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INFLUENCE OF RESPIRATION ON HUMAN SYMPATHETIC SKIN RESPONSE

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Abstract : Sympathetic skin response (SSR) is a reflexly elicited potential of the sweat glands, the afferent and efferent fibres of the reflex are cutaneous sensory fibres (if the SSR is elicited by electrical stimulus) and sympathetic sudomotor fibres respectively. Our earlier study indicated that latency, besides duration and amplitude, of SSR of a given normal individual showed significant variations between many trials of stimulation, even in a single sitting. Since deep inspiration is also an effective stimulus to elicite SSR, the present study was conducted to assess the influence of respiration on SSR. Thirtyfour healthy students participated in the study. The skin of the forearm of the dominant hand was stimulated by electrical square pulse and SSR was recorded from the ipsilateral hand. SSR was elicited and recorded in each subject during the various phases of respiration, namely, end expiration (EE), end inspiration (EI), mid expiration (ME) and mid inspiration (MI). It was observed that the mean values of SSR latency during these respiratory phases (EE : 1.59, EI: 1.51, ME : 1.55, and MI : 1.56 sec) were similar, indicating that the normal respiration might not be responsible for the observed interstimulation variations in latency in any given individual.

Key words : electrical stimulation sympathetic skin response respiration

INTRODUCTION

In many disease conditions, like diabetes mellitus (1), Guillain-Barre syndrome (2), rheumatoid arthritis (3), idiopathic autonomic insufficiency (4), autonomic nervous system gets affected. The main features of the autonomic nervous system involvement are disturbances in cardiac regulation, sweating and visceral functions (5). The clinical tests like, Valsalva's maneuver (6), lying to standing R-R interval ratio (7), standing to lying R-R interval ratio (8), render informations regarding parasympathetic nerves. The blood pressure responses to postural change, isometric exercise and immersion in cold water, assess predominantly sympathetic functions (1). The direct test for quantitatively assessing the function of sympathetic nervous system in human beings, namely the microneurography is invasive and time consuming (9). The abnormalities in sudomotor function of the extremities may preceed any detectable cardiovascular autonomic neuropathy (1). The recently introduced method of testing the latency of sympathetic skin response (SSR) is noninvasive and provides a quantitative measure of nerve impulse conduction in sudomotor sympathetic fibres (10).

The SSR is elicited, in brief, by electrical stimulation of cutaneous nerves. The afferent impulses reaching the spinal cord subsequently activate the postganglionic unmyelinated

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sympathetic nerves, causing synchronised activation of sweat glands. The electrical potential occurring prior to the actual sweating is recorded as sympathetic skin response. The SSR can also be elicited by a sudden deep breath or pain stimulus (11, 12).

While studying in our Laboratory, it was observed that latency, amplitude and duration of SSR of a given subject were showing significant amount of variation between many stimulation trials in a single sitting. While interstimulation variations in the amplitude and duration are commonly seen in literature, such variation in the latency is uncommon (11).

Since inspiratory maneuver is an effective stimulus for eliciting SSR and respiration modulates the sympathetic outflows (13), it was thought that the inter-stimulation variation in SSR latency in any individual might be due to the various phases of respiration. Thus the present study was carried out to assess whether respiration is responsible for the inter-stimulation variation in SSR latency.

METHODS

The study was conducted in 34 healthy student volunteers (age 15-20 yr; Males: 30; Females: 4). The procedure was explained to the subjects and verbal consent was obtained from them before commencement of the study. The Institute Ethical Committee approval was obtained for studying human sympathetic skin response. The entire study was conducted in the electrophysiology laboratory maintained at 28 ± 1°C.

The method for recording SSR was adapted from Shahani et al (10). The subject was lying relaxed in the supine position on a couch. The stimulation and the recording electrodes were fixed in the dominant hand of the subject as described below: The stimulating cathode was fixed in the anteromedial part of the forearm 3 cm proximal to the wrist. The stimulating anode was fixed on the dorsal surface of the forearm. The active recording electrode was fixed on the medial side of the palm of the hand. The reference recording electrode was fixed on the dorsum of the hand. Both stimulating and recording electrodes were ECG cup electrodes (Grass Inst. Co., Quincy, Mass, USA). The ground electrode was fixed near the wrist between the stimulating and the recording electrodes. The recording electrodes along with ground electrode were connected to the isolated input terminals of the pre-amplifier (Model 7P1A, Grass Inst. Co., Quincy, Mass., USA). For recording the respiratory phases, a stethograph was secured around the chest and the small pressure changes in the stethograph were sensed by a volume transducer (PT5A, Grass Inst. Co., Quincy, Mass., USA).

The skin area of the anteromedial part of the forearm near the wrist was stimulated by the cathode using a square wave pulse of 150 V obtained from an isolated stimulator (S_4 SIU-4B, Grass Inst. Co., Quincy, Mass., USA). Regarding the duration of the square wave pulse, for each subject different duration was required to elicit the response and the same duration was used for that particular subject throughout the study. The durations used in the study for all subjects ranged from 0.1 msec - 3 msec.

The SSR and respiratory phases were recorded in a Pen Recorder (Model 7 Ploygraph, Grass Inst. Co., Quincy, USA). The low and high frequencies of the recorder were 0.3 and 35 Hz respectively. The paper speed of the recorder was 25 mm/sec. The sensitivity of the recorder was adjusted in such a way that any spontaneous skin potentials were not recorded and only the evoked SSR was recorded. The stimulations were repeated during the various phases of respiration, namely, end expiration (EE), end inspiration (EI), mid expiration (ME) and mid inspiration (MI) and SSR was recorded for each stimulation (Fig. 1). The latency of SSR was measured manually from the tracings obtained as the time interval from the point of stimulation to the earliest point of the base line deviation.

Statistical analysis : The means of SSR latency obtained during the four respiratory phases were compared by using one way ANOVA. The minimum SSR latency was compared with that of maximum seen irrespective of the respiratory phases, of a particular subject by Student's paired t-test. A p-value of less than 0.05 was considered to denote statistical significance.

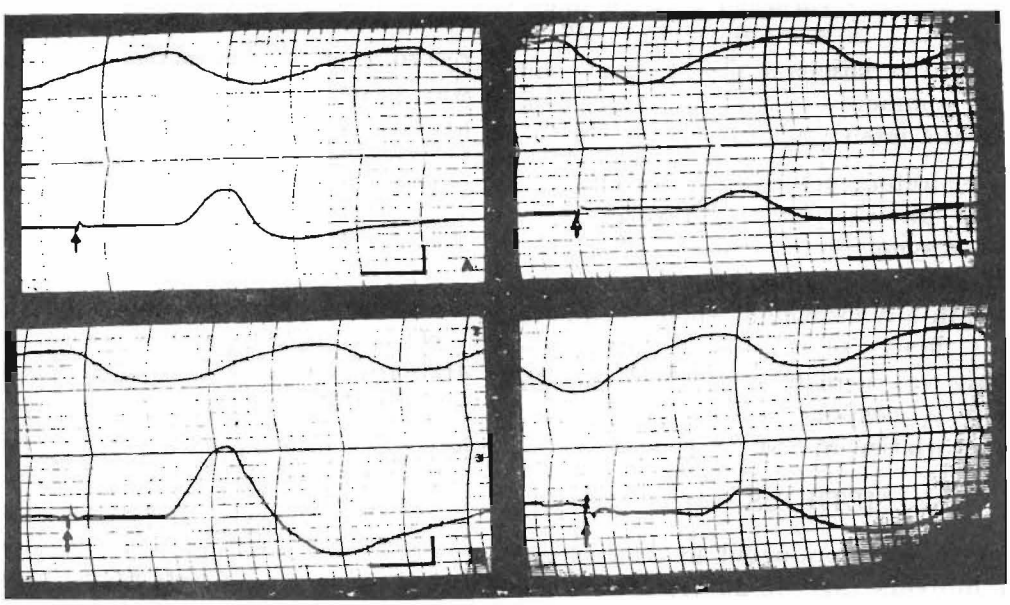

Fig. 1 : Recording of SSR during mid expiration (A), end expiration (B), mid inspiration (C), and end inspiration (D). Top trace in A,B,C, and D shows respiration (upward: expiration, downward: inspiration). Bottom trace in A,B,C, and D shows SSr. Vertical calibration: 500 microvolt; horizontal calibration: 1 sec.

RESULTS

The latency values of SSR obtained during the various phases of respiration, showed interstimulation variation in all the subject studied (Table I). Even within a given respiratory phase the SSR latency value of any given individual was not the same each time stimulated. In fact, each SSR latency value of any individual seen in Table I is the average of 2-3 trials recorded during the particular respiratory phase.

The mean ± SD values of SSR latency obtained during EE, EI, ME and MI for all subjects, were 1.59 ± 0.22, 1.51 ± 0.17, 1.55 ± 0.17 and 1.56 ± 0.26 sec respectively which were statistically similar (ANOVA, $F_{(3,132)}$ =1.038, P=0.378). However, the paried t-test revealed that the minimum value of SSR latency was significantly (P< 0.001) different from the maximum value of SSR latency of any given individual.

DISCUSSION

The values of SSR latency obtained in the present study (range: 1.15–1.59 sec) are similar to those reported for adults. Elie and Guiheneuc (14) reported a mean SSR latency of 1.5 sec and Shahani et al (10) reported a mean value of 1.4 sec. Our earlier study (unpublished) have shown that the values of SSR latency were similar in different age groups between 15 and 60 yr and there was no sex difference of SSR latency in any group studied.

The difference between the maximum and minimum values of SSR latency of any given

TABLE I: SSR latency during end expiration (EE), End Inspiration (EI), Mid Expiration (ME) and Mid Inspiration (MI) in the subjects studied.

Sl. No.	*SSR latency (sec)*			
	EE	*EI*	*ME*	*MI*
1	1.60	1.44	1.50	1.44
2	1.39	1.39	1.56	1.34
3	1.56	1.49	1.55	1.09
4	1.52	1.39	1.47	1.47
5	1.25	1.16	1.24	1.25
6	1.57	1.55	1.71	1.48
7	1.90	1.71	1.56	1.71
8	1.64	1.46	1.44	1.64
9	1.28	1.29	1.17	1.24
10	1.61	1.71	1.60	1.73
11	1.44	1.50	1.61	1.19
12	1.78	1.76	1.76	1.68
13	1.74	1.39	1.39	1.71
14	1.40	1.60	1.55	1.50
15	1.50	1.63	1.51	1.75
16	1.59	1.34	1.52	1.66
17	1.56	1.76	1.56	1.46
18	1.72	1.53	1.76	1.52
19	1.64	1.58	1.74	2.04
20	1.66	1.60	1.68	1.60
21	2.28	1.30	2.08	2.51
22	1.60	1.80	1.52	1.74
23	1.55	1.52	1.56	1.52
24	1.30	1.26	1.38	1.34
25	1.54	1.40	1.46	1.45
26	2.16	1.50	1.28	1.44
27	1.56	1.65	1.56	1.48
28	1.64	1.92	1.72	1.85
29	1.40	1.45	1.45	1.45
30	1.36	1.30	1.60	1.48
31	1.66	1.41	1.55	1.48
32	1.85	1.72	1.69	1.67
33	1.35	1.44	1.41	1.48
34	1.60	1.44	1.54	1.47
Mean	1.59	1.51	1.55	1.56
SD	0.22	0.17	0.17	0.26
SE	0.04	0.03	0.03	0.04

individual irrespective of the respiratory phases is a measure of interstimulation variation of the latency and is highly significant. Elie and Guiheneuc (14) have observed habituation in SSR and in their study, the SSR latencies showed interstimulus fluctuation and habituation-induced-increase (14).

In the present study, the average difference between the maximum and minimum values of SSR latency of any given individual irrespective of respiratory phases is about 0.4 sec. SSR is polysynaptic in origin. The transmission times utilised in the components of the reflex arc of SSR are approximately known (14). The conduction in the afferents of SSR seems to be mediated by type II fibres utilizing about 0.02 sec. The synaptic transmission in the central nervous system, though the detailed neuronal circuitry is not known, utilizes about 0.3 sec. The conduction in the sympathetic afferents utilizes about 0.5 sec and the depolarization of the sweat glands utilizes about 0.6 sec. The interstimulation variation of SSR

latency observed in the present study might not be happening in the conduction in the afferent and efferent nerves since interstimulation variation in the conduction velocity is not commonly reported. The interstimulation variations in the latency and amplitude of SSR were greatly minimized by the use of another simultaneously applied stimulus which may be possibly doing the 'preconditioning' of the central neurons (14). Thus the interstimulation latency variation in the present study might be occurring in the CNS processing of SSR. Since not much details are known regarding the variation in the depolarization of the sweat-glands, its possible role in the interstimulation variation of SSR latency is also not ruled out.

Respiratory modulation of the activity of sympathetic neurons in CNS is well documented. Johnson and Gilbey (13) observed that the sympathetic neurons of tail blood vessel in rats were firing mainly during expiration and the activity was influenced also by the lung inflation cycle. However, the mean values of SSR latency during the various phases of respiratory cycle obtained in the present study were not significantly different. The data of SSR latency also indicated that neither the maximum nor the minimum latency value occurred in any particular respiratory phase. Besides, in a recent study, the sympathetic activity of human skin nerves did not show any respiratory rhythm but exhibited irregular bursts (9). Thus, it was clear that the respiratory phases of quiet breathing did not have any apparent modulation on the sympathetic efferent neurons of SSR.

To summarize, in the present study there was significant interstimulation variation in SSR latency of any given individual. The different respiratory phases were not possibly responsible for such interstimulation variation. Incidentally, this study also provides the normal values of SSR latency for the population studied.

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