep breathing, and an emotional change etc. (Shaver et al., 1962).

There are two kinds of nerve fibers transmitting sensory information from the skin. Afferent nerve fibers are consisted of the myelinated nerve fibers (Group II, III fiber) and the central nervous system processing an information. Efferent fibers are consisted of short preganglionic myelinated B fibers, long unmyelinated postganglionic sympathetic C fibers, and neuroglandular junction. But SSR evoked pathway was not proved clearly (Clinchot & Lorch, 1996).

교신저자 : 김병원
740-704 경북 김천시 삼락동 754, 김천대학교 임상병리학과
Tel: 82.54-420-4048 Fax: 82.54-420-4048
E-mail : tiger3095@gimcheon.ac.kr
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SSR latency (Uncini et al., 1998) and SSR amplitude (Knezevic & Balada, 1985), and SSR existence or non-existence (Elie & Guiheneuc, 1990) had been used as a criteria for readings of normal and abnormal SSR but there were many different opinions. A few studies about SSR diagnostic criteria had performed in domestic and till now we had been used the criteria of overseas (Cheong et al., 1993; Kim et al., 1989).

In this study we studied on the specific characters of the SSR latency and amplitude from normal healthy adults in order to offer a useful SSR diagnostic criteria for Korean.

MATERIALS AND METHODS

We have selected 40 healthy volunteers (male 20, female 20) who were working at a general hospital in Gyeonggi province and had no a sympathetic nervous dysfunction and disorder, a sensory disorder, and a muscular strength weakening from April to October in 2008 yr. The average age and height of subjects were 44.1±15.6 age (20-73 yr of age) and 165±7.8 cm, respectively. To estimate whether disorders of the autonomic nervous system is existence or not, we used a self-administered questionnaire (checking whether or not a dizziness, a dyshidrosis, genital dysfunctions, neurological bladder disorders etc. are existence.) and then the subjects with disorders of the autonomic nervous system were excluded.

Tests were performed in a quiet and warm room, 25-28℃ after subjects took resting on bed for over 10 min at the supine position.

EMG was recorded with two channels. The active surface electrodes attached to the center of the palm/sole. The reference electrodes attached to the dorsum of the hand/foot. The ground electrode attached to the right upper arm. SSR waveforms were recorded from the right median nerve and the right posterior tibial nerve, respectively.

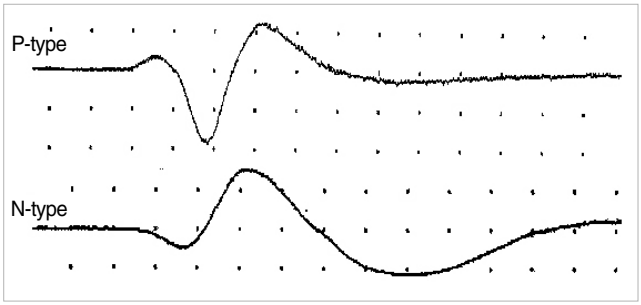

Fig. 1. Waveforms of sympathetic skin response.

Stimuli by bar electrode stimulator were given in the direction of the proximal portion. At this time, the intensity and lasting time of a stimulation were 30 mA and 0.1 sec, respectively.

The SSR onset latency (ms) was calculated from the time between the muscle activity and the first deflection (usually negative) appeared by electrical stimulation and the SSR amplitude (μV) was estimated by potential differences between the base line and the peak of the first deflection. The clearest wave with a stable baseline was selected after electrical stimuli more than 3 times were given to subjects and then the SSR latency and amplitude of the selected wave were measured. Inter-stimulus interval was 2 min to minimize the phenomenon of habituation with repetitive stimulation, After subjects were stabilized at the supine position, the SSR test was carried out in the upper limbs at first and next, the lower limbs.

The SSR waveforms were classified as one of two types, namely, the P type (P), in which the positive component was larger than the negative, and the N type (N), in which the negative component was larger than the positive (Fig. 1).

SSR was recorded by the electromyograph, Sierra Wave (Cadwell Inc., USA) and measuring values were fixed up as Table 1. The average and standard deviation of the SSR latency and amplitude, and the frequency according to waveforms were analyzed by SPSS 10.0 program. SSR differences according to variables were analyzed by T-test. Differences between the right and left sides and between the upper and

Table 1. Set up of the equipment for SSR test

Setting items	Stimulating conditions
Stimulating intensity	30 mA
Stimulating duration	0.1 ms
Frequency filter	0.1-1,000 Hz
Amplification sensitivity	5,000 μV/division
Sweep speed	750 ms/division
Recording electrodes	Disposable surface electrode

lower limbs in the SSR latency and amplitude were analyzed by the paired t-test.

The correlation between SSR and age was analyzed by the correlation coefficient of Pearson and then we selected p-value ($p<0.05$) with a statistical significance.

RESULTS

SSR was obtained from 40 normal healthy Korean. SSR latency from right median nerve was 1,331.22±177.51 ms in right palm and 1,331.74±156.42 ms in left palm, respectively, and from tibial nerve were 1,851.79±220.99 ms in right plantar and 1,874.10±215.01 ms in left plantar, respectively. SSR amplitude from median nerve was 595.83±221.16 μV in right palm and 605.33±226.45 μV in left palm, respectively, and that from tibial nerve was 291.76±133.36 μV in right plantar and 288.77±129.70 μV in left plantar, respectively (Table 2).

From these results, we know that there were no statistically differences in the SSR latency and amplitude between the right and left limbs, but the SSR latency and amplitude were significantly more shorter ($p<0.001$) and higher ($p<0.001$) in the palm than in the plantar, respectively.

The positive (P) type waveform of SSR was appeared in 32 cases (75%) and negative (N) type in 8 cases (25%).

In the correlation coefficient between age and the SSR amplitude and latency in both limbs, the SSR latency with increasing age was prolonged and was shown a statistical correlation at both soles in the lower limbs, and SSR amplitude with increasing age was declined and have a statistical correlation (Table 3). And also the SSR latency with increasing height was prolonged and was shown a statistical correlation at both soles in the lower limbs, and the SSR amplitude with increasing height was increased and was shown a statistical correlation at both soles in the lower limbs (Table 4).

DISCUSSION

SSR can be evoked by potential difference between two skin surfaces after the automatic nerve system makes a sweat gland be activated by various stimuli. The most frequently used method, electrical stimulation of peripheral nerve in the extremity, activates the afferent part of the reflex consisting of thick myelinated sensory fibers (type II) and sensory spinal cord tracts ending in brain stem (Karl et al., 1975).

Many research about SSR had performed because of easily evoking in a clinical laboratory test. But it is a difficult to measure the SSR latency and amplitude because the testing method and EMG setting method had not be standardized (Baba et al., 1988; Shahani et al., 1984).

In spite of habituation of the SSR amplitude, many researcher have used only the SSR amplitude as a significant mark but not the SSR latency.

But Uncini et al. (1998) have reported that the SSR ampli-

Table 2. The SSR latency and amplitude

	Latency (ms)	Amplitude (μV)
Rt. palm	1,331.22±177.51	595.83±221.16
Lt. palm	1,331.74±156.42	605.33±226.45
Rt. sole	1,851.79±220.99	291.76±133.36
Lt. sole	1,874.10±215.01	288.77±129.70

Values are mean±SD.

Table 3. Pearson correlation coefficient between age and the SSR latency and amplitude

	Latency	Amplitude
Rt. palm	0.146	-0.448**
Lt. palm	0.300	-0.368*
Rt. plantar	0.417**	-0.564**
Lt. plantar	0.404**	-0.532**

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).
Values are correlation coefficient.

Table 4. Pearson correlation coefficient between height and the SSR latency and amplitude

	Latency	Amplitude
Rt. palm	0.150	0.176
Lt. palm	0.022	0.209
Rt. plantar	0.451**	0.448**
Lt. plantar	0.402**	0.416**

The same as above.

tude was affected by various factors, the SSR latency was not affected by the tense and stimulus types, and the SSR latency values affected by the efferent nerve were changed consistently according to recording positions. From this results, they suggested that the measurement of the SSR latency had a signigicant meaning in the SSR test.

In domestic study, Park et al. (1993) reported that the SSR latency was changed corresponding not with stimulation positions but with recording positions. Kim et al. (1989) reported that the SSR latency from tibial nerve had no difference between right and left limbs.

In our study, SSR from all 40 healthy subjects was shown as follows. SSR latency at right palm was 1,331.22±177.51 ms, left palm 1,331.74±156.42 ms, right sole 1,851.79±220.99 ms and left sole 1,874.10±215.01 ms, respectively. And SSR amplitude at right palm was 595.83±221.16 μV, left palm 605.33±226.45 μV, right sole 291.76±133.36 μV, and left sole 288.77±129.70 μV, respectively. The SSR latency and amplitude at limbs had no difference between the right and left sides, but they were consistently prolonged and more higher at palm than at plantar. These our results were agreed with the results of Park et al. (1993) in which the SSR latency and amplitude at limbs had no difference between right and sides.

It was reported that distinct changes in the peripheral and central nervous systems according to increasing age were related with the degeneration of the posterior column and the loss of the posterior spinal nerve root fibers which were a large diameter, myelinated, and also the conduction velocity of a sensory nerve was decreased about 1–2 cm/sec per 10 yr after 20 ages (Chodoroff et al., 1985; Corbin & Gardner, 1937). Drory and Korczyn (1993) reported that the SSR latency with increasing age was not changed but the SSR amplitude was decreased, and the decrease of the SSR amplitude was due to the loss of the preganglionic sympathetic nerve and the degeneration of the sweat gland. Kim et al. (1999) reported that the SSR latency with advancing age was prolonged but the SSR amplitude was decreased.

These results were very similar with our study in which with increasing age, the SSR latency and amplitude at both soles were prolonged and declined, respectively and had a statistical correlation. So we know that the prolonged latency and the declined amplitude with increasing age were due to the degenerative changes of the peripheral and the central nervous systems caused by aging.

Elie and Guiheneuc (1990) reported that in a correlation between height and SSR, the SSR latency with increasing height was prolonged (Dettmers et al., 1994). But other reported that SSR was not related with height (Levy et al., 1992; Yang et al., 1997).

In our study, we know that with increasing height, the SSR latency and amplitude at both soles were prolonged and increased, respectively and had a statistical correlation.

On the other hand, SSR according to a polarity is classified two types, positive (P) and negative (N) type. It was reported that P-type was appeared commonly in normal subjects (Toyokura, 1998) and P-type (84%) was more than N-type (26%) in 32 normal subjects (Kucera et al., 2004). These results were very similar with our results in which P-type was 32 (75%) more than N-type 8 (25%) from 40 normal healthy subjects.

Several researches for a clinical use of SSR related with various disease were carried out. Shahini et al. (1984) suggested that from the fact that SSR was decreased in axonal neuropathy, SSR could be used as a useful mark for the diagnosis of diseases injuring an unmyelinated axon. Cheong et al. (1993) reported that the SSR latency and amplitude were prolonged and increased in patients with spinal cord injuries than in normal healthy adults, and also SSR with increasing spinal cord injuries was not evoked easily.

Zimmermann et al. (1995) reported that in patients with a stroke, the SSR latency was prolonged when the nerve stimulating position and recording position were different than same in the left and right sides. And Elie and Guiheneuc (1990) reported that in patients with multiple sclerosis, the abnormal diagnostic rate (94.2%) was higher in the SSR test than in other evoked potential tests.

In research on normal subjects and patients with non-insulin-dependent diabetes mellitus (Type II), Kim (1991) reported that non-SSR was appeared 53% at foots and 22%

at hands, and the SSR amplitude was decreased in patients with SSR than normal healthy subjects but the SSR latency was no difference between patients with SSR and normal healthy subjects. And also Soliven et al. (1987) reported that the SSR amplitude was more prolonged in patients with diabetic neuropathy. But because that was also prolonged in the control group. And so they suggested that in a clinical SSR interpretation, we should make a decision as abnormal when non-SSR was appeared rather than SSR amplitude decreased.

In our study, we obtained the results as follows. 1) the SSR latency and amplitude had no significantly difference between the right and left sides. 2) the SSR latency was shorter ($p<0.001$) in feet than in hands and the SSR amplitude higher ($p<0.001$) in feet than in hands. 3) P-type (32 subjects, 75%) was more than N-type (8 subjects, 25%) in the SSR waveforms. 4) the SSR latency and amplitude with increasing height at both soles were prolonged ($p<0.05$) and increased ($p<0.05$), respectively 5) the SSR latency and amplitude with increasing age at both soles were prolonged ($p<0.05$) and declined ($p<0.05$), respectively.

We expect that these our results on the SSR amplitude and latency in normal healthy subjects can be used as a clinical criteria for the SSR test.

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