

Gastric Myoelectrical Activities in Elderly Human Subjects

— Surface Electrogastrographic Observations —

Naruo NISHIMURA, Michio HONGO, Masahiko YAMADA,
Hitoshi KAWAKAMI and Takayoshi TOYOTA

*The Third Department of Internal Medicine and The Department of Psychosomatic
Medicine, Tohoku University School of Medicine, Sendai, Japan*

Abstract

To investigate the alteration of the gastric electrical activities by aging, we performed electrogastrography (EGG) on 13 asymptomatic young human subjects under 60 years old (the young group) and 12 subjects over 60 years (the elderly group). Surface EGG was recorded at fasting state for 30 minutes in each subject. We expressed the frequency distribution of surface EGG in each subject with the median value of frequency distribution (F_{MED}) to represent the center of the electrical activities, and the interquartile range of frequency distribution (F_{IQR}) as the indicator of regularity. F_{MED} in the young group was 3.0 : [2.9, 3.4] (median : [range]) cycles per minute (cpm), while it was 3.3 : [3.0, 4.0] in the elderly group which showed statistically a significant difference between the groups ($p=0.01$). F_{IQR} in the young group was 0.5 : [0.1, 1.8] and that in the elderly group was 0.55 : [0.4, 1.7], which was not significantly different statistically. These data showed that aging increases the frequencies of the rhythm of surface EGG, without disturbing its regularity. This change may be a part of a spectrum of physiological changes accompanied with aging, and are unlikely to have clinico-pathological significance.

Key words : aging, stomach, electrogastrography, gastric motility

Introduction

Aging has influences on various physical functions. Motor function of the alimentary tract may also be affected by aging. The effects of aging on gastric motility has been evaluated mostly from the aspect of gastric emptying which reflects postprandial gastric motility. There are conflicting data on gastric emptying in elderly subjects. Some data showed delay in gastric emptying of a liquid meal (Horowitz *et al.*, 1984 ; Moore *et al.*, 1983 ; Evans *et al.*, 1981) and of a solid meal (Horowitz *et al.*, 1984) in elderly subjects, whereas other data showed acceleration of liquid meal emptying (Kupfer *et al.*, 1985) or normal emptying of solid meal (Moore *et al.*, 1983).

Smooth muscles of the gastric body and the antrum have specific electrophysiological properties of auto-depolarization, and this autonomicity is called electrical control activity (ECA). In a human stomach, ECA propagates from the gastric body toward the pylorus (Hinder *et al.*, 1977). Electrogastrography (EGG) is a method to record this gastric electrical

activity. This electrical activity can be recorded noninvasively from the abdominal skin surface (Smout *et al.*, 1980; Abell *et al.*, 1985; Hamilton *et al.*, 1986; Familoni *et al.*, 1991). With this surface EGG, various electrical abnormalities were found in several clinical conditions (Geldof, *et al.*, 1986; Abell *et al.*, 1987; Stern *et al.*, 1987; Abell *et al.*, 1991; Koch *et al.*, 1989; Okuno *et al.*, 1990; Chen *et al.*, 1992; Riezzo *et al.*, 1992).

Our aim in the present study is to investigate the effect of aging on the gastric electrical activity by means of surface EGG.

Subjects and Methods

Subjects

A total of 25 volunteers participated in this study. None of them had any gastrointestinal symptom nor diseases which are known to have an influence on gastrointestinal motility. They were 17 males and 8 females. Their age ranged from 23 to 89 years old (mean; 52, median; 51). For analysis, they were divided into two groups by their age. A group of thirteen subjects under 60 years (23 to 51 years, 11 male and 2 female) was defined as the young group, and the other group of twelve subjects over 60 years (60 to 89 years, 6 male and 6 female) was defined as the elderly group. Before participation in this study, informed consents were obtained from each subjects.

Methods

The subjects fasted for more than 5 hours before EGG recording. Smoking was prohibited on the recording day until the end of the study. Surface EGG was recorded as described elsewhere (Okuno *et al.*, 1989; Okuno *et al.*, 1990). Recording was performed in a supine position, using Ag-AgCl electrodes (Lectrode, NEC-San-Ei, Tokyo, Japan) placed on epigastric skin surface after abrasion of the skin by rubbing it with the pretreatment gel (Hi-Clean, Fukuda M.E. Kogyo, Tokyo, Japan). Two sets of bipolar recording were performed simultaneously. Transverse pickup was positioned between the bilateral lower margin of the costal arch

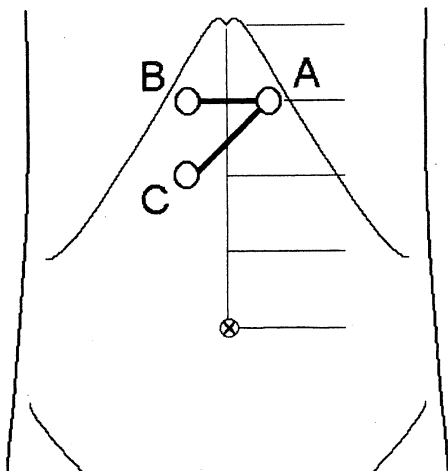


Fig. 1. Placement of electrodes on the abdominal surface. Two sets of bipolar pick-ups (between point A-B; transverse pick-up, and point A-C; oblique pick-up) were placed on the subjects' abdomen.

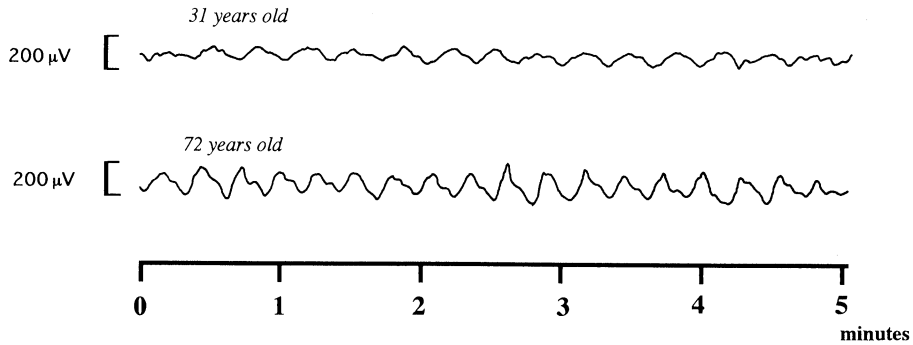


Fig. 2. Traces of surface EGG from the subjects. A 31 years old male in the young group showed the waves of 3.0 cycles per minute (cpm) frequency. A 72 years old male in the elderly group showed the waves around 3.6 cpm frequency. Note that the regularity of waveform is maintained in both subjects.

at the height of the upper quarter between the xyphoid process and the navel (left : point A, right : point B). Oblique pickup was placed between point A and point vertically below the point B at the height of the lower quarter between the xyphoid process and the navel (point C) (Okuno *et al.*, 1989) (Fig. 1). Reference electrodes were placed on the abdominal surface. Electrical signals were amplified through a head amplifier (Bio-Headamplifier 1272, NEC-San-Ei, Tokyo, Japan) and filtered. We used a filter setting of high-cut off as 0.1 Hz and time constant as 3.0 sec (Bio-Electric Amplifier 1253, NEC-San-Ei, Tokyo, Japan). The EGG was recorded on a pen chart recorder (Recti-Horitz, NEC-San-Ei, Tokyo, Japan) with a paper speed of 1 mm/sec. After 10 minutes adaptation, 30 minutes of recording was performed for each subject. Examples of surface EGG are demonstrated in Fig. 2.

Analysis

The record which showed better signal/noise ratio, in either the transverse or the oblique pickups, was served for frequency analysis. Frequency analysis was performed manually measuring the distance between the peak to peak or the bottom to bottom of the trace with a ruler which has scales to convert the distance into frequencies. These ranged from 1.5 to 8.5 cycles per minute (cpm). Analysis was performed by one of the authors who was not aware of the age of the subjects. As the frequency distribution of surface EGG waves in each subject was not always normally distributed, we adopted the median value of frequency distribution (F_{MED}) for the representation of the center, as well as interquartile range of frequency distribution (F_{IQR}) for the indicator of regularity to summarize the individual data. Transient alterations of frequency and rhythm which continued for more than 5 minutes were also noted if present.

Statistical analyses between the groups were performed using the Mann-Whitney test. The correlations or F_{MED} of F_{IQR} and age were calculated by Spearman's correlation coefficient (r_s). All the tests were two-tailed and the significance level was set to 5%. Group data were summarized as median : [range].

Results

F_{MED} in the young group was 3.0: [2.9, 3.4] cpm, while that in the elderly group was 3.3: [3.0, 4.0] (Fig. 3). Though some overlaps were observed, F_{MED} in the elderly group was significantly higher than that in the young group ($p=0.01$). Furthermore, positive and significant correlation between the age and F_{MED} in all subjects was observed ($r_s=0.66$, $p=0.001$).

F_{IQR} was 0.5: [0.1, 1.8] in the young group, and 0.55: [0.4, 1.7] in the elderly group (Fig. 4). There was no significant difference between the groups. No significant correlation between age and F_{IQR} was observed ($r_s=0.05$, not significant).

Neither the F_{MED} or F_{IQR} differed according to the subjects' gender difference.

Transient alteration in frequency and rhythm of the EGG waves was not observed in either group.

Discussion

Surface EGG is a noninvasive and simple technique to perform. However, the method of analysis and the expression of the summary of raw data have not been standardized. To outline the frequency distribution of individual surface EGG data analyzed with computer-aided fast Fourier transformation (Geldof *et al.*, 1986) or running spectral analysis (Riezzo *et al.*, 1992), mean frequency, standard deviation or coefficient of variation were applied. There may be a limitation to the summarization of the frequency distribution by mean and standard deviation because the frequency distributions usually are not distributed normally. Visual analysis of EGG waveforms were used to score the gastric dysrhythmia (Abell *et al.*, 1985;

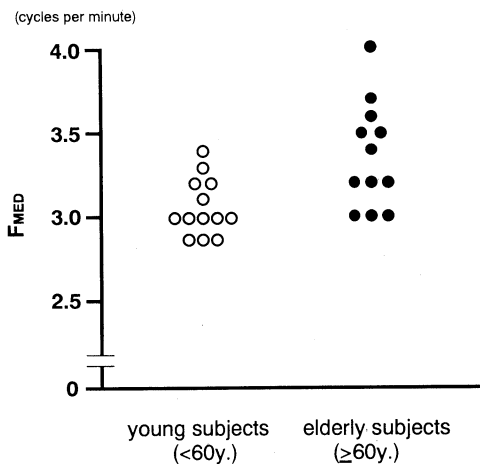


Fig. 3. Median of frequency distribution (F_{MED}) in surface EGG in young and elderly subjects. A significant difference between the groups was observed ($p=0.01$).

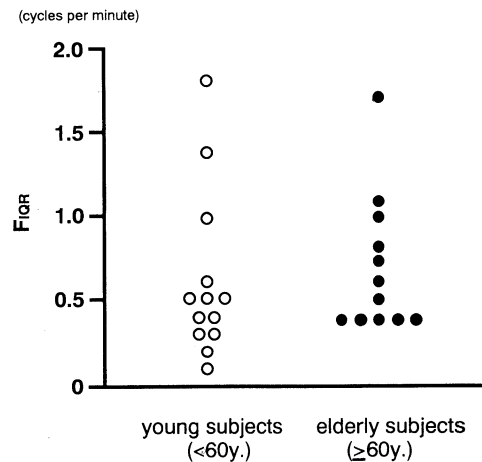


Fig. 4. Interquartile range of frequency distribution (F_{IQR}) in surface EGG in young and elderly subjects. There was no significant difference between the groups.

Abell *et al.*, 1991).

As the frequency distributions of surface EGG waves obtained by visual analysis were not always normally distributed, mean value or standard deviation did not represent its center and range. As our purpose in this study is to investigate the alteration of the frequency and its regularity of EGG rhythm as age increases, we need to express the individual data numerically. To do this, we employed a numerical evaluation of the frequency distribution and the regularity of the EGG waves using median (F_{MED}) and interquartile range (F_{IQR}).

We recorded EGG during the fasting period, because the standard test meal may not be equally loaded to elderly subjects as to the young subjects which may mislead the findings. In our previous observations in diabetic patients (Okuno *et al.*, 1990), abnormal EGG waves were recorded both in fasting and post-prandial period. This may indicate that EGG recording in fasting period is essentially equivalent to postprandial EGG in terms of rhythmicity. Though the gastrointestinal motility varies during fasting period, we did not record intragastric manometry. However, we did not find any transient changes in EGG waves (dysrhythmia) during the recording period, which may indicate that variation in fasting motor activities did not influence our EGG recordings in fasting period.

Our data showed that the frequency of gastric electrical activity expressed as F_{MED} in a fasting state increases with age. On the other hand, F_{IQR} , the indicator for regularity of electrical waves, was not affected by age. Riezzo *et al.* (1991) reported that there was no significant difference in the mean of surface EGG frequency between young and elderly groups. On the other hand, Geldof *et al.* (1986) reported a positive and significant correlation between age and frequency of surface EGG, without any significant change in stability (or regularity). Our data support these findings by Geldof *et al.* (1986).

It is still obscure how aging affects the vagal function in the stomach. In dog experiments, ECA of gastric body and antrum showed disorganized patterns as a result of the occurrence of multiple ectopic pacesetter potentials immediately after vagotomy (Kelly *et al.*, 1969). In human studies, only 4 patients among 37 vagotomized patients had gastric tachyarrhythmia in a fasting state in a long term follow up study (Stoddard *et al.*, 1981). The fewer incidences of gastric dysrhythmia after vagotomy is attributed to the compensation of the gastric intrinsic nervous system through increasing its sensitivity and reconstruction of the neural circuit in ferrets (Andrews *et al.*, 1990). Therefore, we speculate that reduced vagal activity along with age alone is not likely to be a main factor in increasing the EGG frequency in the elderly group. Observations in animal studies showed a decrease in the number of ganglion cells of myenteric plexus in aged guinea pigs (Gabella, 1989), and a decrease in nerve density containing noradrenaline (Baker *et al.*, 1988) or neuropeptides (Feher *et al.*, 1987) in aged rats. A clinical study, in patients with chronic idiopathic intestinal pseudoobstruction without any evident disorders in the central nervous system or the autonomic nervous system, revealed that 3 of 4 patients with depletion of the neurons in their intestinal myenteric plexus showed regular but fast EGG waves with their dominant frequency ranging 6.4–9.4 cpm (Devane *et al.*, 1992). Though the elderly subjects in our study did not show extremely fast rhythm like the patients with pseudoobstruction, degeneration in the myenteric plexus along with age may contribute to the shift of EGG waves to the faster rhythm.

The other candidate for cause of increased surface EGG frequency in the elderly is gastrin. Exogenous gastrin evokes an increase of ECA frequency in dogs after either a pharmacological dose (Kelly, 1970) or a physiological dose (Strunz *et al.*, 1979). The serum gastrin level increases with age because of mucosal atrophy which results in hypoacidity in the stomach (Varis *et al.*, 1979), but it is not clear because we did not measure serum gastrin levels in this study. However, postprandial increase in serum gastrin level does not affect the rhythmicity of postprandial EGG. Therefore, an increase in serum gastrin may be responsible to the increase in EGG frequency in some degree, but the possibility seems to be less likely.

The pathophysiological significance of this fast and regular electrical changes of surface EGG in the elderly has not been reported. Tachygastrica is defined as paroxysmal fast wave over 4.5 cpm of 6 cpm (Abell *et al.*, 1985; Riezzo *et al.*, 1992). Based on this definition, regular but fast electrical changes of surface EGG in the elderly, observed in the study, does not meet the criteria of tachygastrica. Because all of the subjects in our study were free from gastrointestinal symptoms, such electrical changes in the elderly stomach are not likely to have clinico-pathological significance.

References

- Abell, T.L., Camilleri, M, Hench, V.S. *et al.* (1991). Gastric electromechanical function and gastric emptying in diabetic gastroparesis. *Eur. J. Gastroenterol. Hepatol.* **3**: 163-167.
- Abell, T.L. and Malagelada, J.R. (1985). Glucagon evoked gastric dysrhythmias in humans shown by an improved electrogastrographic technique. *Gastroenterology* **88**: 1932-1940.
- Abell, T.L., Malagelada, J.R., Lucas, A.R. *et al.* (1987). Gastric electromechanical and neurohormonal function in anorexia nervosa. *Gastroenterology* **93**: 958-965.
- Andrews, P.L.R. and Bingham, S. (1990). Adaptation of the mechanisms controlling gastric motility following chronic vagotomy in the ferret. *Exp. Physiol.* **75**: 811-825.
- Baker, D.L. and Santer, R.M. (1988). A quantitative study of the effects of age on the noradrenergic innervation of Auerbach's plexus in the rat. *Mechanism of Aging and Development* **42**: 147-158.
- Chen, J. and McCallum, R.W. (1992). Gastric slow wave abnormalities in patients with gastroparesis. *Am. J. Gastroenterol.* **87**: 477-482.
- Devane, S.P., Ravelli A.M., Bisset W.M. *et al.* (1992). Gastric antral dysrhythmias in children with chronic idiopathic intestinal pseudoobstruction. *Gut* **33**: 1477-1481.
- Evans, M.A., Triggs, E.J., Cheung, M. *et al.* (1981). Gastric emptying rate the elderly: Implications for drug therapy. *J. Am. Geriatr. Soc.* **29**: 201-205.
- Familoni, B.O., Bowes K.L., Kingma, Y.J. *et al.* (1991). Can transcutaneous recordings detect gastric electrical abnormalities? *Gut* **32**: 141-146. 1991.
- Feher, E. and Penzes, L. (1987). Density of substance-P, vasoactive intestinal polypeptide and somatostatin-containing nerve fibers in the ageing small intestine of the rats. *Gerontology* **33**: 341-348.
- Gabella, G. (1989). Fall in the number of myenteric neurons in aging guinea pigs. *Gastroenterology* **96**: 1487-1493.
- Geldof, H., Van der Schee, E.J., Van Blackenstein, M. *et al.* (1986). Electrographic study of gastric myoelectrical activity in patients with unexplained nausea and vomiting. *Gut* **27**: 799-808.
- Hamilton, J.W., Bellahsene, B.E., Reichelderfer, M. *et al.* (1986). Human electrogastragrams. Comparison of surface and mucosal recording. *Dig. Dis. Sci.* **31**: 33-39.

- 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.
- Horowitz, M., Maddern, G.J., Chatterton, B.E. *et al.* (1984). Changes in gastric emptying rates with age. *Clinical Science* **67**: 213-218.
- Kelly, K.A. and Code C.F. (1969). Effect of transthoracic vagotomy on canine gastric electrical activity. *Gastroenterology* **57**: 51-58.
- Kelly, K.A. (1970). Effect of gastrin on gastric myoelectric activity. *Am. J. Dig. Dis.* **15**: 399-405.
- Koch, K.L., Stern, R.M., Stewart, W.R. *et al.* (1989). Gastric emptying and gastric myoelectrical activity in patients with diabetic gastroparesis: Effect of long-term domperidone treatment. *Am. J. Gastroenterol.* **84**: 1069-1075.
- Kupfer, R.M., Heppel, M., Haggith, J.W. *et al.* (1985). Gastric emptying and small-bowel transit rate in the elderly. *J. Am. Geriat. Soc.* **33**: 340-343.
- Moore, J.G., Tweedy, C., Christian, P.E. *et al.* (1983). Effect of age on gastric emptying of liquid-solid meals in man. *Dig. Dis. Sci.* **28**: 340-344.
- Oikawa, N., Umetsu, M., Toyota, T. *et al.* (1984). Quantitative evaluation of diabetic autonomic neuropathy by using heart rate variations—Determination of the normal range for the diagnosis of autonomic neuropathy. *Tohoku J. Exp. Med.* **148**: 233-241.
- Okuno, Y., Hongo, M., Ujiie, H. *et al.* (1989). Percutaneous recording of gastric electrical activity (electrogastrography): Its technic and analysis (in Japanese). *Jpn. J. Smooth Muscle Res.* **25**: 55-60.
- Okuno, Y., Hongo, M., Nishimura, N. *et al.* (1990). Electrogastrography (EGG) in patients with diabetic autonomic neuropathy with reference to gastric emptying (in Japanese). *Autonom. Nerv. Syst.* **27**: 534-540.
- Riezzo, G., Pezzolla, F. and Giorgio, I. (1991). Effect of age and obesity on fasting gastric electrical activity in man: A cutaneous electrogastrographic study. *Digestion* **50**: 176-181.
- Riezzo, G., Pezzolla, F., Darconza G. *et al.* (1992). Gastric myoelectrical activity in the first trimester of pregnancy: A cutaneous electrogastrographic study. *Am. J. Gastroenterol.* **87**: 702-707.
- Smout, A.J.P.M., Van Der Schee, E.J. and Grashuis, J.L. (1980). What is measured in electrogastrography? *Dig. Dis. Sci.* **25**: 179-187.
- Stern, R.M., Koch, K.L., Stewart, W.R. *et al.* (1987). Spectral analysis of tachygastria recorded during motion sickness. *Gastroenterology* **92**: 92-97.
- Stoddard, C.J., Smallwood, R.H. and Duthie, H.L. (1981). Electrical arrhythmias in human stomach. *Gut* **22**: 705-712.
- Strunz, U.T., Code, C.F. and Grossman, M.I. (1979). Effect of gastrin on electrical activity of antrum and duodenum of dogs. *Proc. Soc. Exp. Biol. Med.* **161**: 25-27.
- Varis, K., Ihamäki, T., Harkonen, M. *et al.* (1979). Gastric morphology, function, and immunology in first-degree relatives of probands with pernicious anemia and controls. *Scand. J. Gastroenterol.* **14**: 129-139.
- Wilbur, B.G. and Kelly, K.A. (1973). Effect of proximal gastric, complete gastric, and truncal vagotomy on canine gastric electric activity, motility, and emptying. *Ann. Surg.* **178**: 295-303.

(Received February 28, 1995 ; Accepted March 22, 1995)