J Anesth (2009) 23:75–79
DOI 10.1007/s00540-008-0692-5

Journal of
Anesthesia

Electrogastrography during and after cesarean delivery

Masayuki Oshima, Kazuyoshi Aoyama, Kengo Warabi, Toshimasa Akazawa, and Eiichi Inada

Department of Anesthesiology and Pain Medicine, Juntendo University, School of Medicine, 2-1-1 Hongo, Bunkyo-ku, Tokyo 113-8421, Japan

Abstract
Purpose. Although it has been generally believed that parturients have delayed gastric emptying during anesthesia, the most recent reports suggest that gastric emptying is not delayed during pregnancy except during labor. Electrical slow waves in the stomach determine the frequency and the peristaltic nature of gastric contractions. In this study we performed electrogastrography during and after elective cesarean section (CS) in an attempt to evaluate gastric motility.
Methods. Sixteen American Society of Anesthesiologists physical status I or II term parturients undergoing elective CS were enrolled. Combined spinal-epidural anesthesia was initiated with 10 mg of bupivacaine plus 10 μg of fentanyl. Four-channel electrogastrography was obtained for 10 min prior to venous catheter insertion (baseline), 10 min following spinal injection of bupivacaine and fentanyl (Sp-1), 10 to 20 min following spinal injection (Sp-2), 10 min prior to the end of operation (end), and finally 10 min on the seventh postoperative day (POD 7).
Results. The mean ± SD values for dominant frequency of electrogastrography (DF) were determined as: 1.57 ± 0.36 cpm (baseline), 1.81 ± 0.32 cpm (Sp-1), 2.08 ± 0.36 cpm (Sp-2), 1.96 ± 0.36 cpm (end), and 3.02 ± 0.28 cpm (POD 7). The DF of Sp-1, Sp-2, and end were significantly higher than that of baseline ($P < 0.05$). The DF of POD 7 was significantly higher than that of baseline, Sp-1, Sp-2, and end ($P < 0.01$).
Conclusion. Electrogastrography analysis suggests that the frequency of gastric contractions during CS was less than that in the postpartum period.

Key words Electrogastrography · Cesarean section

Address correspondence to: M. Oshima
Presented, in part, at the American Society of Anesthesiologists 2005 Annual Meeting, October 22-26, 2005, Atlanta.
Received: July 4, 2007 / Accepted: September 8, 2008

Introduction

Gastric physiology during pregnancy may differ from that during the nonpregnant state because of changes in hormone levels (e.g., progesterone and motilin) and the displacement of the stomach by the gravid uterus. Recent studies of gastric emptying in nonlaboring women at term, using acetaminophen absorption [1–3], applied tomography [4], gastric impedance [5], and ultrasonography [3,6], all suggest that gastric emptying is not delayed during pregnancy except during labor.

Because gastric motility may be changed by the stages of labor and anesthesia, gastric motility should be assessed in series in the perioperative period. Electrogastrography may be a suitable technique to measure gastric motility continuously and repeatedly because of its noninvasiveness. Electrical slow waves in the stomach determine the frequency and the peristaltic nature of gastric contractions. Electrogastrography has been used to make a diagnosis and to evaluate the effects of treatment in patients with gastrointestinal motility disorders [7].

We hypothesized that gastric motility was likely to be depressed before cesarean section. Accordingly, the present study aimed to determine changes in gastric motility using electrogastrography before and after elective cesarean section. We also tried to determine the effects of high spinal anesthesia upon electrogastrography.

Patients, materials, and methods

After obtaining institutional review board approval and written informed consent, 16 American Society of Anesthesiologists physical status I or II term parturients undergoing elective cesarean section in the morning after an overnight fast were enrolled. Parturients diagnosed with diabetes mellitus and those on gastric motility drugs were excluded from the study.

Anesthetic technique

No premedication was administered. Following initial measurement of vital signs, in the right lateral position, combined spinal-epidural anesthesia was performed using a two-needle, two-interspace method. After securing the epidural catheter at the T12-L1 interspace, spinal anesthesia was initiated with 10 mg of hyperbaric bupivacaine (Marcain Injection spinal 0.5% hyperbaric; AstraZeneca, Osaka, Japan) and 10 μg of fentanyl (Fentanest Injection, Sankyo, Tokyo, Japan). The parturient was then placed in the supine position, and the operating table tilted leftward to achieve left uterine displacement to avoid aortocaval compression. Cesarean section was started after obtaining sensory block level to T4. If the anesthetic level was insufficient, 0.375% ropivacaine was injected epidurally to achieve T4 sensory blockade.

Experimental protocol

On arriving at the operating room in the morning after an overnight fast, baseline values for the electrogastrogram (baseline) were recorded with the patient in the supine position with left uterine displacement. Electrogastrogram was recorded over a 10-min period at each experimental measuring point. The perioperative measuring periods included 10 min following spinal injection of bupivacaine and fentanyl (Sp-1), 10 to 20 min following spinal injection (Sp-2), and 10 min prior to the end of operation (end). The measurement was repeated on the seventh postoperative day (POD 7) in the morning after an overnight fast. We set these time points in order to exclude overlapping periods.

Recording and analysis of electrogastrograms

After gentle skin abrasion to enhance electrical conduction, five Ag/AgCl adhesive electrodes (Red Dot; 3 M Medical Devices, St. Paul, MN, USA) were attached to the abdominal skin surface in the epigastric region (Fig. 1). Four-channel monopolar recordings were conducted with a portable recording device (NIPRO electrogastrogram EG; NIPRO, Osaka, Japan) with the patient in the supine position in as quiet an environment as possible. The electrogastrogram signals were isolated using a bandpass filter between 1.5 cycle per min (cpm) (roll-off, 18 dB/octave) and 5.4 cpm (roll-off, 48 dB/octave), and then digitally recorded (13 bit) at a sampling rate of 1 Hz. Although the American Motility Society Clinical GI Motility Testing Task Force recommends that the fasting recording period is 30 min [8], the manufacturer of our device and software used in this study recommend that recording period is at least 10 min. Therefore, we decided to record 10 min at each experimental measurement point. The raw data were analyzed by a person who was blinded to the timing of the recordings.

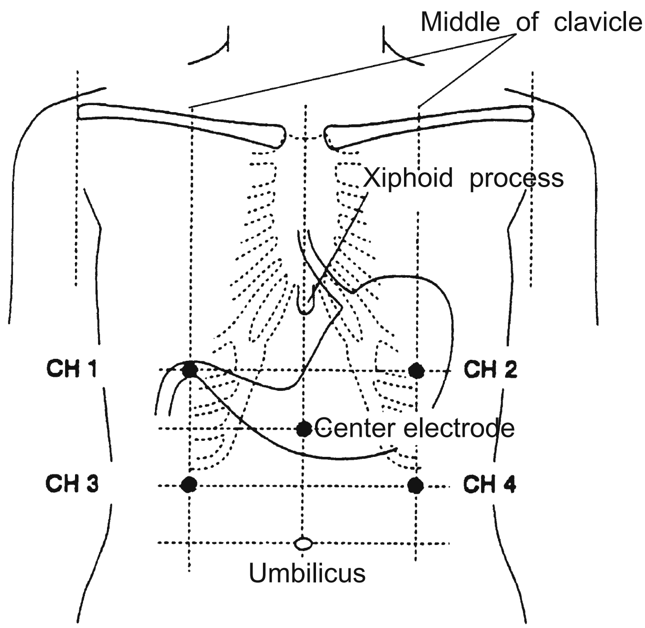

Fig. 1. Positioning of the electrogastrography (EGG) electrodes. The center electrode was placed halfway between the xiphoid process and the umbilicus. The four-channel electrode was placed at the cross-point of two imaginary lines, one horizontal line halfway between the center electrode and the xiphoid process or the umbilicus, and one vertical line in the middle of the clavicle. *CH*, channel

Approximately 600 data points from each channel were obtained in the 10-min study period. The electrogastrogram data were transferred to a computer to calculate the dominant frequency, using running spectral analysis.

After recording of the raw electrogastrogram data, electrogastrogram signal analysis was performed using fast Fourier transformation at 512 points. Resolution of the frequency was 0.12 cpm, which was determined from the sampling rate (1 Hz) and the segment duration for spectral analysis (8 min 32 s). The dominant frequency of each electrogastrogram (DF) was defined as the frequency appearing with the peak power value of spectra. All data were analyzed using EGS2 software (Gram, Urawa, Japan). DF at each experimental time-point for individual subjects was calculated as the mean of four-channel values.

Statistical analysis

Before performing the present study, we had performed a pilot study, including five parturients undergoing elective cesarean section, in which the difference of DF between baseline and POD 7 was 1.2 cpm, and the SD of the DF at baseline was 0.3. The required sample size for $\alpha = 0.05$ and $\beta = 0.2$, estimating difference = 1.0 cpm and estimating SD = 0.7 was eight parturients. Therefore, we enrolled 16 parturients to increase the power of this study.

Data values are expressed as means ± SD if not stated otherwise. Differences at each testing period were tested by analysis of variance (ANOVA) for repeated measures and post-hoc comparison by Bonferroni's test. Statistical analysis was performed using StatView 5.0 software (Abacus Concepts, Berkeley, CA, USA). A P value less than 0.05 was considered significant.

Results

Demographic analysis showed that the parturients were 33.8 ± 5.3 years old, 157.1 ± 7.5 cm in height, 63.6 ± 9.3 kg in weight, and 38 weeks and 1 day ± 1 day in gestational age. All women successfully underwent cesarean section without additional epidural injection.

Statistical analysis demonstrated that the DF of Sp-1, Sp-2, and end was significantly higher than that of baseline ($P < 0.05$). Analysis also showed that the DF of POD 7 was significantly higher than that of baseline, Sp-1, Sp-2, and end ($P < 0.01$; Fig. 2).

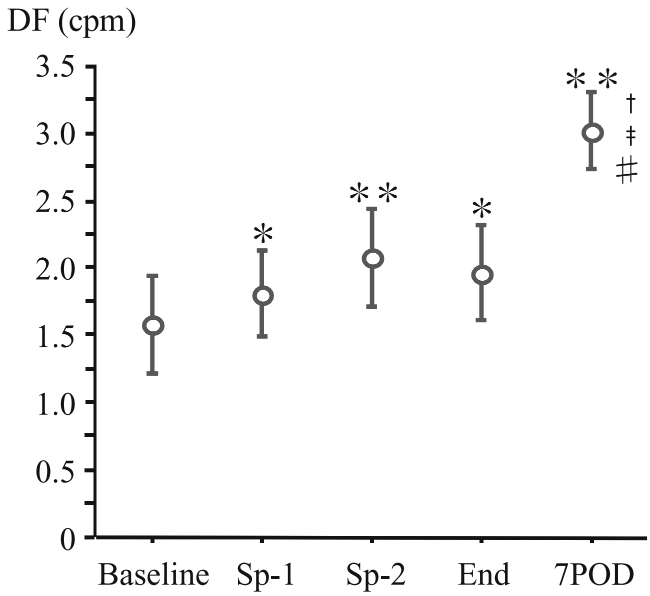

Fig. 2. Dominant frequency of electrogastrography (*DF*) during cesarean section and the postpartum state (postoperative day 7; *POD* 7). Data values are expressed as means ± SD. *Baseline*, 10 min after arrival of the patient in the operating room in the morning after an overnight fast, in the supine position with left uterine displacement; *Sp-1*, 10 min following spinal injection of bupivacaine and fentanyl; *Sp-2*, 10 to 20 min following spinal injection; *End*, 10 min prior to the operation ending; *7 POD*, for 10 min on the seventh postoperative day. $^{*}P < 0.05$ vs Baseline; $^{**}P < 0.01$ vs Baseline; $^{\dagger}P < 0.01$ vs Sp-1; $^{\ddagger}P < 0.01$ vs Sp-2; $^{\#}P < 0.01$ vs End

Discussion

Gastric peristaltic movement is conducted from the upper one-third part of the stomach to the pylorus. The stomach muscle itself also presents a myogenic character to mediate stomach motility. Pacemaker cells exist around greater curvature in the upper part of the stomach body, and electrical signals are conducted towards the pylorus at a rate of 3 cpm. Both slow wave (SW; electrical control activity) and spike (electrical response activity) are the well-known components of stomach myoelectricity. The slow waves trigger the onset of spike potentials, which in turn initiate coordinated contractions of the gastric smooth muscles. DF is very similar to the SW rhythm [9].

The electrogastrogram data in the present study demonstrated that the DF of POD 7 was significantly higher than that of baseline, Sp-1, Sp-2, and end, suggesting that gastric motility appeared to be slower before and during cesarean section. Our results are consistent with the classical observations. During pregnancy, there is usually slight diminution of gastric tone and motility [10].

Analysis also showed that the DFs of Sp-1, Sp-2, and end were significantly higher than that of baseline, suggesting improved gastric motility during cesarean section under spinal anesthesia. High spinal anesthesia may alter autonomic outflow to the gut, potentially altering gastric motility, and this could have played a direct role in the changes observed in the study.

Intrathecally injected opioids can strongly delay gastric emptying, both in animals [11–13] and in humans [14,15], and opioids can also increase gastric motility. In the present study, intrathecal fentanyl may have changed the DF via three possible sites: the central nervous system (cephalad spread in the cerebrospinal fluid), the spinal cord, or the nerve plexuses in the stomach wall [14]. Because systemic levels of fentanyl after intrathecal administration would be expected to be low after as small a dose as that used in the present study, it is unlikely that the changes in the DF were due to a local effect on opioid receptors in the stomach. Although intrathecal fentanyl in the present study may have changed the DF via the central nervous system and/or the spinal cord, our results suggested that the effect of intense sympathetic blockade on the DF produced by high spinal anesthesia was stronger than that of intrathecal fentanyl.

Pain has a delaying effect on gastric emptying [16], probably due to stimulation of the sympathetic nervous system, although endogenous opioids, beta-endorphins, and enkephalins may also play a role [17].

Because parturients in this study were scheduled for elective cesarean section, they had no contraction pain and pain was unlikely to have influenced the results.

There is a general belief that preoperative anxiety may have a negative influence upon gastric emptying. Several small studies have reported no differences in terms of gastric emptying in preoperative compared with postoperative periods [18–20], even when associated with increased anxiety during the preoperative period [20]. Although we did not objectively evaluate the anxiety of parturients during the present study, we could not explain the changes in the DF during cesarean section by the presence of anxiety alone. It might have been clearer if we had measured baseline values in the days prior to cesarean section to completely rule out maternal anxiety.

A variety of techniques have been used to determine gastric emptying during pregnancy and labor, and most of these studies were limited to the period during labor. A recent study noted that gastric emptying was not delayed in healthy, nonobese parturients at term who ingested 300 ml of water following an overnight fast [3]. Although aspiration is not a significant risk in an appropriately prepared woman presenting for elective cesarean section, the time course of return to normal gastric function after cesarean section has not been clearly elucidated. Because postpartum tubal ligation is usually performed after delivery, it is, at present, not clear whether or not the patient undergoing postpartum tubal ligation remains at risk of aspiration. Further study is needed to clarify when the electrogastrogram will return to normal.

There are some limitations in the present study. The role of electrogastrograms in the diagnosis and treatment of gastrointestinal motility disorders still remains to be elucidated [9,21]. Another potential limitation is in terms of electrode positioning and whether positioning using skin surface landmarks could accurately measure the same stomach component activity with or without stomach displacement by the gravid uterus. The intraoperative electrogastrography recordings were done in the left tilt position. The body position may alter electrogastrography recordings. In an attempt to reduce the potential effect of gastric position in electrogastrography assessment, we measured a four-channel electrogastrogram instead of a single-channel electrogastrogram, and compared DF as a mean of four-channel DF values at each experimental timepoint.

We did not assess other parameters (such as percent time in DF range, distribution of the electrogastrogram power spectrum, and dominant power). Although DF is very similar to the SW rhythm, SW amplitude is influenced by various patient factors (for example, skin conductance, electrode position, stomach configuration, wall thickness of abdomen and stomach) and recording systems. Absolute values of electrogastrogram power are affected by electrode position and body position. Furthermore, skin resistance in patients in our study may have changed between recording periods, as pregnancy and anesthesia alter blood flow and may alter resistance [9]. Therefore, electrogastrogram parameters other than DF would not have been exactly compared during this study period, and we therefore analyzed electrogastrograms with DF.

We measured electrogastrograms on POD 7 as the nonpregnant state. It would have been clearer if we had measured electrogastrograms and compared them to those in nonpregnant patients scheduled for elective surgery under spinal/epidural anesthesia. Furthermore, it would have been more definitive if we had studied electrogastrograms before and after cesarean section in the fasting and postprandial state.

The interpretation of our results in the clinical situation needs some caution. Because gastric motility and gastric emptying should be differentiated, further studies are needed to elucidate whether electrical gastric motility has clinical implications.

To summarize, although we cannot draw conclusions on the clinical significance of our findings, the frequency of gastric contractions before and during cesarean section was less than that on POD 7. However, the frequency of gastric contractions during cesarean section after spinal anesthesia was increased compared with baseline values, as measured by the electrogastrogram.

References

1. Whitehead EM, Smith M, Dean Y, O'Sullivan G. An evaluation of gastric emptying times in pregnancy and the puerperium. Anaesthesia. 1993;48:53–7.
2. Macfie AG, Magides AD, Richmond MN, Reilly CS. Gastric emptying in pregnancy. Br J Anaesth. 1991;67:54–7.
3. Wong CA, Loffredi M, Ganchiff JN, Zhao J, Wang Z, Avram MJ. Gastric emptying of water in term pregnancy. Anesthesiology. 2002;96:1395–400.
4. Sandhar BK, Elliott RH, Windram I, Rowbotham DJ. Peripartum changes in gastric emptying. Anaesthesia. 1992;47:196–8.
5. O'Sullivan GM, Sutton AJ, Thompson SA, Carrie LE, Bullingham RE. Noninvasive measurement of gastric emptying in obstetric patients. Anesth Analg. 1987;66:505–11.
6. Chiloiro M, Darconza G, Piccioli E, De Carne M, Clemente C, Riezzo G. Gastric emptying and orocecal transit time in pregnancy. J Gastroenterol. 2001;36:538–43.
7. Kelly KA. Pacing the gut. Gastroenterology. 1992;103:1967–9.
8. Parkman HP, Hasler WL, Barnett JL, Eaker EY. Electrogastrography: a document prepared by the gastric section of the American Motility Society Clinical GI Motility Testing Task Force. Neurogastroenterol Motil. 2003;15:89–102.
9. Chang F-Y. Electrogastrography: basic knowledge, recording, processing and its clinical applications. J Gastroenterol Hepatol. 2005;20:502–16.

10. Vanner RG, Goodman NW. Gastro-oesophageal reflux in pregnancy at term and after delivery. Anaesthesia. 1989;44:808–11.
11. Ruckebusch Y, Bardon T, Pairet M. Opioid control of the ruminant stomach motility. Life Sci. 1984;35:1731–8.
12. Improta G, Broccardo M. Effect of selective mu1, mu2, and delta 2 opioid receptor agonists on gastric functions in the rat. Neuropharmacology. 1994;33: 977–81.
13. Tsuchida D, Fukuda H, Koda K, Miyazaki M, Pappas TN, Takahashi T. Central effect of mu-opioid agonists on antral motility in conscious rats. Brain Res. 2004;1024:244–50.
14. Kelly MC, Carabine UA, Hill DA, Mirakhur RK. A comparison of the effect of intrathecal and extradural fentanyl on gastric emptying in laboring women. Anesth Analg. 1997;85: 834–8.
15. Lydon AM, Cooke T, Duggan F, Shorten GD. Delayed postoperative gastric emptying following intrathecal morphine and intrathecal bupivacaine. Can J Anaesth. 1999;46:544–9.
16. Volans GN. Absorption of effervescent aspirin during migraine. BMJ. 1974;4:265–8.
17. Thompson DG, Richelson E, Malagelada J-R. Perturbation of upper gastrointestinal function by cold stress. Gut. 1983;24:277–83.
18. Marsh RH, Spencer R, Nimmo WS. Gastric emptying and drug absorption before surgery. Br J Anaesth. 1984;56:161–4.
19. Nygren J, Thorell A, Jacobsson H, Larsson S, Schnell PO, Hylen L, Ljungqvist O. Preoperative gastric emptying: effects of anxiety and oral carbohydrate administration. Ann Surg. 1995;222:728–34.
20. Lydon A, McGinley J, Cooke T, Duggan PF, Shorten GD. Effect of anxiety on the rate of gastric emptying of liquids. Br J Anaesth. 1998;81:522–5.
21. Camilleri M, Hasler WL, Parkman HP, Quigley EMM, Soffer E. Measurement of gastrointestinal motility in the GI laboratory. Gastroenterology. 1998;115: 747–62.