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EFFECTS OF DIFFERENT PSYCHOPHYSIOLOGICAL STRESSORS ON THE CUTANEOUS ELECTROGASTROGRAM IN HEALTHY SUBJECTS

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ABSTRACT

To evaluate the effect of psychophysiological stress on the gastric electrical activity, the cutaneous electrogastrography (EGG), a non-invasive technique, was performed in ten healthy subjects. Three different stressful (cold pressor test, arithmetic task, and Stroop color-word test) tests and a non-stressful (reading a booklet) task were administered, and EGG parameters (dominant frequency, coefficient of variation of dominant frequency, and gastric power) were recorded during baseline, task and rest periods.

Neutral task did not affect EGG parameters. During stressful stimulations, a slight decrease in the dominant frequency and an increase in the coefficient of variation of the dominant frequency were found. During arithmetic task, the gastric power significantly increased (baseline vs *stimulus P=0.008; stimulus* vs *rest P=0.015; baseline* vs *rest P=0.011), and a statistically significant difference beween gastric power during arithmetic and neutral task was observed (P = 0.007). During Stroop test, the gastric power showed only a trend toward significance (baseline* vs *stimulus P=0.018; stimulus* vs *rest P=0.018). A wide interindividual variability was recorded during the stress period. Therefore, the individual susceptibility to psychological stress may influence the EGG response and gastric electrical activity. In conclusion, cutaneous electrogastrography may be used as a non-invasive technique to study the effects of acute stressors on the gastric electrical activity.*

KEYWORDS*: Cutaneous electrogastrography, psychophysiology, stress, gastric electrical activity, man.*

INTRODUCTION

Several previous studies have shown that stress affects gastrointestinal motility (Creed, 1985; Bass, 1986; Steptoe, 1991). In the last decades a large number of controlled and uncontrolled experimental studies have been performed to elucidate these effects (Holtmann & Enck, 1991).

Different techniques are now available to record the gut motility. Invasive methods, such as intraluminal recording tubes, generally cause discomforts in subjects which may interfere with the induced experimental stress and limit the interpretation of results. For this reason, attempts have been made to study gastrointestinal motility by means of non-invasive methods (Bolondi *et al.*, 1985; Holtmann & Enck, 1991).

Cutaneous electrogastrography (EGG) is a reliable technique of non-invasive recording used to study the gastric electrical activity in patients with functional disorders of the digestive tract (Abell & Malagelada, 1988), notably the relationship between acute stress and motility in patients as well as in healthy subjects (Stern, 1983). EGG studies frequently use cold pressor test (Thompson *et al.*, 1982; 1983; Stanghellini *et al.*, 1983; 1984; Fone *et al.*, 1990;

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Stern *et al.*, 1991) and mental arithmetic task (Davis *et al.*, 1969; Holzl *et al.*, 1979; Thompson *et al.*, 1983) as acute stressors, but Stroop colour-word test has never been used.

The aim of this study was to evaluate the effect of different acute stressful stimulations on the electrical activity of stomach in healthy subjects by means of cutaneous EGG.

MATERIAL AND METHODS

Subjects

Ten healthy volunteers (5 men and 5 women, mean age: 31.7 ± 4.7 yrs) entered the study. The criteria of inclusion were: age 20-40 yrs; absence of cardiac, psychiatric, metabolic, and gastrointestinal diseases; no previous participation in experimental stress studies and no drug consumption for 3 days before experiment.

The experiment protocol was approved by the Scientific Committee of our Institute. Subjects provided a written informed consent before the start of test.

Procedure

Subjects were asked to abstain from alcohol and smoking, and to be fasted at least for 12 hours before the study. All examinations started at 9.00 a.m. Subjects comfortably laid in the supine position in a quiet, silent room, and EGG was continuously recorded. The perceived stress was assessed by a visual analogue scale (VAS). Subjects were asked to rate their actual psychological state: they put a mark on a 10 cm line with two labels printed at the two ends, "extremely relaxed" and "extremely tense", respectively. The distance between the mark and the left end of line (0 mm) represented the score of the subjective tension (Mc Dowell & Newell, 1987). Before the starting of the stress protocol, subjects were given time (20 min) to adapt themselves to the experimental setting. After the adaptation period, subjects were administered a 5 min neutral task which consisted in reading a booklet on animal life. It was administered in order to control the spontaneous variability of EGG and the unspecific attention effects. After that period, three different stressors were randomly administered to each subject in order to avoid a sequence stressor bias. A 5 min baseline period preceded a stressful stimulation lasting 5 min which was followed by a rest period of 10 min. VAS was administered after adaptation and stress periods. At the end of this sequence, a 20 min recovery period was recorded (see Fig. 1).

Description of the stressors

Cold Pressor Test. It is a physical irritating stimulus, based on the unpleasant stimulation of afferent nerve endings obtained with the immersion of non-dominant hand into cold water at 4°C for 30 s, with rewarming intervals of 15 s. This sequence was repeated for 5 min according to Wolff (1951).

Stroop Colour-Word Test. A table with the names of colours written in a colour ink which is different from the meaning of word (i.e. the word "blue" is written in red ink). Subjects were asked to name the color of ink and to ignore the word meaning. The stress experience arises from the conflict between color perception and cognitive naming of stimuli (Stroop, 1935). This so-called Stroop stressor period lasted for 5 min. An effort was made to drive the test in a stressful way in order to highlight the emotional condition of subjects. They vocalized their answers and were frequently urged to increase the speed of

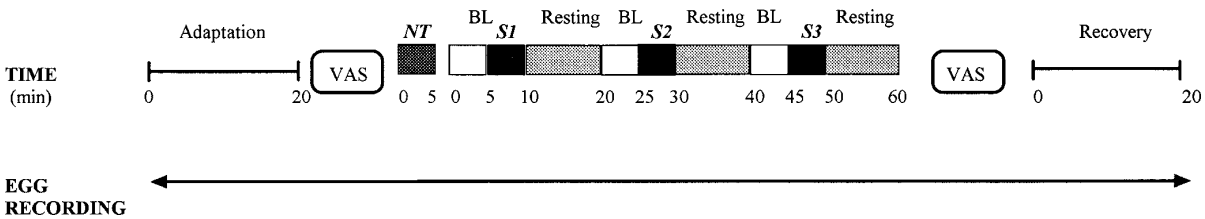

Fig. 1. SCHEME OF THE STUDY DESIGN. A 20 min adaptation period preceded the stress protocol. After the adaptation period, a 5 min neutral task (NT) which consisted in reading a booklet on animal life, was administered. Three different stressors (cold pressor test, arithmetic task, and Stroop color-word test) were randomly administered. Each stressor (S1, S2, S3) lasted 5 min. It was preceded by a 5 min baseline period (BL) and followed by 10 min rest period. A 20 min recovery period was recorded after the experiment.

their performance since they were told that the performance was very poor.

Mental Arithmetic Task. Subjects were asked to progressively subtract a seven- and seventeen-digit number from a given number over a 5 min period. The arithmetic task was conducted in the same stressful way as the Stroop test.

EGG recording technique

The cutaneous electrodes of the same type as used in electrocardiography were used (*Red Dot* 2249 3M). The location of the electrodes on the cutaneous surface, previously scrubbed with diethyl ether, was described in Chiloiro *et al.* (1994). The electrical activity was recorded on a paper chart (*Reega Minihuit TR Alvar*) for the visual inspection. Simultaneously, the signal was amplified and filtered (bioelectric Amplifier 8811A *Hewlett Packard;* cutoff frequency filter set at 0.6 and 30 cpm) and then digitalized (sampling frequency at 5 Hz) and fed into a computer (Vectra RS 20 *Hewlett Packard*). Amplifier sensitivity was the same for the 10 subjects. Data filtering and processing were performed by means of *Redtech* GiPC software. Since motion artifact appeared to increase the amplitude of the EGG signal, all recordings were visually inspected; only artifact-free periods were selected for analysis.

Spectral analysis is currently the most commonly method used to analyze the EGG (Linkens, 1978). Van der Schee *et al.* (1982) have described a method to make both frequency and time analysis possible, the running spectral analysis (Fig. 3).

The following parameters were evaluated in each subject for each period of the protocol, as reported in a previous paper (Riezzo *et al.*, 1992): 1/ mean gastric frequency (FC); 2/ coefficient of variation of the gastric frequency (CV) which reflects subtle changes of the gastric slow wave; 3 power content of the dominant gastric frequency (PW).

Statistical analysis

All values are expressed as mean ± SEM. Data were analyzed by using Wilcoxon's signed-rank test. The level of statistical significance of EGG parameters was adjusted for multiple comparison (n=3) by means of the Bonferroni procedure. A P value <0.017 was considered to be statistically significant. The comparison of VAS scores between pre- and post-experimental protocol was considered significant at a P value <0.05.

RESULTS

During the adaptation period, FC was 2.63 ± 0.13, CV 37.19 ± 6.06, and PW 21.5 ± 4.9. During the recovery period, FC was 2.45 ± 0.1, CV 33.38 ± 3.09, and PW 15.0 ± 4.5. No significant difference was observed in EGG parameters between adaptation and recovery periods. EGG data showed a profile characterized by a slight decrease in FC, and an increase in CV and PW. Particularly, during the cold test a high increase in CV was found, though it was

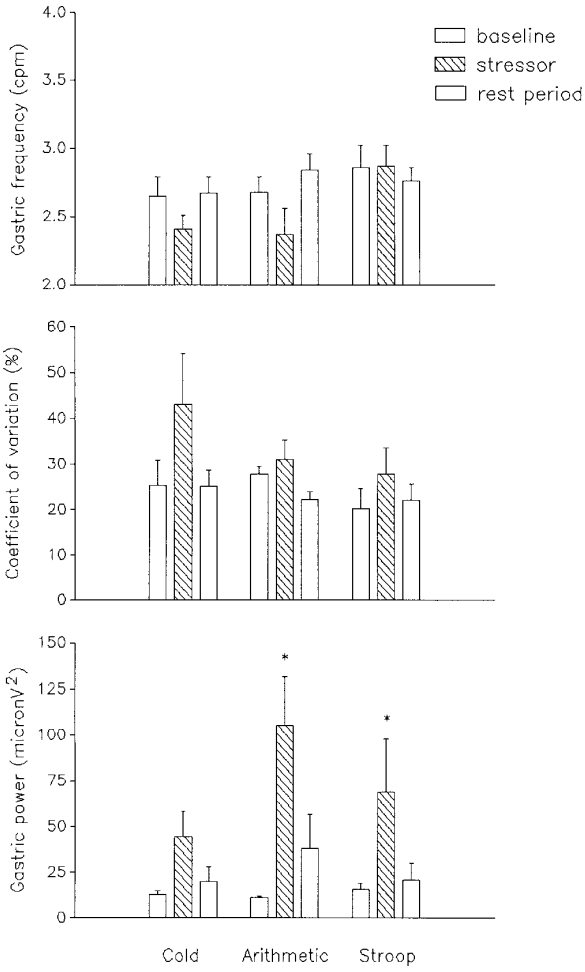

Fig. 2. PROFILES OF THE MEAN DOMINANT FREQUENCY (FC), COEFFICIENT OF VARIATION OF THE GASTRIC FREQUENCY (CV), AND SPECTRAL POWER (PW) FOR EACH STRESSFUL STIMULATION. EGG parameters were calculated from baseline, stressors, and rest periods. A slight decrease in dominant frequency, an increase in the coefficient of variation of gastric frequency, and an increase in spectral power during each acute stress (Arithmetic: baseline *vs* stimulus P=0.008; stimulus *vs* resting P=0.015; baseline *vs* resting P=0.011. Stroop: baseline *vs* stimulus P=0.018; stimulus *vs* resting P=0.018) can be observed. Data expressed as mean ± SE. * indicate significant changes.

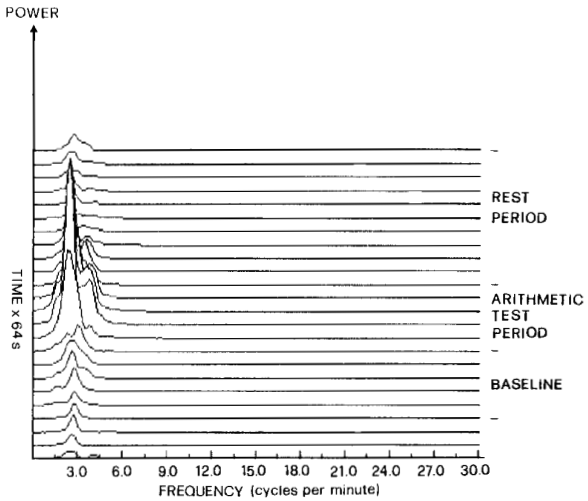

Fig. 3. RUNNING SPECTRA ANALYSIS OF A SUBJECT. Spectral power is the third dimension that appears to rise from the page. A high increase in power during arithmetic task can be clearly seen.

not statistically significant. Mental arithmetic caused a significant increase in PW (baseline *vs* stimulus: P=0.008; stimulus *vs* rest: P=0.015; baseline *vs* rest: P=0.011). A clear trend toward significance was observed also during the Stroop test (baseline *vs* stimulus: P=0.018; stimulus *vs* rest: P=0.018) (Fig. 2)

During the neutral task, EGG parameters were not significantly affected; FC was 2.84 ± 0.36, CV 26.75 ± 6.80, and PW 18.0 ± 3.27. EGG parameters were not significantly affected by the neutral task. A statistically significant difference was observed in PW between mental arithmetic and neutral task (P=0.007), and a trend toward significance was obtained between Stroop and neutral task (P=0.018). There was a significant difference in VAS score between pre- and post-experiment assessment (1.10 ± 0.22 *vs* 3.44 ± 0.82; P=0.04).

Figure 3 shows the running spectra obtained from a subject. The plot shows the changes in FC and PW over the time. After mental arithmetic, an increase in PW can be observed. No subject had gastrointestinal discomfort during the experiment.

DISCUSSION

Our findings confirm that the response to stress affects gastric electrical activity; in particular, a significant increase in gastric spectral power has been observed.

Previous studies have demonstrated that acute stress affects gastric motility, considered as gastric emptying time, antral motility, and gastric electrical activity (Holtmann & Enck, 1991). Stern *et al.* (1991) have studied fed and fasted healthy subjects. They have found that cold stress significantly decreased the power of normal 3 cpm EGG activity in fed subjects whereas fasted subjects showed a great variability in their responses, including paradoxical increases in power. Moreover, in Stern's study no subject has shown gastric dysrhythmia. We studied only fasted subjects showing a similar EGG pattern to cold stress as the fasted subjects in Stern's study. Other studies have demonstrated that the mean amplitude of EGG increases in healthy subjects performing mental arithmetic tasks and decreases during the rest period (Thompson *et al.*, 1983; Davis *et al.*, 1969; Vandecreek *et al.*, 1985). We found that EGG power increased also during the Stroop stimulation. To our knowledge, no study has used the Stroop Colour-Word test in the EGG recording, so we are not able to compare our results with those of the literature.

A profile of responses was obtained by comparing EGG data recorded during baseline, stressors, and rest periods. Stress caused an increase in PW and CV. Particularly, EGG data showed a statistically significant increase in PW during mental arithmetic task. Subjects did not seem to have completely recovered during the 10 min rest period following the mental task, and power value was higher than at baseline. We can state that the mental arithmetic task is the most stressful condition compared to cold and Stroop stimuli. These effects were due only to the stressful stimulation because an unspecific effect of the subjects' attention to the experimental condition can be excluded. Indeed, stress induction was demonstrated by a significant increase in subjective perceived stress (difference in VAS score recorded before and after the stress protocol), and EGG gastric power during the neutral task was significantly different from that during arithmetic task.

Only the arithmetic task showed a statistically significant increase in gastric power. It is likely that the lack of statistical significance during the other periods of the experiment was due to the low number of samples and/or the great interindividual variability. During the recording sessions, we observed a great variability in the psychological reactions of each subject to stressors. For example, during arithmetic test,

those subjects who were able to perform the mental task without any difficulty, showed no variation in EGG values, while subjects very irritated and emotionally distressed showed the greatest variation in the gastric electrical parameters. Therefore, this demonstrates that the individual ability and emotional susceptibility influence the gastric responses to psychological stressors.

In conclusion, the present study has shown that in a sample of healthy subjects fasting EGG activity is affected by different psychological stressors. The study has also demonstrated that a non-invasive technique as the cutaneous EGG may be a useful tool to analyze the effects of acute psychological stressors on gastric electrical activity.

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