Postprandial Electrogastrographic Changes with or without Parasympathetic Nerve Blockade

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Abstract

To investigate the relationship between postprandial electrogastrographic changes and parasympathetic nervous activity, 10 healthy adult males (20 to 29 years old) volunteered for EGG recording in the following conditions: 1) butylscopolamine bromide (scopolamine) administration to block parasympathetic nervous activity; 2) after food intake; and 3) during a postprandial period after the parasympathetic blockade. Power spectral analysis of EGG was performed according to Akaike's autoregressive model. When the parasympathetic nervous activity was blocked, there were no changes in the dominant frequency of the EGG. During the postprandial period, the dominant frequency in EGG increased significantly, and postprandial dip (transient frequency decrease after the food intake) was observed in 8 of the 10 subjects. During the postprandial period after scopolamine administration, the dominant frequency of EGG did not increase, and postprandial dip was observed in only two subjects. These results suggest that the parasympathetic nervous activity is involved in occurrence of postprandial gastric motor function and postprandial electrogastrographic changes.

Key words: EGG, Parasympathetic nerve, Food intake

Introduction

The mechanisms of the regulation of gastric motility by the central nervous system and the peripheral enteric nervous system have not been elucidated completely. Electrogastrography (EGG) is a method to record gastric electrical activity from the surface of the body. The stomach possess electrical activity (Alvarez et al., 1922) which was originated from 'pace maker region' located in the greater curvature of the stomach near the junction of the fundus and proximal gastric corpus (Hinder et al., 1977). It was reported that in the extracellular gastric electrical signals derived with serosal electrodes, two kinds of gastric electrical potential changes had detected. The first one was periodically potential changes which referred to as electric control activity (ECA). The frequency of ECA was 3 cycle per minute and not associated with gastric peristaltic activity. The second one, so called electric response activity

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(ERA) was related to the gastric contraction movement for the increase in plateau depolarization (Smout et al., 1980). It is thought that both ECA and ERA are reflected in the surface EGG. Fasting electrical activity and mechanical activity were studied simultaneously by means of cutaneous electrodes (EGG) and intraluminal pressure recording in humans. As a result, motor quiescence was characterized by a constant low amplitude from baseline of EGG. At the changeover from motor quiescence to motor activity, increase in amplitude could be distinguished (Geldof et al., 1986). EGG signals usually increase in amplitude during gastric contractions (Smout et al., 1980; Hamilton et al., 1986). The present study is intended to investigate the electrogastrographic changes induced by alteration of parasympathetic nerve activities in healthy young males. EGG was employed to evaluate the changes in postprandial gastric electric activity with and without the blockade of parasympathetic nervous activity by scopolamine administration.

**Materials and methods**

1. **Subjects**

   Ten healthy adult male volunteers (20 to 29 years old), agreed with written informed consent to participate to the present study. No subjects had cardiovascular, pulmonary, or gastrointestinal disorders, and none had been taking any medication. 1) A parasympathetic blockade test, 2) food intake test, and 3) food intake test following the parasympathetic blockade, were conducted on each subject. The three independent tests were randomly performed on different days.

2. **EGG recording**

   Each subject was led into a test room after a fasting period of three hours or more and asked to assume the supine position. Two Ag-AgCl electrodes were placed on the upper abdominal surface. The right electrode was placed at the height of midway between the xiphoid and the umbilicus on right mid-clavicular line. The left electrode was placed at the height of midway between the xiphoid and another electrode on left mid-clavicular line (Figure 1). The reference electrode was placed on the back of the left hand. The EGG signals were filtered with a high frequency cut off at 0.1 Hz, and a time constant of 3 seconds, and recorded on an FM data recorder (TEAC MR-30, Tokyo, Japan). During the recording of EGG, the subjects took supine position.

3. **Data analysis**

   The obtained data were digitalized at 1 kHz by an analog/digital converter (Canopus Electronics ADX-98E, Kobe, Japan) installed in a microcomputer (NEC PC-9821 XE, Tokyo, Japan). EGG analysis were performed for 20 minutes before food intake or the parasympathetic blockade, and for 20 minutes after the meal or scopolamine administration. The power spectral density in the EGG was computed with a program for the autoregressive model (Akaike et al., 1969). This program provided individual power, amplitude (amplitude was estimated by the equation of $(2 \times \text{power})^{1/2}$) and frequency of each spectral component.
Frequency showing highest power at 0.02-0.08 Hz in the spectral analysis was defined as the dominant frequency (Figure 2). Changes in the amplitude of dominant frequency before and after either the test meal, parasympathetic blockade or both were defined as the power ratio (postload-power/preload-power). Visual inspection was performed to determine the presence
or absence of the transient frequency decrease (0.02 to 0.03 Hz), postprandial dip, which is usually found in the EGG in normal subjects (Nelsen et al., 1968; Duthie et al., 1971; Geldof et al., 1986; Kaneko et al., 1995) immediately after food intake (Figure 3).

4. Procedures

1) Parasympathetic blockade test.

0.8 mg/kg of scopolamine (TANABE SEIYAKU CO., LTD, Osaka, Japan), an anticholinergic agent, was intravenously administered in the right forearm of the subject after 20 minutes recording of normal EGG, and followed by 20 minutes recording.

2) Food intake test.

200 ml of milk and solid food (containing 25 g of protein, 20 g of fat, and 30 g of sugar for a total of 600 kcal) were used as test meal. The subjects were asked to sit-up and consumed test meals for 5 minutes. The postprandial EGG was recorded for 20 minutes.

3) Food intake test with parasympathetic blockade.

Scopolamine was intravenously administered and test meal was consumed for 5 minutes immediately after.

5. Statistical analysis

Data were expressed as the means±SD. Paired t-tests were used to investigate the difference of the EGG parameters. In all statistical tests, p<0.05 was considered to be significant.

Results

EGG during the preload period from all 10 subjects, exhibited a spectrum that contained a dominant frequency in the normal range of 0.04 to 0.06 Hz (2.4 to 3.6 cpm) in all tests. EGG following scopolamine injection significantly decreased in amplitude, but no significant changes in dominant frequency. EGG in the postprandial period showed a significant increase in both dominant frequency and amplitude. Postprandial dip was observed in 8 of the 10 subjects after food intake. EGG in the postprandial period following scopolamine injection showed no
significant changes in dominant frequency with weak increase in amplitude and increase in power ratio by food intake was inhibited by scopolamine significantly (Table 1, Table 2, Figure 4). Postprandial dip was diminished in 8 of the 10 subjects with scopolamine.

**Discussion**

The results in the present study on frequencies of EGG are summarized as follows. 1) No significant changes occurred in the EGG dominant frequency following the parasympathetic
blockade by scopolamine. 2) EGG dominant frequency increased significantly during the postprandial period with transient slowing immediately after meal (postprandial dip). 3) Scopolamine blocked postprandial changes of EGG frequencies.

EGG is a method to record gastric electrical activity from the surface of the body (Geldof et al., 1986; Hongo et al., 1994). The first report of EGG recording was reported by Alvarez in 1922 (Alvarez et al., 1922). Recent advances in recording devices have led to the wide acceptance of EGG as a simple, non-invasive method for investigating the gastric motor function. However, the meaning of the waveforms of EGG and the mechanism contributing wave generation are still not understood.

It is reported that scopolamine blocks mediation of postganglionic fiber to postsynaptic receptor (Itoh et al., 1988) and its half life is 2.9 ± 1.2 hours (Melkkilä et al., 1993). In this study, EGG following scopolamine significantly decreased in amplitude, but no significant changes in dominant frequency. A 0.8 mg/kg dose of scopolamine is ordinarily used in clinical applications. When the medication in this amount is administered intravenously, the suppression of the peristaltic contraction of the stomach can be observed by means of fluoroscopy (Kato et al., 1956). These suggest that the diapause of the gastric contraction by the parasympathetic blockade is not due to a direct effect on the pacemaker activity, and that the reduction of EGG amplitude may be a direct effect on postsynaptic muscarinic receptor to inhibit contraction of gastric smooth muscle.

A significant increase in the dominant frequency of EGG was observed during the postprandial period. This result suggests that the intake of food caused activation of the gastric pacemaker. Postprandial increases of amplitude on EGG have been reported (Okuno et al., 1990; Chen et al., 1991; Kaneko et al., 1995). With regard to the frequency, some researchers have reported an increase (Chen et al., 1991; Kaneko et al., 1995) in frequency while others have claimed that there were no changes (Okuno et al., 1990; Varannes et al., 1991). In our study using solid food, a significant increase in not only amplitude but also dominant frequency was observed. However, the mechanism responsible for the increase in the EGG frequency during the postprandial period is not understood. The amplitude increase in EGG seems to be mediated by two factors: the postprandial increase in the gastric contraction (Geldof et al., 1986) and the gastric distension bringing the stomach closer to the recording electrodes.

Postprandial dip, which is a transient decrease in frequency that occurs within a few minutes after ingestion of food, was observed in eight subjects. It is usually found in normal subjects (Nelsen et al., 1968; Duthie et al., 1971; Geldof et al., 1986; Kaneko et al., 1995). Its onset is probably mediated by the physical distention of the stomach due to food ingestion. However, specific details are yet to be determined. In pathological conditions, such as anorexia nervosa (Abell et al., 1987), functional dyspepsia (Geldof et al., 1986), and autonomic nerve disorder (Kaneko et al., 1992), the incidence of this phenomenon decreases. It is suggested that autonomic nervous activity is involved in occurrence of postprandial dip. The physiological significance and the cause of the postprandial dip still need to be elucidated.

Parasympathetic blockade by the intravenous administration of scopolamine abolished postprandial EGG reaction in the form of an increase in the dominant frequency. The power ratio significantly reduced, and postprandial dip was observed in only 2 of the 10 subjects.
From these results, it appears that the onset of postprandial gastric motor function and the occurrence of postprandial dip require parasympathetic neural control. Some earlier reports indicated that patients who had undergone a vagotomy did not show increase in frequency and amplitude in EGG during the postprandial period (Geldof et al., 1990). These observations are consistent with the results obtained in the present study. Diminished postprandial changes in EGG frequencies in dominant waves, postprandial dip in early postprandial phase and increase in frequency following postprandial dip, which might be controlled via neural activity of parasympathetic neurons. Namely, both muscular events and neural events occurred postprandial period were blocked by muscarinic inhibition by scopolamine. This possibility, along with the cause of postprandial gastric motor function, requires further study.

Conclusion

EGG following scopolamine significantly decreased in amplitude. In the postprandial period, increases in both dominant frequency and amplitude of EGG inhibited by parasympathetic blockade, and postprandial dip was diminished by parasympathetic blockade, too. These results suggest that the parasympathetic nervous activity is involved in occurrence of postprandial gastric motor function and postprandial electrogastrographic changes.

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References

Abell, T.L., Malagelada, J.R., Lucas, A.R., Brown, M.L., Camilleri, M., Go, V.L.W., Azpiroz, F., Callaway, C.W., Kao, P., Zinsmeister, A.R. and Huse, D.M. (1987). Gastric electromechanical and neurohormonal function in anorexia nervosa. Gastroenterology 93: 958-965.

Akaike, H. (1969). Fitting autoregressive models for prediction. Ann. Stat. Math. 21: 237-247.

Alvarez, W.C. (1922). New methods of studying gastric peristalsis. Am. J. Physiol. 201: 287-291.

Chen, J. and McCallum, R.W. (1991). Response of the electric activity in the human stomach to water and a solid meal. Med. & Biol. Eng. & Comput. 29: 351-357.

Duthie, H.L., Kwong, N.K., Brown, B.H. and Whittaker, G.E. (1971). Pacemaker potential of the human gastroduodenal junction. Gut 12: 250-256.

Geldof, H., Schee, E.J.V.D., Blankenstein, M.V. and Grashuis, J.L. (1986). Electrogastrographic study of gastric myoelectrical activity in patients with unexplained nausea and vomiting. Gut 27: 799-808.

Geldof, H., Schee, E.J.V.D., Blankenstein, M.V., Smout, A.J.P.M. and Akkermans, L.M.A. (1990). Effects of highly selective vagotomy on gastric myoelectrical activity: An electrogastrographic study. Dig. Dis. Sci. 35: 969-975.

Geldof, H., Schee, E.J.V.D. and Grashuis, J.L. (1986). Electrogastrographic characteristics of interdigestive migrating complex in humans. Am. J. Physiol. 250: G165-171.

Hamilton, J.W., Bellisene, B.E., Reicherlderfer, M., Webster, J.H. and Bass, P. (1986). Human electrogastrograms. Comparison of surface and mucosal recordings. Dig. Dis. Sci. 31: 33-
Hinder, R.A. and Kelly, K.A. (1977). Human gastric pacesetter potential: site of origin, spread and response to gastric transection and proximal gastric vagotomy. *Am. J. Surg.* **133**: 29-33.

Hongo, M. and Satake, M. (1994). Electrogastrography. *Research forum on Digestive Disease* **1**: 245-253.

Itoh, H. (1988). The medicine acting peripheral synapse. In: Textbook of pharmacology, ed. by Y. Misu, 6th ed., Eikodo, Tokyo, pp. 171-183.

Kaneko, H., Sakakibara, M., Mitsuma, T. and Morise, K. (1995). Possibility of postprandial electrogastrography for evaluating vagal/nonvagal cholinergic activity in humans, through simultaneous analysis of postprandial heart rate variability and serum immunoreactive hormone levels. *Am. J. Gastroenterol.* **90**: 603-609.

Kaneoke, Y., Koike, Y., Sakurai, N., Washimi, Y., Hirayama, M., Hoshiyama, M. and Takahashi, A. (1992). Electrogastroenterography: Application to patients with degenerative diseases of the nervous system. *The Autonomic Nervous System* **29**: 38-43.

Kato, T., Keihata, K. and Mori, H. (1956). The application of hyoscine-N-butylbromide in gastrointestinal radiologic diagnosis. *Rinsho Syokakibyogaku* **4**: 390-400.

Melkkilä, A., Kanto, J. and Lisalo, E. (1993). Pharmacokinetics and related pharmacodynamics of anticholinergic drugs. *Acta Anaesthesiol. Scand.* **37**: 633-642.

Nelsen, T.S., Kohatsu, S. and Palo, Alto. (1968). Clinical electrogastrography and its relationship to gastric surgery. *Am. J. Sur.* **116**: 215-222.

Okuno, Y., Hongo, M., Yamada, M., Nishimura, N., Ueno, M. and Takayoshi, T. (1990). Effect of feeding on recording characteristics of electrogastrography (EGG) in normal subjects. *Jpn. J. Smooth. Muscle. Res.* **26**: 219-224.

Smout, A.J.P.M., Schee, E.J.V.D. and Grashuis, J.L. (1980). What is measured in electrogastrography? *Dig. Dis. Sci.* **25**: 179-187.

Varannes, S.B., Mizrahi, M. and Dubois, A. (1991). Relation between postprandial gastric emptying and cutaneous electrogram in primates. *Am. J. Physiol.* **261**: G248-G255.

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