Effects of Carbohydrate Meals of Varying Consistency on Gastric Myoelectrical Activity

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ABSTRACT

Background: **There is at present no agreement on the type of test meal to be used when performing EGG. To our knowledge the response of the stomach to high carbohydrate isocaloric meals of different consistencies has not been formally assessed.**

Aim: **To study 1) the effects of high carbohydrate meals of varying consistency on EGG activity; and 2) the effects of increasing the calorie content of a meal without changing its consistency and composition on the postprandial EGG.**

Subjects: **Eighteen healthy volunteers, six males (age: 21-35 year, weight: 45-60 kg) and 12 females in the follicular phase of the menstrual cycle (age: 24-30 years, weight: 45-55 kg).**

Methods: **Following an overnight fast subjects were given three high carbohydrate, low fat, isocaloric meals (165-170 kcal) of different consistencies (solid, semisolid, liquid), on three separate days in a random order. The liquid and semisolid meals were equal in volume (200 ml) while the volume of the solid meal was smaller. One hour EGG recordings were done in the fasting and fed states in each subject. As a second step, ten of the above volunteers (taken randomly) were given the solid test meal on a separate day after increasing the calorie content of the meal to 350 kcal.**

Results: **The power of the EGG at the dominant frequency significantly increased after solid (175 kcal meal: fasting 49 ± 12 dB vs. fed 57 ± 13 dB; p<0.05, 375 kcal meal: fasting 48.5 ± 12.9 dB vs fed 58.1 ± 11.7 dB) and semisolid (fasting 50 ± 12 dB vs. fed 55 ± 13; P<0.05). The increase in power was not significantly different when fed with solids and semisolids. There was no statistically significant change in EGG power during the first 15 or 60 minutes after the liquid meal. Feeding showed no significant effect on the dominant frequency and the percentage of 2-4 cpm waves of the EGG with any of the three types of test meals.**

Conclusions: **Solid and semisolid meals high in carbohydrate and low in fat are capable of inducing a significant increase in the EGG power in normal subjects. Isocaloric solid and semisolid meals have similar effects on gastric slow wave activity. EGG appears unaffected by the liquid meal. Therefore only an increase in the power of the EGG can be regarded as normal if a high carbohydrate solid or a semisolid meal is given as the test meal when performing an EGG.**

Keywords: Electrogastrography, test meal consistency, gastric myoelectrical activity

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INTRODUCTION

Gastric motility is controlled by gastric myoelectrical activity which originates in a pacemaker situated along the greater curvature of the stomach. Gastric myoelectrical activity consists of slow waves and spikes. Spikes superimposed on slow waves are associated with gastric contractions. Cutaneous electrogastrography (EGG) is a non invasive, well tolerated and reliable means of recording gastric myoelectrical activity.

Investigation of the myoelectrical response of the stomach to a meal is of importance in patients suspected of having gastric motility disorders. Some of these disorders (e.g. idiopathic gastroparesis, diabetic gastroparesis, nausea and vomiting of pregnancy) are known to be associated with abnormalities of gastric myoelectrical activity[2-6]. Recording of postprandial EGG following a test meal has become an accepted component of gastric motility studies[2,3]. Lack of a standardised test meal to study postprandial gastric myoelectrical activity is a drawback in EGG interpretation. It is well known that properties of a meal such as volume, composition and consistency affect gastric motility and emptying by neural and humoral factors. Several studies have shown that constituents of a test meal affect the postprandial gastric electrical activity[2,7-9]. Moreover, food habits and preferences differ from country to

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Table 1. Fasting and postprandial EGG parameters (mean ± SD) in the three study sessions (step 1 of the study).

	Solid Meal (175 kcal) (n=18)			Semisolid Meal (n=18)			Liquid Meal (n=18)		
	PDF	PDP	% 3 cpm	PDF	PDP	% 3 cpm	PDF	PDP	% 3 cpm
Fasting	2.75 ± 0.37	49.9 ± 12.7	86.6 ± 21.3	2.87 ± 0.29	50 ± 12.3	87.6 ± 13.6	2.82 ± 0.39	52 ± 11.9	86.5 ± 17
Fed	2.83 ± 0.25	57.3 ± 12.9	91.1 ± 17	2.99 ± 0.29	55.3 ± 12	86.5 ± 16	2.92 ± 0.30	52 ± 13.9	80 ± 18.9
P value	NS	<0.05	NS	NS	<0.05	NS	NS	NS	NS

Number of subjects (n), period dominant frequency (PDF), Period dominant power (PDP), % of 2-4 cpm waves (% 3 cpm), P values were in comparison with the fasting data.

country (The traditional Sri Lankan diet consists mainly of carbohydrates and is low in animal proteins). Therefore preparation of a test meal acceptable to all the subjects undergoing electrogastrography seems to be a difficult task.

The effects of meals with the same calorie content but with different consistencies on gastric myoelectrical activity is of importance when selecting a test meal most appropriate for a patient undergoing electrogastrography (e.g. some patients referred for electrogastrography are unable to ingest a solid test meal while some others are unable to take a large meal or do not prefer to take a large meal as the test meal).

Myoelectrical activity of the stomach in response to isocaloric meals of different consistency has also not been formally assessed. The aims of our study are (1) to investigate the effects of high carbohydrate meals of varying consistency on postprandial EGG activity; and (2) to study the effects of increasing the calorie content of a given test meal without changing its composition and consistency on postprandial EGG activity.

METHODS

Step I

Subjects: 18 healthy volunteers, six males (age: 21-35 year, weight: 45-60 kg) and 12 females (age: 24-30 years, weight: 45-55 kg) in the follicular phase of the menstrual cycle (since the gastric electrical activity is reported to be affected by the phase of the menstrual cycle)[13] were recruited for the study. The subjects were not on any medication during the period of the study. None had any symptoms relating to the gastrointestinal tract, nor any illness or surgery involving the gastrointestinal tract. Informed consent was obtained from all the volunteers prior to the study. The study had been approved by the Ethics Committee of the Faculty of Medicine, University of Kelaniya.

Test meals: Each subject was given three low fat, high carbohydrate, isocaloric meals of different consistency in random order, each after an overnight fast. The solid meal consisted of white bread (75 g) and jam (15 g), and the semisolid meal consisted of a pre-cooked mixture made out of rice flour, green gram flour, and sugar ("Nestum"– 35 g) mixed with water (l00 ml). Apple juice (200 ml) with added sugar (l5 g) was given as the liquid meal. The calorie content of each meal was l65-170 kcal and consisted of 35-40 g carbohydrates, 1-3 g proteins and 1-2 g fat. The volume of the semisolid and the liquid meal was 200 ml. The volume of the solid meal was less than that of the other meals.

Step 2

Ten of the above volunteers were taken randomly and given the solid test meal used above on a separate day after increasing the calorie content of the meal to 350 kcal (i.e. by giving four slices of white bread with jam (25 g) instead of two slices given in step 2 of the study.

EGG recording: One hour EGG recordings were obtained in the fasting and fed states in each subject. They were kept in the supine position in a quiet room during the study and were requested to minimise body movements during the period of recording. Gastric electrical activity was recorded using three surface electrodes (two active and one reference electrode). Electrodes were placed on the abdomen after preparing the skin with a sandy skin preparation jelly to reduce the impedance of the circuit formed by the electrodes and the body. Standardised electrode placement locations for a single channel EGG recording were used[10]. The first active electrode was placed at the midpoint between the xiphoid process and the umbilicus while the second active electrode was placed 5 cm above and 45° to the left of the first electrode. The reference electrode was kept 10 cm away and to the right of the first electrode in the same plane. Single channel EGG recording was performed using Digitrapper – EGG (Synectics Medical, Sweden) with a sampling frequency of 4 Hz.

Due to low signal to noise ratio of the EGG, data analysis was performed using ElectroGastroGram software – version 6. 30 (Synectics Medical, Sweden). Before computerised analysis, visual inspection of

the EGG recording was performed in order to remove motion artefacts. Computerised spectral analysis of the recordings were done and the following EGG parameters were obtained for the fasting and fed periods[7-9]: a) Dominant frequency (DF) represents the frequency of the gastric slow wave. The normal gastric slow wave frequency is 3 cpm (2-4 cpm). Dominant frequency between 0.5-2 cpm is considered as bradygastria and between 4-9 cpm is considered as tachygastria. b) Percentage of 2-4 cpm gastric slow waves defined as the percentage of time during which the normal 3 cpm waves are observed in the EGG. c) Dominant power (DP) - depends on the amplitude and the regularity of the EGG. Decibel units (dB) were used to represent the power of the gastric slow wave. Assuming a sinusoidal signal with an amplitude A, power P is expressed as P (dB) = 20 x log (A). In a power spectrum of an EGG the frequency et which the power has a peak value is called the dominant frequency and the peak power is called the dominant power .

Statistical analysis: Student's paired t-test was applied to compare different EGG parameters between the study sessions. P values of <0.05 were considered as statistically significant.

RESULTS

Fasting EGG recordings were obtained from each subject prior to the test meals. In step I of the study the mean dominant frequency, the percentage of normal 3 cpm waves and the power of the fasting EGG were not significantly different (n=18, DF p>0.05) on the three recording days indicating the reproducibility of fasting data. The mean dominant frequency was 2.75 cpm ± 0.37, 2.87 cpm ± 0.29 and 2.82 cpm ± 0.39 on day 1, day 2 and day 3 respectively. The mean power was 49.9 dB ± 12.7, 50 dB ± 12.3 and 52 dB ± 11.9 on day l, day 2 and day 3 respectively. The analysis of variance showed that the mean pre-prandial gastric frequency and power were not significantly different on the three days (P>0.05). Regular slow waves (>70%) were recorded on the electrogastrogram in all subjects pre and post prandially (n=16) except two of them who had gastric dysrrhythmias exceeding 30% of the electrogastrography recording. One showed bradygastria in the pre (52%) and postprandial (67%) EGG in a single study session and the other subject showed bradygastria in the fasting EGG (50%) which was reverted back to normal after the solid test meal. A reduction in normal 3 cpm waves in the EGG (<70%) has been observed in few normal control subjects in a previous study[11] suggesting the possibility of a normal variation in the gastric electrical activity.

Postprandial response of the EGG to test meals

Compared with fasting values there was a significant increase in the dominant power of the EGG following the solid meal (Table). There was no significant increase in the dominant frequency after the solid meal (Table). The percentage of 2-4 cpm gastric slow waves showed a noticeable increase after the solid meal but the increase was not statistically significant (Table). The same observations were made after increasing the calorie content of the solid test meal in step 2 of the study (n=10, fasting DF- 2.81 ± 0.3; n=10, fed DF 2.81 ± 0.42; P>0.05: n=10, fasting DP – 48.5 ± 12.9; n=10, fed DP 58.1 ± 11.7; P<0.05).

The results with the semisolid meal were similar: The semisolid meal didn't have a significant effect on the frequency of the EGG or percentage of 2-4 cpm gastric slow waves compared to fasting values (Table). The power of the dominant frequency increased significantly after the semisolid test meal (Table). The postprandial increases in the dominant power were not significantly different between the solid and semisolid test meals (post prandial power increase with the solid meal 7.2 dB ± 12; with the semisolid meal 5.6 ± 11.8, P>0.05).

In contrast to the above findings the liquid meal (even though isocaloric with the other meals and equal in volume to the semisolid meal) failed to produce significant changes in EGG power during the first 15 and 60 min. postprandial periods (n=18, fasting 52 ± 11 dB vs. fed $^{15\ min}$ 52.2 ± 13.5 dB: n=18, fed $^{60\ min}$ 52 ± 12 dB; P>0.05) . The liquid meal also did not cause a significant increase in EGG frequency or percentage of 2-4 cpm gastric slow waves (n=18, fasting DF 2.82 ± 0.39, fed DF 2.92 ± 0.30, P>0.05: fasting % 3 cpm activity 86.5 ± 17, fed % 3 cpm activity 80 ± 18.9, P>0.05).

DISCUSSION AND CONCLUSIONS

Our results indicate that there is an increase in the dominant power of the postprandial EGG following solid and semisolid meals, but not liquid meals. Power or amplitude increase of the EGG at the dominant frequency after solid meals has been observed by many investigators[2,3,7-9]. It is widely accepted that this is due to the increased strength of contractile activity in the stomach in response to such a meal[1-4]. Even though it has previously been shown that there is a significant increase in the dominant frequency of the EGG after a solid meal[2,3,7-9,12,13] our results failed to show such an increase. Results of a previous study by Levanon et al [8] on the effects of meal volume and composition on gastric myoelectrical activity have shown that low calorie test meals are unable to generate expected postprandial

changes in the gastric myoelectrical activity. However even after increasing the calorie content of the solid test meal we failed to demonstrate a significant increase in the frequency of the EGG. Therefore inability to detect a significant increase in the dominant EGG frequency after solid and semisolid meals in the present study could not be attributed to the low calorie content of our test meals. Compared with the test meals given by other investigators[7-9] our meals consisted mainly of carbohydrates and had a low protein content. Furthermore compared with the fat content of the low calorie test meal given in the study by Levanon et al[8] our test meals had a very low fat content. Various study groups[2,9] have shown that fat preload results in a decrease in the EGG dominant power due to inhibition of spike activity in the stomach. Therefore, in spite of the low caloric content, the power increase we observed with solid and semisolid test meals in the first step of our study may be due to the low fat content of our meals. However, the impact of dietary protein concentration on the frequency and the power of the EGG has not been studied.

Compared with the other two test meals in step 1 of the study, the liquid test meal failed to induce any changes in the observed EGG parameters within the 15- and 60-minute periods that followed the meal. This is in spite of the liquid meal being of the same caloric content and composition as the solid meal and also the same volume as the semisolid meal. In a study by Chen and McCallum[7], it was shown that water was not capable of inducing contractions in the distal stomach, and they attributed the power increase observed with liquids to gastric distension which brings the stomach closer to the recording electrodes. However, in the study by D. Levanon et al[8], a low volume meal was capable of producing similar postprandial EGG power changes as the reference meal. The reduced calorie meal having the same weight and volume of the reference meal was not capable of increasing the EGG amplitude. Similarly, in step 2 of our study, in spite of the increased calorie content and the volume of the solid test meal the postprandial EGG power increase was not significantly different from that observed with the solid test meal in step 1 of the study Therefore, it can be argued that gastric distension doesn't make a significant contribution to the power changes observed in the EGG that followed the test meals. In keeping with the above finding and the results of previous studies we believe that as with water, a liquid test meal is unable to increase gastric contractility. This is in spite of some common characteristics with regard to calorie content, composition and volume it may share with solid and semisolid meals.

Our results indicate that solid and semisolid meals high in carbohydrate and low in fat content are capable of inducing a significant increase in the EGG power in normal subjects within the first 60 minutes following the meal. Furthermore, high carbohydrate isocaloric solid and semisolid meals seem to have similar effects on gastric slow wave activity. The increase in EGG frequency seen with other test meals was not seen. Therefore only an increase in the dominant power of the EGG can be regarded as a normal response if a high carbohydrate solid or a semisolid meal is used as the test meal when perfoming an EGG.

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