Does body posture affect the parameters of a cutaneous electrogastrogram?

Krzysztof JONDERKO¹,², Anna KASICKA-JONDERKO¹ and Barbara BŁOŃSKA-FAJFROWSKA³

¹Department of Basic Biomedical Science, School of Pharmacy,
²Department of Physiology, Institute of Occupational Medicine and Environmental Health, Medical University of Silesia, Poland

Abstract

In a study aimed to test the effect of body position on the parameters derived from surface electrogastrograms, 17 healthy volunteers (2M, 15F; median age 22.5 years) attended in random order two examination sessions held on separate days. A 30-min recording of the interdigestive gastric myoelectrical activity (GMA) was followed by a 90-min postprandial recording after intake of a 394 kcal mixed solid-liquid test meal. For the first examination the subject was examined in a recumbent position, whereas for the second examination a sitting position was maintained. The dominant frequency and relative time occupied by normogastria was negligibly affected by the posture of the subject during GMA recording. However, a decrease in the dominant power (DP) of the gastric slow waves was observed during both the interdigestive and the postprandial recording period in a sitting position compared to a recumbent position. Consequently, the fed to fasted state DP ratio remained unaffected by body posture during GMA recording. The results indicate that by carefully observing procedural guidelines, good quality electrogastrograms can be obtained with a sitting subject, enabling the provision of comparable parameters to those achieved from standard examination in a recumbent position.

Key words: body posture, electrogastrography, gastric myoelectrical activity

Introduction

Since first described by Alvarez (1922), electrogastrography has evolved into a valuable method of non-invasive recording of gastric myoelectrical activity (GMA). Obtaining high quality electrogastrograms requires observation of basic procedures, such as appropriate preparation of the skin for the attachment of the electrodes, provision of a comfortable ambiance in the examination room for the patients, as well as their conscious co-operation during the procedure in order to avoid or at least minimize the number of artefacts contained in the
recording (Jonderko et al., 2004a). To reduce motion artefacts, it is preferable to examine the subject in a supine position. Sometimes, however, an experimental protocol requires that the subject be upright, for example if a subject is expected to perform specific manual tasks during the electrogastrographic examination such as during a stress test (Stern et al., 1987; Kasicka-Jonderko and Jonderko, 2000).

This study was undertaken to evaluate the effect of a subject’s body position during an electrogastrographic examination on the parameters characterizing the GMA recorded both after fasting and after stimulation of the stomach with a mixed solid-liquid test meal.

**Methods**

**Subjects**

Seventeen healthy subjects agreed to participate in the study, among them were 2 men and 15 women, with a median age of 22.5 years, (range 18–25) and an average body mass index of 20.33 kgm$^{-2}$ (range 17.10 to 24.46).

During the screening interview the participants declared themselves as being in full health according to the World Health Organisation criteria. Criteria which would have excluded subjects from the study were symptoms suggestive of functional or organic diseases of the digestive tract, current use of any drugs which might affect gastrointestinal motility or pregnancy. The study was conducted in accordance with the Helsinki Declaration, and each volunteer gave a written consent to participate after being informed of the aim, protocol and methodology of the study.

**Study protocol**

The subjects came to the laboratory in the morning, after a 12-h overnight fast and abstinence from cigarette smoking in the case of two of the men. Three Ag/AgCl electrodes (type EK-S 55P, Sorimex, Poland) were placed on the abdomen: the first active (A1) electrode was fixed in the midline, half way between the xyphoid process and umbiculus, the second active (A2) electrode was fixed at point lying 5 cm distant to A1 on a line leading up at a 45 degree angle towards the left costal margin, whereas the reference electrode (R) was positioned on the right side of the abdomen below the right costal margin at its intersection with the right anterior axillary line. The preparatory procedure involved shaving the skin if necessary, then careful abrasion until the skin was pink using Every paste (Sorimex, Poland/Italy). Finally a drop of high conductive gel for electroencephalographic recordings (MediGel, Sorimex, Poland/Italy) was applied directly to the conductive surface of each electrode just before fixing to the skin. The electrical resistance between each pair of electrodes was checked with the use of a digital ohmmeter (type M3850D, Metex, Korea), and if this exceeded 5 K Ohms, the respective electrodes were removed and the entire preparatory procedure recommenced. The electrodes were connected to a Polygraf HR recording system (Synectics Medical AB, Sweden) working at a sampling frequency of 8 Hz while recording and digitizing the GMA. The digitized voltage sequences were stored on a computer hard disk for further analyses.

Each volunteer attended in random order two examination sessions on separate days. The
Body posture and EGG parameters

sessions differed in that on one day the fasted and postprandial GMA was recorded with the subjects sitting in a comfortable armchair, whereas during the other session the subjects remained in a recumbent position, lying on their back on a couch, except for the period when a test meal was served. After 30 min, the interdigestive GMA was recorded. Then, at time point designated ‘0’, the subjects ate a test meal consisting of a 50 g slice of white bread covered with scrambled hen’s egg fried on 10 g butter, together with a 250 ml glass of 1.5% fat content milk. The total energy content of the meal was 394 kcal (18.7 g protein, 18.5 g fat and 36.1 g carbohydrates). Up to ten minutes was allowed for the subjects to ingest the meal. Postprandial gastric myoelectrical activity was recorded for 90 min from time ‘0’.

Quality control of the contact of the electrode to the skin

At every examination session the electrical resistance between the three electrode pairs (A1-A2, A1-R, A2-R) was measured at the beginning and again at the end of the GMA recording.

Analysis of GMA recordings

The GMA traces that were obtained were analyzed off-line using dedicated software (Multigram v. 6.40, Synectics Medical AB, Sweden) by an independent researcher who was unaware of the experimental conditions linked to a particular data set (AK-J). At first a visual inspection of the raw traces was performed in order to identify sections containing motion artefacts. Then a fast Fourier transform (FFT) was run on consecutive 256-sec data sets with a 196-sec overlap. For each of the resulting power-frequency spectra (termed FFT frames) the dominant frequency (DF), and power at dominant frequency (DP) was computed. The following frequency ranges were adopted to classify the DF of a FFT frame: 1–2.25 cpm for bradygastria, 2.26–3.75 cpm for normogastria, and 3.76–10 cpm for tachygastria (Jonderko et al., 2004). The resulting data, arranged in a time domain with a one-min shift, were exported to an ASCII file for subsequent analysis using a custom-made Excel spreadsheet. For the interdigestive and postprandial observation periods, the median DF in cpm and the geometric mean of DP in $\mu V^2$ was computed; the DP was next expressed in dB units, i.e., a product of the natural logarithm of the DP multiplied by ten. An overall meal-induced change in DP relative to the fasted situation, termed $\Delta$DP, was derived by computation of the net difference in dB between the relevant DPs. In addition, the maximum instantaneous postprandial increase in DP, designated Max$_{\Delta}$DP, was calculated as the difference between the highest DP from among the postprandial FFT frames and the average pre-prandial DP. Moreover, the relative period of normogastria within each observation period, as well as the instability coefficients of the DF (DFIC) and DP (DPIC) were computed (the latter parameter for the interdigestive period only) (Parkman et al., 2003).

Statistical analysis

The data obtained were checked for normal distribution using the Kolmogorov-Smirnov test (Armitage, 1978). If a data set did not deviate from a normal distribution, statistical analysis of the results was performed using the Student $t$ test for paired probes. Otherwise Wilcoxon’s matched pairs test was applied. In the case of the resistance between electrodes, a repeated measures analysis of variance (R_ANOVA) was applied as appropriate. Significance of
differences between means was then checked post hoc with the Tukey’s honest significant difference (HSD) test (Armitage, 1978). Statistical significance was set at the $P<0.05$ level, two-tailed. If not otherwise stated, the results are presented as the mean ± SE. All statistical analyses were performed with the use of the Statistica 6.1.478.0 software, licence # adbp409a903816ar (StatSoft, Inc., 2004).

**Results**

The average times for the ingestion of the test meal were not statistically different at $6.3 \pm 0.4$ min and $5.6 \pm 0.5$ min respectively in the recumbent and sitting positions.

According to the R_ANOVA results, there was no significant difference between the resistances measured between the electrodes used for the surface electrogastrography when the sessions with the subject in a recumbent position were compared to those in a sitting position. The electrical conductivity between the electrodes did not deteriorate during the two-hour recording sessions, and in fact the R_ANOVA showed that the electrical resistance was statistically significantly lower at the end of a session when compared to the start (results not shown).

Postprandial changes in the DF, typical of a meal-evoked stimulation of the GMA, were observed on the two study days: a short-term increase in the DF at the start of the meal, followed by a nadir of the DF, the so-called DF dip, after which the DF rose again above the pre-prandial level. As depicted in Fig. 1, the time course of the postprandial changes in the DF was similar on both study days, irrespective of the posture of the subjects during the GMA examination.

The posture of the subject during recording of the interdigestive GMA did not significantly affect the DF, DFIC, or the relative time occupied by normogastria (Table 1). However, the median DP while a fasted subject was sitting was roughly one half of the corresponding median DP during a recumbent session (Table 1). Although the large variation in the interdigestive DP resulted in no significant difference being found between the postures ($P=0.076$ with the Wilcoxon’s test), it should be noted that the difference between DP sitting and DP recumbent was negative in 11 cases (median $-228 \mu V^2$, interquartile range: $-326$ to $-26 \mu V^2$) and positive in 6 cases (median $13 \mu V^2$, interquartile range: 9 to $30 \mu V^2$). While the DPIC in sitting subjects was greater than in recumbent subjects, this difference was not statistically significant (Table 1).

After the stimulation of the meal, slightly less normogastria was observed when the surface electrogastrogram was taken with a sitting subject, as compared to a recumbent subject, however this minor difference was not statistically significant (Table 2). Whereas the average postprandial DF was identical in the two positions, the DFIC appeared to be larger with a sitting than in a recumbent posture, although this was not statistically significant (Table 2). The most striking difference was observed in the postprandial DP. As in the pre-prandial period, the median DP in the fed state when a subject was sitting was about one half of the corresponding median DP in the recumbent position (Table 2). The difference between DP sitting and DP recumbent was negative in 13 cases (median $-106 \mu V^2$, interquartile range: $-353$ to $-86 \mu V^2$), as opposed to being positive in only 4 cases (median $41 \mu V^2$, interquartile range: 14 to $147 \mu V^2$).
This posture-dependent difference in the postprandial DP was statistically significant (Table 2). On the other hand, neither the overall nor the maximum meal-induced change in DP was significantly different when the corresponding values from the recumbent and the sitting posture sessions were compared.

**Discussion**

A thorough literature search revealed no previous systematic study of the effects of body posture on the recording of GMA by surface electrogastrography. Within a typical clinical
setting, electrogastrographic examination is usually performed with a patient lying comfortably to minimize artefacts in the GMA recording. However, under certain circumstances, research applications of electrogastrography require GMA recording to be performed while the subject is sitting. In our laboratory we have applied this variation of the electrogastrographic procedure while examining the effect of laboratory stressors, such as computer games, handgrip isometric exercise, noise, cold pressor test (Kasicka-Jonderko and Jonderko, 2000), cigarette smoking (Jonderko et al., 2000) and sham feeding (Jonderko et al., 2004b) on the GMA in humans.

Studies performed using radiolabelled solid, liquid, or mixed solid-liquid meals and gamma camera scintigraphy indicate that gastric emptying kinetics may be affected by body posture (Jonderko, 1987a). A study by Moore et al. (1988) showed that a 208 kcal meal with the solid phase radiolabelled with $^{99m}$Tc emptied slower in a lying position compared to a sitting position. However, when gastric evacuation of a radiolabelled solid meal was examined in the absence of liquid, no significant effect of body posture (sitting vs. left lateral decubitus) on gastric emptying was discernible (Doran et al., 1998). Whereas, comparison of gastric half emptying times revealed that the outflow of a radiolabelled nonnutrient meal from the stomach was twofold faster in a sitting position than in a left lateral position (Anvari et al., 1995). A test meal, similar in formula and caloric content to that used in the present study, was used by Spiegel et al. (2000). They established that the gastric emptying of the solid component of a 427 kcal composite test meal was slower in a supine position compared to a sitting position only after 60 min or more. Therefore the duration of the recording of the postprandial GMA in the present study was extended beyond the standard period of one hour (Parkman et al., 1997; Levanon et al., 1998). In fact, the postprandial observation time used in this study matched the scintigraphically determined gastric half emptying time of the solid phase of the meal used by us, which was found to be 92 ± 3 min in healthy subjects in a sitting position (Jonderko, 1987b).

The present results indicate that the dominant frequency and related parameters of the electrogastrogram (DFIC, relative time occupied by normogastria) were only negligibly affected by the posture of the subject during GMA recording. A comparison of the electrogastrograms taken with the subject in either a supine or a sitting position revealed, however, a striking difference in the dominant power. While this difference was only statistically significant in the

### Table 2. Effect of the body posture of a subject on the electrogastrogram recorded during 90 min of the postprandial period

<table>
<thead>
<tr>
<th></th>
<th>Normogastria (%)</th>
<th>DF (cpm)</th>
<th>DFIC (%)</th>
<th>DP ($\mu V^2\cdot$dB)$^1$</th>
<th>$\Delta$DP (dB)</th>
<th>Max$_{\Delta}$DP (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recumbent</td>
<td>89.6 ± 2.8</td>
<td>3.12 ± 0.04</td>
<td>17.4 ± 2.5</td>
<td>194 (106; 353)$^2$</td>
<td>2.0 (–1.4; 7.5)</td>
<td>9.2 (4.4; 13.3)</td>
</tr>
<tr>
<td>Sitting</td>
<td>82.8 ± 3.5</td>
<td>3.12 ± 0.05</td>
<td>23.9 ± 2.4</td>
<td>86 (61; 103)</td>
<td>2.9 (0.0; 4.8)</td>
<td>9.3 (6.3; 12.2)</td>
</tr>
</tbody>
</table>

DF = dominant frequency (cpm, cycle per minute), DFIC = dominant frequency instability coefficient, DP = dominant power, $\Delta$DP = overall postprandial increment in the dominant power, Max$_{\Delta}$DP = maximum instantaneous postprandial increment in the dominant power, NS = difference statistically not significant; $^1$ DP values are given either in $\mu V^2$ (upper row) or dB (lower row); $^2$ data are medians with interquartile range indicated in brackets.
postprandial period, in both observation periods the median DP in the electrogastrogram of sitting subjects amounted to about one half of the corresponding median DP for recumbent subjects. This finding is unlikely to be due to technical factors in the GMA recording procedure, as a stringent control of the quality of the electrical contact of the electrodes to the skin was observed, and no significant difference was found in the resistances measured between the electrodes used for the surface electrogastrography when the sessions with the recumbent position were compared to those in the sitting position. Thus the most reasonable explanation of our finding pertaining to the DP is that the distance from the electrodes to the stomach might have been closer in the supine position than in the sitting position. We recently presented data which indicated that in a recumbent subject, the decreased distance between the electrodes accounts for only 13.6–17.2% of the augmented DP after intake of increasing volumes of an acaloric liquid load (Jonderko et al., 2004c). In a sitting position, however, gravity might have shifted the stomach downwards, thus increasing its distance from the recording electrodes. Nevertheless, from the point of view of research or clinical applications of electrogastrography, assessment of meal-evoked changes in DP relative to the fasted situation, rather than just consideration of net DP values, would provide the relevant information. Therefore the important finding of our study is that the transition from the interdigestive to the postprandial GMA pattern can be equally well discerned in either position. This is because neither the overall nor the maximum meal-induced change in DP was affected significantly by the posture of a subject.

Summing up, we conclude that with careful observation of procedural guidelines, good quality electrogastrograms can be obtained with a sitting subject, providing equally relevant parameters, as with the standard examination procedure in a recumbent position.

**Acknowledgements**

The work was supported in part by a research grant 3 P05D 054 24 obtained from the Ministry Of Scientific Research And Information Technology (formerly: State Committee For Scientific Research) of the Republic of Poland—contract # 0617/P05/2003/24, and a statutory research fund of the Institute of Occupational Medicine and Environmental Health—contract # NFP-4/2004.

**References**


Jonderko, K. (1987a). Radionuclide studies on gastric evacuatory function in health and in the duodenal


(Received February 23, 2005; Accepted March 25, 2005)