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Inhibitory Effect of White Wine on Gastric Myoelectrical Activity and the Role of Vagal Tone

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Although extensively investigated throughout the gastrointestinal tract, the influence of alcohol on gastric motility is still unclear. Our aim was to investigate the effect of wine on gastric myoelectrical activity and vagal activity. Ten healthy subjects were studied in two sessions with the electrogastrogram (EGG) for 30 min at baseline, 30 min after ingesting the test liquid [white wine (12.5% alcohol) or matched juice], and 60 min after a standard test meal. Spectral analysis was performed to compute EGG parameters and their postprandial changes. The vagal activity was assessed based on spectral analysis of the heart rate variability (HRV) signal derived from the ECG recording. White wine preload significantly diminished the postprandial increase in EGG dominant power compared to juice preload (1.16 ± 1.57 vs 5.48 ± 1.01 dB, $P < 0.001$). A significant decrease in vagal activity was observed after wine (23.40 ± 4.30 vs 17.43 ± 3.40%, $P < 0.005$), which remained unchanged after the test meal (23.40 ± 4.30 vs 16.77 ± 4.40%, $P < 0.05$). This decrease was not noted in the juice session. A correlation was established between changes after wine consumption in EGG dominant power and in the percentage of the vagal activity ($r = 0.89$, $P < 0.05$). In conclusion, white wine preload inhibits the postprandial EGG dominant power, suggesting a possible inhibition of postprandial gastric contractions. This effect may be associated with diminished vagal activity.

KEY WORDS: alcohol; electrogastrography; gastrointestinal motility; gastric slow wave; stomach; heart rate variability.

Controversial reports concerning the role of alcohol in gastric motility have been presented by numerous investigators: accelerated gastric emptying (1, 2), delayed gastric emptying (3–6), or no motility changes at all (7, 8). All studies have been performed using different methods of gastric emptying. Most of them were done invasively by inserting a tube into the stomach. It is also of note that in many of these studies, a liquid meal was used, which evaluates only one component of the process of gastric emptying. Reasons accounting for the wide range of the results may be attributed to the diversity of variables among the studies. Different alcohol beverages were used (2, 9), with different percentages and doses (10), routes of administration (11), control groups, etc. The number of explanations matches the diversity of results, implicating neural, humoral, and local mediators. The effect of alcohol on gastric myoelectrical activity that regulates gastric motility has not been studied.

Gastric motility is regulated by gastric myoelectrical activity that is composed of slow waves and spikes. While the slow waves are associated with rhythm and regularity, the superimposed spikes are associated with antral contractions (12). The electrogastrogram

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(EGG) is a measurement of this activity from the abdominal surface. Its simultaneous recording from the gastric serosa has shown that the dominant frequency of the EGG reflects the frequency of the gastric slow waves, and its relative change in dominant power/amplitude is associated with gastric contractility (13–15). Further studies have emphasized the correlation between the EGG and impaired motility. In one study, 74% of patients with documented gastroparesis (delayed gastric emptying measured by scintigraphy) exhibited a range of abnormalities in the EGG (16). In another, all patients with abnormalities in both EGG rhythmicity and power had delayed gastric emptying (17).

The effect of alcohol on the autonomic nervous system has also been investigated using spectral analysis of heart rate variability (HRV) (18–20). Similar to its influence on the gastrointestinal tract, alcohol was shown to exert inconsistent effects on the autonomic system.

The aim of the current study was to investigate the effect of white wine on gastric myoelectrical activity and its possible correlation with cardiac vagal tone using noninvasive electrogastrography and electrocardiography. We created an almost natural setting utilizing a noninvasive method, a socially acceptable amount of wine, and a practical standard test meal. The effect of white wine was evaluated by comparison with a corresponding matched beverage, in order to eliminate as many variables as possible and get closer to the "net" effect of the alcoholic beverage chosen, the white wine. The possible mechanism for the influence of white wine on the gastrointestinal tract has been further investigated by adding a simultaneous heart rate variability measurement. Thus, the autonomic nervous system has been reflected in both myoelectrical activity and heart rate variability

MATERIALS AND METHODS

Subjects. Ten healthy volunteers (all European Americans) were studied. Asians were excluded to avoid possible different responses to wine. None had any gastrointestinal symptomatology, disease, or surgery. Average age was 29.7 ± 3 years, ranging from 23 to 56 (8 men, 2 women). The mean body mass index of the subjects was 25.3 kg/m^2 with a range from 21.3 kg/m^2 to 29.2 kg/m^2. One woman was menopausal and the other women were studied in the follicular phase of menses to avoid the influence of hormonal changes. All volunteers consumed wine occasionally, but not more than twice a week. No subject was under any medications during the study period. The Institutional Review Board approved the protocol and each participant signed a consent form prior to the study.

Study Design. The study was performed in two separate sessions after a fast of at least 6 hr before the recording. In one session, wine (120 ml of white wine, 12.5% by volume; Lindshein, Australia) was ingested within 3 min and in the other, the same amount of juice matched with wine in volume, pH, sodium concentration, sugar, and caloric content. The drinks were at room temperature. The two sessions were randomized and were done on two separate days within one week. The sessions were in the same period of the day. The EGG and ECG were performed for 30 min before and 30 min after the ingestion of wine or juice, and a consecutive hour following a standard meal (475 kcal, protein 21%, fat 17%, carbohydrate 61% and fiber 2 gms) (21, 22) consumed within 10 min. The measurement of the EGG took place in a quiet room where the subjects could watch regular TV programs in a supine position. They were asked to minimize their movements, and talking or reading was not allowed during the recording.

EGG Measurement and Analysis. Gastric myoelectrical activity was recorded noninvasively using surface electrogastrography. The abdominal skin was prepared with skin-prep jelly to reduce the impedance. Then, three silver–silver chloride ECG electrodes were placed on the prepared abdominal surface according to information published in previous studies, where the stomach was localized by ultrasonography (21, 22). The first electrode was set above the antrum (located 1–3 cm right of the midline, between the xiphoid process and the umbilicus), the second, 45 degrees and 5 cm above and left to the first electrode, and the third (reference) electrode at the left costal margin, horizontal to the first electrode. The electrodes were connected to a portable ambulatory device with a recording frequency of 1–18 cpm, (Digitrapper EGG, Synectics, Medical Inc., Shoreview, Minnesota, USA). The EGG signal was sampled at a rate of 1 Hz.

Motion artifacts or profound breathing movements were deleted by visual inspection before computerized spectral analysis (23). EGG data were assessed using the following parameters: (1) the dominant frequency—the frequency at which the EGG power spectrum has a peak power in the range of the 2–4 cpm; and (2) the dominant power—the power of the dominant frequency is associated with the amplitude and regularity of the EGG. The dominant frequency and power of the EGG were computed using smoothed (or overall) power spectral analysis method (16).

ECG Measurement. The ECG was recorded using three bipolar electrodes connected to an Alice 3 Polysomnographic System (Healthdyne, Inc., Marietta, Georgia, USA). The R-R intervals were derived from the ECG. The signal of R-R intervals was interpreted and sampled at 1 Hz using MATLAB (The MATH Works, Inc., Natick, Massachusetts, USA). The spectral analysis method was used to compute percentage of low frequency (LF) component at a frequency of 0.04–0.15 Hz and the percentage of high frequency (HF) component at a frequency of 0.15–0.5 Hz (24). The percentage was defined as the ratio of the area under the curve in the power spectrum in the specified frequency band and that in the whole spectral band (0.0–0.5 Hz). The ratio (LF/HF) reflects the balance between the sympathetic activity and the parasympathetic activity.

Statistical Analysis. All data were expressed as mean ± SEM, and $P < 0.05$ was considered as statistically significant. Student's t test was performed to assess the differences in EGG and HRV parameters between wine and juice. The Pearson test was used to study the correlation between gastric myoelectrical activity and heart rate variability.

RESULTS

Immediate Effect of Wine or Juice on Dominant Power of EGG. Regular gastric slow waves, which were recorded in the baseline EGG, and recordings obtained in one subject before and after wine are presented in Figure 1. The immediate effects of juice and wine ingestion were measured in the 30-min period following their ingestion, and the results were compared with the 30-min baseline recording in the fasting state. As shown in Figure 2, the dominant EGG power was increased by 3.01 ± 1.15 dB ($P < 0.03$) after juice ingestion, while after wine it showed a decrease of 0.73 ± 0.90 dB (NS). The difference between these two responses was statistically significant ($P < 0.04$).

Effect of Wine or Juice Preload on Postprandial Dominant Power of EGG. Effects of juice or wine preload on the postprandial EGG were evaluated by comparing the relative changes of the dominant power in the postprandial state versus the fasting baseline state. A significant increase (5.48 ± 1.01 dB, $P < 0.0007$) in the dominant power of the postprandial EGG was observed with juice preload. This increase was, however, not noted in the study session

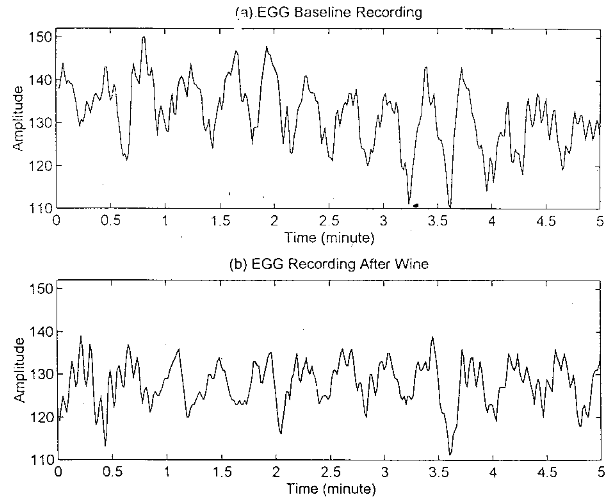

Fig 1. EGG recordings in one subject before (a) and after (b) ingestion of wine. A decrease in the amplitude of the EGG after wine is noted.

with wine preload (1.15 ± 1.57 dB, $P > 0.05$). The difference in the postprandial change in the dominant power between the two sessions was statistically significant ($P < 0.001$, see Figure 3).

Effect of Wine on Dominant Frequency of EGG. The dominant frequency was not changed after ingestion of wine (2.88 ± 0.08 vs 2.96 ± 0.12 cpm, $P > 0.6$), but increased significantly postprandially (2.88 ± 0.08 vs 3.1 ± 0.05 cpm, $P < 0.009$) similar to the expected response to food with no intervention.

Immediate and Preload Effects of Wine on High Frequency (HF) Band of HRV. A significant decrease in the HF component of the HRV was observed immediately after wine ingestion (23.40 ± 4.3 vs

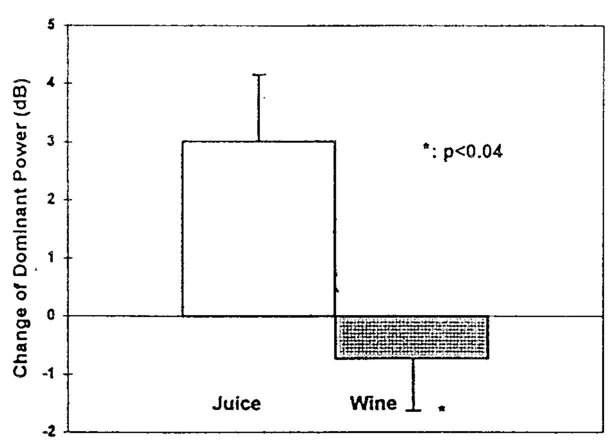

Fig 2. Immediate effect of wine and juice ingestion on the dominant power of the EGG in the fasting state. The difference between the increase in the dominant power after juice ingestion and the decrease after wine ingestion was statistically significant.

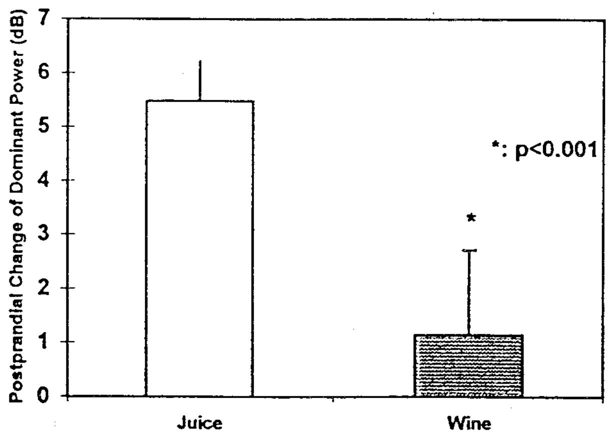

Fig 3. Postprandial changes of the dominant power of the EGG with wine and juice preload. The postprandial increase of the dominant power was significantly diminished with wine preload, in comparison with juice preload.

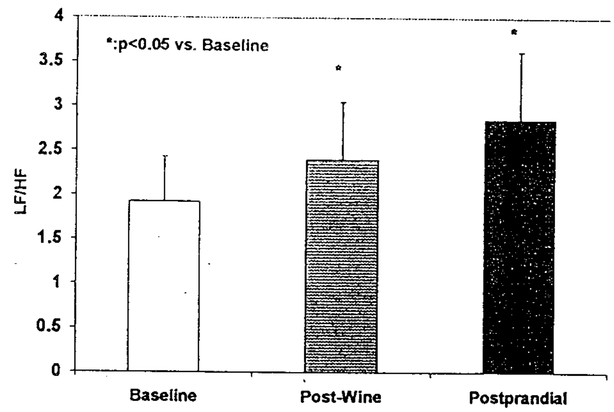

Fig 5. Immediate and preload effects of wine on the low frequency/ high frequency (LF/HF) ratio of the HRV. Wine decreases both significantly.

17.4 ± 3.40%, $P < 0.005$). A significant decrease in the HF was also noticed following the test meal, with wine preload (23.40 ± 4.30 vs 16.80 ± 4.40%, $P < 0.05$) (Figure 4).

Immediate and Preload Effects of Wine on Low Frequency/High Frequency (LF/HF) Ratio of HRV. Wine increased the LF/HF ratio, both immediately after ingestion (1.92 ± 0.51 vs 2.40 ± 0.65, $P < 0.05$) and following the test meal (1.92 ± 0.51 vs 2.85 ± 0.77, $P < 0.04$) (Figure 5).

Correlation Between EGG and HRV. A correlation was established between the postprandial changes of the EGG dominant power and the postprandial changes of the percentage of the HF component in the power spectrum of the HRV ($r = 0.89$, $P < 0.05$).

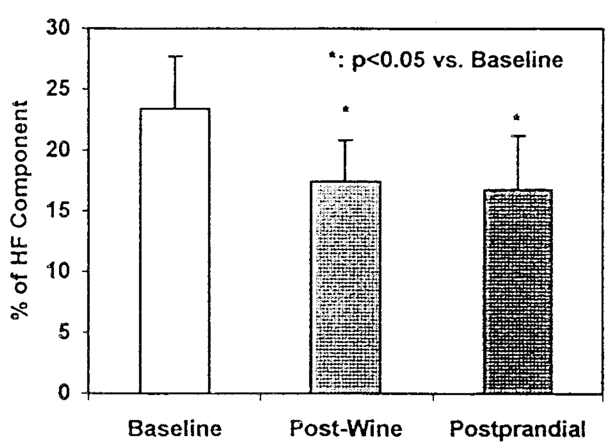

Fig 4. Immediate and preload effects of wine on the high frequency (HF) component of the HRV. Wine influences this component by a significant decrease in both instances.

DISCUSSION

Effect of Wine on Gastric Myoelectrical Activity. Unlike most studies investigating the influence of alcohol on gastric function by measuring gastric emptying, we assessed gastric myoelectrical activity using the EGG. Standardization of information collected in those studies was difficult, owing to the lack of common denominators (type, percentage, and quantity of alcohol used, test meals, controls, etc.). We tried to eliminate some of the confounding variables by using a closely matched beverage and a solid test meal. In our study, the acute ingestion of white wine in healthy volunteers resulted in a characteristic pattern that was confined to a single EGG parameter: the dominant power. White wine reduced gastric myoelectrical activity, and this might be translated into the inhibition of the forceful propulsive movements of the stomach. No changes were observed in the dominant frequency or the percentage of normal slow waves, suggesting that wine does not affect the basic rhythm and regularity of the gastric slow wave.

Review of the literature classifies the acute effect of alcohol on gastric emptying according to its kinetic effect; in some, certain types of alcohol or doses are considered. Pure ethanol and whisky caused a delayed gastric emptying of both liquid and solid meals in several studies in humans (2–5, 7), as well as in animals (6, 11), while others noted an increased rate of emptying (1). White wine produced varying results ranging from no change (8), to delay (2) and even acceleration of gastric emptying (9). Beer was reported to increase the rate of emptying (9). In terms of quantity, larger amounts of alcohol were shown to cause a significant prolongation of gastric emptying

(10, 11). The diversity of observations produced numerous theories and additional studies, most targeting hormonal changes. In one study, alcohol beverages were reported to decrease in pancreatic enzyme secretion (25). The role of gastrin, a potent inhibitor of gastric contractile activity, was explored by several groups (26, 27). One of them documented a high production of gastrin following wine and beer. Another study demonstrated a delay in the release of ACh, which is known to stimulate gastric contractions and emptying (27).

Effect of Wine on Heart Rate Variability. In this study we found that both immediate and preload ingestion of white wine resulted in a significant decrease of the percentage of the high frequency components of the HRV, with a simultaneous increase of the LF/HF ratio. While the HF is believed to reflect the parasympathetic or vagal activity, the LF represents mostly the sympathetic activity (28, 29).

Several previous studies investigated the acute effect of alcohol on the autonomic nervous system, using a similar methodology, and the data were in an agreement with this current study. Koskinen et al reported a significant decrease in the HF component with a moderate amount of alcohol in healthy volunteers (18). Murata et al found an increase in the heart rate and a negative correlation with the HF change (19). The study by Van Der Borne et al showed an increase in LF/HF, attributed to an increase in the LF component (20). The chronic use of alcohol was shown to provide a more uniform pattern of reduced vagal activity (30, 31). The total damage to the autonomic nervous system in general and the parasympathetic activity in particular was found to be dose dependent (32).

Correlation Between EGG and HRV. Simultaneous recordings of the EGG and the ECG were performed in two previous studies. Watanabe et al investigated the effect of water ingestion on the EGG dominant power and the HF component of the HRV (33). Although the HF component showed no significant changes, it was positively correlated with the increase of the EGG dominant power. Kaneko et al performed a similar study and reported an increase in the EGG dominant power, a transient increase in the HF, and no changes in the LF/HF ratio (34); the correlation between the EGG power change and the change of the HF component was not reported. It is of note that both studies used a low noncaloric liquid meal and a short period of recording, which might have led to results different from the current study.

One of the most interesting results in our study is the correlation between the gastric myoelectrical activity and the cardiac rhythm. White wine induced comparable changes in the dominant power of the EGG and the HF component of the HRV. The common mechanism may involve the vagal tone that affects both organs. The postprandial increase in the dominant power of the EGG has been established in numerous studies (21, 22, 35). The role of the vagus as a mediator of this increase has also been shown in several studies using sham feeding or demonstrating the lack of this phenomenon in patients who underwent vagotomy (36). The correlation of the EGG and the HF component of the HRV may suggest that the reduction of the EGG power was mediated via the vagal mechanism.

In summary, white wine diminishes the amplitude of gastric myoelectrical activity and cardiac vagal activity. The change of gastric myoelectrical activity may be mediated via vagal mechanism.

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