Pediatr Surg Int (2004) 19: 760–765
DOI 10.1007/s00383-003-1053-y

ORIGINAL ARTICLE

M. Yagi · S. Homma · M. Kubota · Y. Iinuma
S. Kanada · Y. Kinoshita · M. Ohtaki · S. Yamazaki
H. Murata

The herbal medicine Rikkunshi-to stimulates and coordinates the gastric myoelectric activity in post-operative dyspeptic children after gastrointestinal surgery

Published online: 9 January 2004

Abstract Rikkunshi-to (TJ-43), a gastroprotective herbal medicine, has been used for the symptomatic relief of adult patients with dyspepsia. However, its mechanism has yet to be fully elucidated. The aim of this study is to evaluate the effect of TJ-43 on the gastric myoelectric activity in post-operative dyspeptic patients, whose symptoms persisted for over 1 year after gastrointestinal surgery. Electrogastrography (EGG) recordings were performed to calculate the biomechanical parameters on the dominant peak frequency (DPF). Eight pediatric patients with dyspeptic symptoms after gastrointestinal surgery were examined and six age-matched children without any dyspeptic symptoms were used as controls, and they were compared with nine age-matched children without any dyspeptic symptoms after gastrointestinal surgery as subcontrols. All patients exhibited symptomatic relief after the administration of TJ-43, and the mean symptom score decreased significantly after the treatment of TJ-43 over a 1-month period ($P < 0.0001$). The variability index (VI) and the percentage of normal waves (PNW) were calculated as irregularity parameters of DPF. The power ratio (PR) was calculated as a parameter of the gastric contractile activity. There were no significant differences in the VI and PNW between the controls and patients during the postprandial state after therapy, even though significant differences existed regarding those parameters between the controls and patients before the therapy. There were no significant differences in the DPF, VI, and PNW between the controls and subcontrols. Furthermore, PR exhibited a significant increase after therapy ($P < 0.05$). However, there was a significant difference in the PR between the controls and subcontrols ($P < 0.05$). Postprandial dip was observed in all control subjects, eight patients in the subcontrols, and two patients after administration of TJ-43, respectively. An abnormal gastric electrical activity therefore seems to be an important factor in the pathophysiology of post-operative dyspeptic children. The coordinating and stimulating effect of TJ-43 on the gastric myoelectric activity therefore seems to play an important role in the reduction of dyspeptic symptoms.

Keywords Rikkunshi-to · Gastric myoelectric activity · Dyspepsia · Gastrointestinal surgery

M. Yagi (✉) · M. Kubota · Y. Iinuma · S. Kanada
Y. Kinoshita · M. Ohtaki · S. Yamazaki · H. Murata
Department of Pediatric Surgery,
Niigata University Graduate School of Medical and Dental Sciences, 1-757 Asahimachi-dori,
Niigata-City, 951–8510 Niigata, Japan
E-mail: yagimi@med.niigata-u.ac.jp
Fax: +81-25-2270781

S. Homma
Department of Organ Physiology,
Niigata University Graduate School of Medical and Dental Sciences, 1-757 Asahimachi-dori,
Niigata-City, 951–8510 Niigata, Japan

Introduction

Dyspeptic symptoms, suggesting such functional upper gastrointestinal disorders, as postprandial vomiting, regurgitation, belching, bloating, fullness, and early satiety, sometimes appear in adult patients after undergoing gastrointestinal surgery [15, 16, 25]. This constellation of symptoms, in the absence any structural abnormalities or focal mucosal lesions of the gut, is known as dyspepsia [1]. A recent study has shown that pediatric subjects who have these symptoms represent a heterogenous population encompassing functional gastrointestinal disorders [11].

Because abnormal gastrointestinal motor patterns were identified in some patients with dyspepsia and prokinetic drugs were observed to have a beneficial effect on these patients, dyspeptic syndrome is thus suggested to be due to an abnormal gastroduodenal motility [1, 12]. It is also worth noting that a number of reports have described abnormalities in the gastric electrical activity in patients with unexplained dyspeptic symptoms and delayed gastric emptying [5, 28]. Rikkunshi-to (TJ-43), a

gastroprotective herbal medicine, is reported to be effective for symptomatic relief in patients with dysmotility-like functional dyspepsia [6, 21]. However, its mechanisms have not yet been fully elucidated. Since TJ-43 improves the impaired gastric emptying of such patients [21], this aspect is thought to be its main mechanism of action. Furthermore, the stomach has a reservoir function to accommodate the intake of food and liquid. Disturbances in these functions may cause either epigastric fullness or early satiety, which are the main symptoms in patients with dysmotility-like functional dyspepsia [23, 24]. However, the effect of the herbal medicine Rikkunshi-to (TJ-43) has not yet been evaluated regarding its influence on the gastric myoelectric activity. The aim of this study was to measure and evaluate both the fasting and postprandial gastric myoelectric activity in patients with post-operative dyspeptic symptoms both before and after the administration of TJ-43.

Patients and methods

Patients

In the eight children with persisting symptoms of dyspepsia after gastrointestinal surgery, we obtained their informed consent to undergo an electrogastrographic examination and TJ-43 therapy. They were examined at our hospital from September 1994 to March 2000, and six healthy children without any clinical symptoms and nine post-operative children without dyspeptic symptoms were used as controls and subcontrols, respectively. The mean age at examination was 9.0 ± 6.9, 9.4 ± 1.4, 7.4 ± 4.1 years in the patients, controls, subcontrols, respectively. Their median age was 9.5, 8.3, 8 years, respectively.

The underlying disorders and operations of the patients were as follows: esophageal atresia ($n=2$)(esophago-esophagostomy), esophageal achalasia ($n=1$)(Heller's myotomy with Dor-Nissen fundoplication), esophageal hiatal hernia ($n=1$)(Nissen fundoplication), gastroesophageal reflux ($n=1$)(Dor-Nissen fundoplication), duodenal atresia ($n=1$)(duodenoduodenostomy), lower celosomia ($n=1$)(repair),and biliary atresia($n=1$)(Kasai operation). All patients showed dyspepsic upper abdominal symptoms for over 1 year after operation.

The most common symptom was postprandial epigastric discomfort ($n=8$). Other presenting complaints were regurgitation ($n=1$), anorexia ($n=5$) or early satiety ($n=8$), and belching ($n=3$). In four children, the weight was below -2 SD. In all patients, upper gastrointestinal radiography or endoscopy excluded post-operative structural abnormalities of the gut. Infections, metabolic diseases and neurological diseases were also excluded.

The underlying disorders and operations of the subcontrols were as follows: esophageal atresia ($n=2$) (esophago-esophagostomy), and biliary atresia ($n=7$) (Kasai operation). None of the children of the subcontrols showed either any dyspepsic upper abdominal symptoms or liver dysfunction.

Electrogastrography (EGG) recording

The gastric myoelectric activity was recorded, using a non-invasive method, by means of surface electrodes attached to the epigastric abdominal wall along the axis of the distal stomach which was previously localized by ultrasonography [8, 17, 26]. The electrodes were connected to a polygraph. The high cut-off filter and time constant were set at 0.5 Hz and 5 s, respectively. Because of interindividual anatomical variations, various recording sites were tried to find the best combination of leads which generated the best signal-to-noise ratio for the analysis. The EGG signal was simultaneously recorded on the polygraph and on a magnetic data recorder. This was later digitized (real-time sampling rate: 2 Hz) and fed into a personal computer for a spectral analysis, namely, a method by which the wave form data are decomposed into various frequency components and the relative contribution of a given frequency band to the entire signal is called the 'power' of the frequency band. This analysis has the greatest contribution of its frequencies in the range of 2.4–4.0 cycles per minute (cpm) and thus demonstrates its highest 'power' at that frequency range [27].

The EGG recordings were performed for 30 min during a fasting period and for 30 min after the test meal. A low-residue diet (Clinimeal, Eizai Co., Japan) was used as test meal with a calorie density of 1 kcal/ml and 10 kcal/kg body weight. The children were examined in the supine position after an overnight fast [8, 17, 26]. In this series, the EGGs were recorded before and after TJ-43 therapy. Informed consent was obtained from both the patients, controls, subcontrols and their parents.

EGG data analysis

A visual analysis of the EGG wave forms is neither possible nor objective. Therefore, a spectral analysis was used to compute the power of the EGG signal as a function of its frequency components. Spectral analyses were represented by pseudo-three-dimensional plots, where the electrical frequencies (0–15 cpm) were plotted on the horizontal axis and time (in 128-s intervals) on the vertical axis. This procedure generates a series of overlapping spectra and makes both a frequency and time analysis possible (running spectral analysis) [8, 17, 26]. A quantitative and statistical analysis of the EGG data was performed to investigate the effects of TJ-43 on the frequency, amplitude, and regularity of the EGG after the spectral analysis using the maximum entropy method (MEM) in the fasting and postprandial state. The calculated parameters are as follows: (1) dominant peak frequency (DPF), (2) variability index of the DPF (VI), (3) percentage of normal gastric slow waves (PNW), and (4) peak power ratio (PR).

1. DPF was defined as the frequency at which the EGG power spectrum has its maximum peak power. The DPF usually falls in the range of 0.5 to 15 cpm [8, 17, 26]. The normal range of DPF is controversial [2, 5, 28], but we considered the range to be abnormal if it was not between 2.4 and 4 cpm in our series of studies [27]. Tachygastria was defined as a dominant frequency of greater than 4 cpm. Bradygastria was defined as a dominant frequency of less than 2.4 cpm. A dysrhythmic episode had to be present for at least 2 min with the absence of the normal gastric signal. The dominant frequency and the corresponding power were computed with each EGG tracing, using the maximum entropy method (MEM) [8, 17, 26].
2. Variability index of the DPF (VI) was defined as the ratio (standard deviation of DPF)/DPF.
3. After ensemble means of the spectra (EMS) were calculated in the fasting and postprandial state, the area enclosed between the curve of the EMS and baseline was defined as the total area of the spectra (TAS). PNW was defined as the percentage of area enclosed between 2.4 and 4.0 cpm (normal wave area, NWA) in TAS, that is, $\mathrm{PNW} = (\mathrm{NWA}/\mathrm{TAS}) \times 100$.
4. The power at the DPF in the power spectrum is the EGG peak power. The peak power ratio (PR) was defined as the relative difference (the postprandial power/the fasting power) in the peak power (in squared microvolts) at the DPF between the fasted and postprandial states [8, 17, 26].

Postprandial dip

Postprandial dip, which is a transient decrease in frequency that occurs within a few minutes after ingestion of food, is

usually found in normal subjects [5]. In our series, we evaluated whether or not this phenomenon was found before and after administration of TJ-43 from the view point of running spectral analysis.

Symptom evaluation (gastrointestinal symptom scores)

The clinical response was determined by an assessment of the symptoms (nausea, vomiting, early satiety, anorexia, bloating, and abdominal pain) before and after 4 weeks of TJ-43 according to Riezzo's evaluation [18]. The severity of symptoms was graded from 0 (none) to 3 (severe) [18]. The final score represented the addition of the individual scores with a total possible score of 18.

Herbal medicine Rikkunshi-to (TJ-43) administration

Rikkunshi-to is the Kampo medicine formulation, originally described in the Kampo classics, Liu-Jun-Zi Tang (the formal name in a classic book on Chinese herbal medicine is Manbyoukaisyun, written by a Chinese physician Kyou Enken in 1587 A.D.). The powder extract of herbal medicine Rikkunshi-to (TJ-43) was manufactured by Tsumura Co. (Tokyo, Japan). TJ-43 was extracted from a mixture of *Atractylodis lanceae rhizoma* (component ratio, cr = 4), *Ginseng radix* (cr = 4), *Pinelliae tuber* (cr = 4), *Hoelen* (cr = 4), *Zizyphi fructus* (cr = 2), *Aurantii nobilis percarpium* (cr = 2), *Glycyrrhizae radix* (cr = 1) and *Zingiberis rhizoma* (cr = 0.5) [7]. This is a fixed-ratio formulation of eight medicinal herbs and roots in a form such that the quality and volume of ingredients are uniform, as determined by a quantitative chemical analysis of sentinel compounds within each ingredient. The standard product classification number of the Japanese Ministry of Health, Labor and Welfare is 5200141D1034, and its Japanese health insurance number is (61AM) 3260. The safety of TJ-43 regarding its administration to infants and children has not yet been fully established because its usage in infants and children has not reached a sufficient number for that purpose. However, authorized guidelines allow its use in infants and children under the careful observation of a medical doctor. Therefore, TJ-43 was authorized as a medical drug for ethical use and it is usually administrated by a medical doctor to patients ranging from infants to adults in Japan. In this series, TJ-43 was orally administered to the patients three times a day for over 1 month (10.0 ± 8.2 months) at a dose of 0.2 g/kg/day (below 40 kg body weight) or 7.5 g/day (over 40 kg body weight).

Statistical analysis

A statistical analysis was performed using Student's *t*-test. The data were expressed as the mean ± SD. Probability values were considered statistically significant at the 0.05 level or less.

Results

TJ-43 was orally administered to the patients for 10.0 ± 8.2 months based on the EGG recordings in the pre-treatment condition. Each patient reported an improvement in the gastrointestinal symptom score which decreased significantly from 9.250 ± 1.282 points to 3.125 ± 0.835 points after the therapy ($P < 0.0001$).

TJ-43 therapy was withdrawn in five patients with dyspeptic symptoms after 11–30 months (mean 21 months) of administration. These five patients had no obvious symptoms of recurrence without TJ-43 therapy.

Electrogastrographic findings

Clear episodes of gastric dysrhythmia were recognized by a visual inspection of the raw EGG signals in all patients before therapy. Figure 1 shows an example of an EGG running spectral analysis display in a pediatric patient before and after TJ-43. Before TJ-43, a clear episode of dysrhythmia is shown. After a 7-month administration of TJ-43, the gastric electrical activity was found to have remarkably improved.

Table 1 summarizes data of DPF, VI and PNW in the controls and in patients before and after TJ-43 administration. DPF during the postprandial state in patients was 3.5 ± 0.29 cpm and 3.5 ± 0.22 cpm before and after TJ-43 administration, respectively. There was no significant difference before and after TJ-43 administration. The DPFs during the postprandial state in patients were higher than those in the controls but without a significant difference (before TJ-43: $P = 0.08$, after TJ-43:

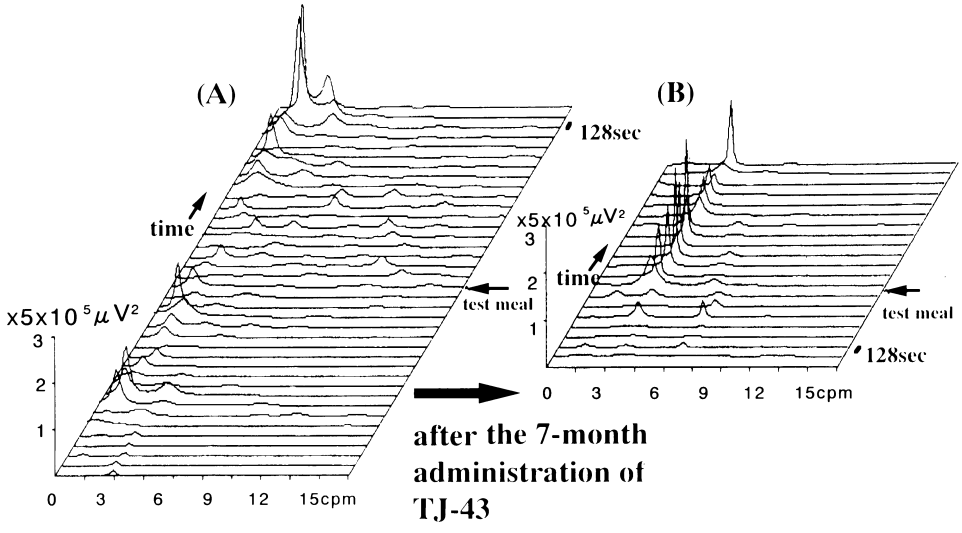

Fig. 1A, B An example of the EGG running spectral array.: **A** Before TJ-43 administration: at 4.5 years of age, post-operative biliary atresia in female patient without jaundice: She presented anorexia and early satiety. **B** After 7-month administration of TJ-43, at 5.2 years of age, in addition to the relief of her gastrointestinal symptoms, the irregularity and power ratio of EGG were improved remarkably

Table 1 Dominant peak frequency (DPF), variability index of the DPF (VI), and percentage of normal slow waves (PNW) in patients before and after TJ-43 administration in comparison to the controls

	Fasted					Postprandial				
	Controls	Patients		*P* value		Controls	Patients		*P* value	
		Before TJ 43	After-TJ43	P^a	P^b		Before TJ 43	After-TJ43	P^a	P^b
DPF (cpm)	3.3 ± 0.25	3.4 ± 0.34	3.3 ± 0.31	0.52	0.96	3.3 ± 0.23	3.5 ± 0.29	3.5 ± 0.22	0.08	0.09
VI	0.12 ± 0.078	0.14 ± 0.062	0.13 ± 0.058	0.61	0.84	0.087 ± 0.032	0.17 ± 0.071	0.12 ± 0.07	0.026	0.37
PNW (%)	43 ± 23	30 ± 13	36 ± 16	0.20	0.51	62 ± 13	31 ± 19	42 ± 22	0.005	0.072

[a]Controls vs patients before TJ-43 therapy
[b]Controls vs patients after TJ-43 therapy

Table 2 Dominant peak frequency (DPF), variability index of the DPF (VI), and percentage of normal slow waves (PNW) in patients and subcontrols in comparison to the controls

	Fasted			Postprandial		
	Controls	Subcontrols	*P* value	Controls	Subcontrols	*P* value
DPF (cpm)	3.3 ± 0.25	3.2 ± 0.31	0.29	3.3 ± 0.23	3.2 ± 0.31	0.55
VI	0.12 ± 0.078	0.12 ± 0.056	0.95	0.087 ± 0.032	0.13 ± 0.057	0.16
PNW (%)	43 ± 23	44 ± 18	0.95	62 ± 13	48 ± 14	0.07

$P = 0.09$) (Table 1). Although there was a significant difference in VI between the controls and patients before TJ-43 administration ($P < 0.05$), there was no significant difference between the controls and patients after TJ-43 administration during the postprandial state (Table 1). Furthermore, there was no significant difference between the controls and patients after TJ-43 administration during the postprandial state although there was a significant difference in postprandial PNW between the controls and patients before TJ-43 administration ($P < 0.01$). Based on the results of VI and PNW, the patients showed an increased rhythmical stability of the DPF after therapy (Table 1). There were no significant differences in DPF, VI, and PNW between the controls and subcontrols (Table 2).

The PRs in the controls and subcontrols were 11.3 ± 8.1 and 3.3 ± 1.9. The PR in the patients was 2.2 ± 0.85 and 4.7 ± 2.1 before and after TJ-43 administration, respectively. There was a significant difference in the PR between the controls and patients ($P < 0.05$). There was a significant difference in the PR between the controls and subcontrols ($P < 0.05$). Furthermore, there was a significant difference in the PR of the patients before and after TJ-43 administration ($P < 0.05$). Based on the results of PR, the patients demonstrated an increased gastric contractile activity after therapy (Fig. 2). Postprandial dip was observed in all control subjects and two patients after administration of TJ-43.

There was no significant correlation between the symptomatic score improvement and the changes in the EGG parameters after TJ-43 therapy.

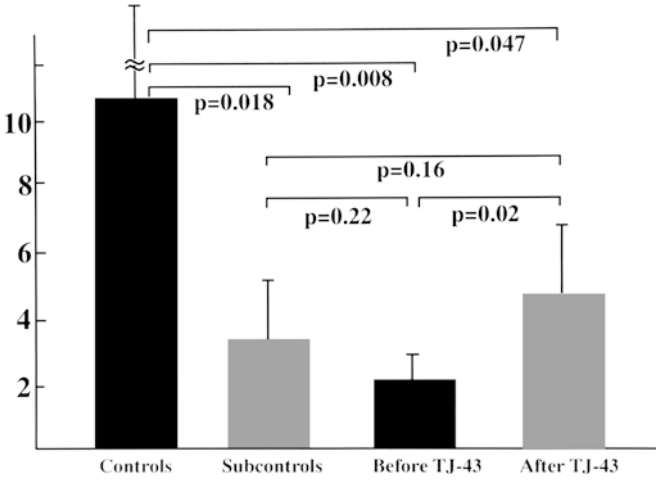

Fig. 2 Power ratio (PR). A significant difference was observed between the controls and patients (both before and after TJ-43 administration) ($P < 0.05$). Furthermore, a significant difference was observed in the PR of the patients before and after TJ-43 administration ($P < 0.05$)

Discussion

EGG has been used in the diagnostic work in adult patients with unexplained dyspeptic symptoms. In previous studies, a variety of gastric electrical abnormalities had been reported, including a decreased or absent postprandial increase in the electrogastrographic amplitude, an instability of gastric frequency, and an abnormally high (tachygastria) or low (bradygastria) slow wave frequency [5, 28]. These electrical abnormalities, which were related to the frequency of gastric activity, are usually called gastric dysrhythmias. The fact that a large proportion of our patients with dyspepsia showed gastric dysrhythmias is not unexpected as motor events in the stomach are controlled by the electrical activity of gastric smooth muscle cells. An abnormal electrical activity of the stomach might disturb the motor events by either destroying the orderly patterns of gastric peristalsis or by inhibiting the strength of

muscular contractions [4]. The most common dysrhythmia described in adult patients with gastric electrical abnormalities is tachygastria. A relationship between tachygastria and delayed gastric emptying has been previously suggested in vivo from a patient with idiopathic gastroparesis [22]. Although the neurohumoral mechanisms involved in the production of tachygastria are unknown [4], experimental evidence has shown the inhibition of cholinergic activity to shorten the refractory period of smooth muscle cells while increasing the slow wave frequency [19]. This suggests that in patients with dyspepsia a defective release of acetylcholine from the intramural cholinergic nerves might give rise to both the occurrence of gastric electrical dysrhythmias and a decreased motility.

Even in children, gastric dysrhythmias have been reported in a variety of diseases such as dyspepsia, CIIPS, gastric rupture, esophageal atresia, gastroesophageal reflux, and short bowel syndrome [1, 2, 3, 9, 17, 18, 20, 26]. EGG has been shown to be useful as a non-invasive screening test for pediatric gastrointestinal motility disorders. In children, there are patients such as our patients who exhibit long-term dyspeptic symptoms after gastrointestinal surgery. However, surprisingly few reports exist which objectively evaluate these dyspeptic patients before and after prokinetic therapy in children [1, 18].

There are several agents with an antiarrhythmic effect as well as prokinetic effects, such as domperidone, cisapride, and TJ-43. In adult patients with diabetic gastroparesis, a normalization of the electrical activity has been seen after domperidone administration [14]. Cisapride has been demonstrated to improve gastric emptying and the myoelectrical activity in children with dyspepsia [1, 18]. However, there have been few reports objectively evaluating herbal medicines, such as TJ-43, as a prokinetic drug [7, 21]. Antagonistic double innervation by excitatory cholinergic nerves and inhibitory noncholinergic nonadrenergic nerves is involved in the functional regulation of the gastrointestinal smooth muscles. The decreased gastric emptying in dysmotility-like dyspepsia is considered to be due to the impairment of the excitatory cholinergic nervous system [21]. From the view point of gastric motility control by gastric myoelectric activity, an improvement in the normal slow wave percentage of EGG is thought to possibly contribute to more effective gastric contractions or gastroduodenal coordination, and, as a result, it may lead to a faster gastric emptying time.

Although there were no significant differences in DPF, VI, and PNW between controls and subcontrols, there was a significant difference in the PR between the controls and subcontrols ($P < 0.05$). These facts suggest that the gastric contractile activity of the subcontrols may be potentially lower than that of the controls in spite of regular rhythm in gastric myoelectric activity. Furthermore, five of eight dyspeptic patients were able to stop taking TJ-43. Although EGG examinations were not carried out after the withdrawal of TJ-43, these facts might be due to maturational changes with lasting antiarrhythmic and prokinetic effects of TJ-43 on the gastric myoelectric activity.

Postprandial dip, which is a transient decrease in frequency that occurs within a few minutes after food ingestion, was observed in two patients after administration of TJ-43. It is usually found in normal subjects like our controls [5]. Its onset is probably mediated by the physical distention of the stomach due to food ingestion. Although the physiological significance and the cause of the postprandial dip are yet to be determined, it might be related to gastric adaptive relaxation. In pathological conditions, such as functional dyspepsia, and autonomic nerve disorder, the incidence of this phenomenon decreases [5, 13]. It is suggested that autonomic nervous activity is involved in the occurrence of postprandial dip.

Regarding the relationship between proximal gastric relaxation and gastric emptying, Hausken et al. suggested that an impairment in the relaxation response caused antral distention, thus resulting in a disturbance of gastric emptying [10]. Therefore, the improvement in the retarded gastric emptying after treatment with TJ-43 in patients with dyspeptic symptoms might be due to the recovery of gastric adaptive relaxation [7, 21]. Our study demonstrated a clear correlation between EGG and symptoms, and also confirmed the antiarrhythmic (coordinating) and prokinetic (stimulating) effects of TJ-43 on the gastric electrical activity in children with dyspeptic symptoms. All these data support the notion that gastric dysrhythmias can play an important role in the treatment of children with dyspepsia.

In conclusion, abnormal gastric electrical activity seems to play an important role in the pathophysiology of post-operative dyspeptic children. The antiarrhythmic effect of TJ-43 as well as its prokinetic effect on the gastric contractile activity therefore seems to play a relevant role in the reduction of dyspeptic symptoms.

References

1. Cucchiara S, Minella R, Riezzo G, Vallone G, Vallone P, Castellone F, Auricchio S (1992) Reversal of gastric electrical dysrhythmias by cisapride in children with functional dyspepsia. Dig Dis Sci 37:1136–1140
2. Cucchiara S, Riezzo G, Minella R, Pezzolla F, Giorgio I, Auricchio S (1992) Electrogastrography in non-ulcer dyspepsia. Arch Dis Child 67:613–617
3. Devane SP, Ravelli AM, Bisset WM, Smith VV, Lake BD, Milla PJ (1992) Gastric antral dysrhythmias in children with chronic idiopathic intestinal pseudoobstruction. Gut 33: 1477–1481
4. Dubois A (1989) Gastric dysrhythmias: pathophysiology and etiologic factors. Mayo Clin Proc 64:246–250
5. Geldof H, Van der Schee EJ, Van Blankenstein M, Grashuis JL. (1986) Electrogastrographic study of gastric myoelectrical activity in patients with unexplained nausea and vomiting. Gut 27:799–808
6. Goso Y, Ogata Y, Ishihara K, Hotta K (1996) Effects of traditional herbal medicine on gastric mucin against ethanol-induced gastric injury in rats. Comp Biochem Physiol C Pharmacol Toxicol Endocrinol 113:17–21

7. Hayakawa T, Arakawa T, Kase Y, Akiyama S, Ishige A, Takeda S, Sasaki H, Uno H, Fukuda T, Higuchi K, Kobayashi K (1999) Liu-Jun-Zi-Tang, a kampo medicine, promotes adaptive relaxation in isolated guinea pig stomachs. Drugs Exp Clin Res 25:211–218
8. Homma S, Shimakage N, Yagi M, Hasegawa J, Sato K, Matsuo H, Tamiya Y, Tanaka O, Muto T, Hatakeyama K (1995) Electrogastrography prior to and following total gastrectomy, subtotal gastrectomy, and gastric tube formation. Dig Dis Sci 40:893–900
9. Homma S, Yagi M, Uchiyama M, Iwafuchi M (2000) Isopower mapping of electrogastrograms in short bowel syndrome. Med Biol Eng Comput 38:653–658
10. Husken T, Berstad A (1994) Effect of glyceryl trinitrate on antral motility and symptoms in patients with functional dyspepsia. Scand J Gastroenterol 29:23–28
11. Hyams JS, Davis P, Sylvester FA, Zeiter DK, Justinich CJ, Lerer T(2000) Dyspepsia in children and adolescents: a prospective study. J Pediatr Gastroenterol Nutr 30:413–418
12. Jian R, Ducrot F, Ruskone A, Chaussade S, Rambaud JC, Modigliani R, Rain JD, Bernier JJ (1989) Symptomatic, radionucleotide and therapeutic assessment of chronic idiopathic dyspepsia. A double-blind placebo-controlled evaluation of cisapride. Dig Dis Sci 34:657–664
13. Kaneoke Y, Koike Y, Sakurai N, Washimi Y, Hirayama M, Hoshiyama M, Takahashi A (1992) Electrogastroenterography: application to patients with degenerative disease of the nervous system. Auton Nervous Syst 29:38–43
14. Koch KL, Stern RM,Stewart WR, Vasey MW (1989) Gastric emptying and gastric myoelectrical activity in patients with diabetic gastroparesis: effect of long-term domperidone treatment. Am J Gastroenterol 84:1069–1075
15. Lindsetmo RO, Johnsen R, Revhaug A (1998) Abdominal and dyspeptic symptoms in patients with peptic ulcer treated medically or surgically. Br J Surg 85:845–849
16. Mistiaen W, Van Hee R, Blockx P, Bortier H, Harrisson F(2001) Gastric emptying rate for solid and for liquid test meals in patients with dyspeptic symptoms after partial gastrectomy and after vagotomy followed by partial gastrectomy. Hepatogastroenterology 48:299–302
17. Ohtani S, Iwafuchi M, Ohsawa Y, Uchiyama M, Yagi M, Homma S (1995) Electrogastrography in patients after operative repair of gastric rupture. Pediatr Surg Int 10:233–236
18. Riezzo G, Cucchiara S, Chiloiro M, Minella R, Guerra V, Stat D, Giorgio I (1995) Gastric emptying and myoelectrical activity in children with non-ulcer dyspepsia. Effect of cisapride. Dig Dis Sci 40:1428–1434
19. Sarna SK, Daniel EE (1974) Threshold curves and refractoriness properties of gastric relaxation oscillators. Am J Physiol 226:749–755
20. Siegel A, Mayr J, Huber A, Uray E (1998) Postprandial tachygastria is frequent in infants with gastroesophageal reflux. Pediatr Surg Int 13:569–571
21. Tatsuta M, Ishii H (1993) Effect of treatment with Liu-Jun-Zi-Tang (TJ-43) on gastric emptying and gastrointestinal symptoms in dyspeptic patients. Aliment Pharmcol Ther 7:459–462
22. Telander RL, Morgan LG, Kreulan DL, Schmalz PF, Kelly KA, Szurszewski JH (1978) Human gastric atony with tachygastria and gastric retention. Gastroenterology 75:497–501
23. Troncon LEA, Bennett RJM, Ahluwalia NK, Thompson DG (1994) Abnormal intragastric distribution of food during gastric emptying in functional dyspepsia patients. Gut 35:327–332
24. Troncon LEA, Thompson DG, Ahluwalia NK, Barlow J, Heggie L (1995) Relations between upper abdominal symptoms and gastric distention abnormalities in dysmotility like functional dyspepsia and after vagotomy. Gut 37:17–22
25. Wijnhoven BPL, Salet GAM, Roelofs JMM, Smout AJPM, Akkermann LMA, Gooszen HG (1998) Function of the proximal stomach after Nissen fundoplication. Br J Surg 85:267–271
26. Yagi M, Homma S, Iwafuchi M, Uchiyama M, Matsuda Y, Maruta T (1997) Electrogastrography after operative repair of esophageal atresia. Pediatr Surg Int 12:340–343
27. Yagi M, Homma S, Iwafuchi M, Uchiyama M, Ohtaki M (2000) The herbal medicine Rikkunshi-to stimulates gastric myoelectric activity in children with dysmotility-like dyspepsia. Neurogastroenterology 12:499
28. You CH, Chey WY, Lee KY, Menguy R, Bortoff A (1981) Gastric and small intestine myoelectrical dysrhythmia associated with chronic intractable nausea and vomiting. Ann Intern Med 95:449–451