Postprandial hypotension in elderly subjects: spectral analysis of heart rate variability and electrogastrograms

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Introduction

Since the first report on hypotensive reactions after meals (postprandial hypotension) in patients with Parkinsonism, by Seyer-Hansen, these reactions have also been reported in various other pathological conditions, such as diabetes mellitus, autonomic dysfunction, and Alzheimer’s disease, as well as in healthy elderly people. Postprandial hypotension has an etiology of fainting spells. Although various studies have reported the pathogenesis of postprandial hypotensive reactions, few studies have examined this pathogenesis by analyzing autonomic function in terms of heart rate variability.

In recent years, advances in medical and electrical technology have facilitated the detection of stable electrogastrographic signals (electrogastrogram; EGG), without distortion in waveforms, by removing the noise components, such as that of respiration, with superfilters. Thus, gastric motility, i.e., digestive tract movement, can be noninvasively and serially evaluated. Further, the analysis of heart rate variability has made it possible to evaluate the autonomic nervous system. In particular, power spectral analysis of heart rate variability, which measures sympathetic and parasympathetic activities, is useful for quantitatively evaluating autonomic nervous function.

In order to clarify the mechanism of postprandial hypotension in the elderly, we investigated the influence of gastric motility and autonomic nervous activity on hypotensive reactions after meals in elderly subjects, in whom postprandial hypotension may occur readily, and compared this influence with that in younger subjects.

Background. In order to clarify the mechanism of postprandial hypotension in the elderly, the influence of gastric motility and autonomic nervous activity on hypotensive reactions after meals was investigated, using electrogastrograms (EGGs) and spectral analysis of heart rate variability. Methods. EGGs, heart rate variability, blood pressure, and blood catecholamine levels before and after a meal were measured in 20 healthy young subjects (mean age, 25.6 ± 5.6 years; young group) and in 20 healthy elderly subjects (mean age, 78.3 ± 5.6 years; elderly group). Results. In the analysis of heart rate variability, no significant changes were observed in the low-frequency component (LF power), high-frequency component (HF power), or LF/HF ratio after the meal in the young group. In the other hand, the LF/HF ratio was significantly increased after the meal in the elderly group. In the EGG analysis, the peak power amplitudes after the meal were significantly increased compared with those before the meal in both groups. After the meal, the peak power amplitudes in the young group were significantly greater than those in the elderly group. The baseline blood noradrenaline level (before the meal) was higher in the elderly group than in the young group, but the level of this catecholamine in the elderly group did not increase significantly after the meal. Conclusions. It is suggested that the down-regulation of catecholamine may be one of the causes of postprandial hypotension in the elderly. The response to secreted catecholamine and the compensatory response to decreased blood flow in the systemic circulation were impaired in the elderly group, which finding may explain the high incidence of postprandial hypotension in the elderly subjects.

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Subjects and methods

Subjects

This study population consisted of 20 healthy young subjects (young group, aged 25.6 ± 5.6; years; range, 20 to 35 years) and 20 healthy elderly subjects (elderly group, aged 78.3 ± 5.6 years; range, 70 to 85 years). In both groups, the subjects had no history of cardiac disorder, no physiological abnormality, a systolic blood pressure of less than 130 mmHg, a diastolic blood pressure of less than 85 mmHg at rest, normal standard electrocardiogram (ECG) findings, normal chest X-ray findings, and normal urinalysis findings. Because gastric motility is influenced by the volume and content of meals, solid food (700 kcal, including 23 g of fat, 120 g of sugar, and 30 g of protein) was given to all subjects. Furthermore, to exclude the influence of circadian variation on autonomic nervous activity, all subjects began their meals at noon. Individuals who were receiving an autonomic agonist, such as a β-blocker or an anticholinergic agent, were not included in this study. Prior to participation in this study, all subjects gave their written informed consent, and we obtained approval from the Institutional Ethics Committee.

Analysis of heart rate variability

In both groups, two-channel ECGs (CM5 and CC5 leads) were serially recorded, using a Holter ECG (SM-50; Fukuda Denshi, Tokyo, Japan), from 60 min prior to the meal to 120 min after the end of the meal. To avoid the influence of postural change on the autonomic nervous system, the ECGs were recorded with the subject in a sitting position. The Holter ECG magnetic tape was analyzed using a work station (DWM-9000H; Fukuda Denshi). Data on R-R intervals on the ECG were input to a personal computer via a communication cable (RS232C), and were analyzed using a Holter data processing program (Fukuda Denshi) and a time-series data-analyzing system (MemCalc Ver 2.5; Suwa Trust, Tokyo, Japan).

For spectral analyses of heart rate variability, the low-frequency component (LF power; 0.04–0.15 Hz), high-frequency component (HF power; 0.15–0.40 Hz), and the ratio of LF power to HF power (LF/HF) were calculated by a fast Fourier transform (FFT) algorithm before and after the meal. Some researchers have speculated that the LF components express sympathetic nervous function, including parasympathetic nervous function. The HF components reflect parasympathetic nervous function related to respiration. In addition, the LF/HF ratio is considered to be an index of sympathetic-vagal balance or sympathetic nervous function. However, because LF/HF is inversely proportional to the size of the HF components, it has been reported that some increases in this index may reflect reduced cardiac parasympathetic activity. Heart rate variability was analyzed at 4-min intervals, and mean values were calculated before and after the meal.

Electrogastrography recording and analysis

An ambulatory electrogastrographic recorder (Nipro EG; A & D Company, Tokyo, Japan) was used to obtain EGGs from the fasting state (after a fast of more than 5 h) at rest to 2 h after a meal. The central terminal electrode for the EGG was placed halfway between the xiphoid process and the navel, and the other four electrodes were, respectively, placed above and below and to the left and right of the stomach. This ambulatory EGG recorder weighs 300 g, and four-channel EGGs were recorded stably, using a tenth filter sampling at 1-s cycles. Data recording was performed at 13 bits, with a sampling frequency of between 2.1 and 6.0 cycles/min (cpm). Data obtained were transferred to a personal computer via an RS-232C port, and FFT analysis was performed with respect to 512 points, using software for EGG (Nipro EG; A & D Company, Tokyo, Japan).

Using FFT analysis, dominant frequencies and their amplitudes (peak powers) were obtained from four-channel EGGs during fasting, and 30, 60, 90, and 120 min after a meal, and the mean values of the four channels were calculated at each of these times. The postprandial/fasting dominant frequency ratio (frequency ratio) and the postprandial/fasting peak power ratio (power ratio) were also evaluated.

Blood pressure and blood catecholamine levels before and after meals

Blood pressure was measured at fasting, and 30, 60, 90, and 120 min after the meal, using a mercury blood pressure manometer. Blood levels of catecholamines (i.e., adrenaline, noradrenaline, dopamine) were measured at fasting and 60 min after the meal by collecting venous blood through the cubital vein. Catecholamines were measured by high-performance liquid chromatography.

Statistical analysis

All values are given as means ± SDs. Statistical analysis was performed using StatView 5.0 software (SAS Institute, Cary, NC, USA) on a PC. Comparison between two groups was performed by one-way analysis of variance (ANOVA) and multiple comparisons and by two-way ANOVA (two-tailed). The relationships between variables in the two groups were studied by simple regression analysis. Statistical significance was set at P < 0.05.