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Original Article

Gastric myoelectrical activities in elderly severe tetanus: Useful marker to increase volume and calorie of nasogastric tube feeding

K. Obayashi^{a,*}, M. Ueda^a, T. Yamashita^b, Y. Misumi^b, T. Hirahara^b, M. Tasaki^a, T. Ohshima^b, M. Uchino^b, Y. Ando^a

^a Department of Diagnostic Medicine, Graduate School of Medical Sciences, Kumamoto University, 1-1-1 Honjo, Kumamoto 860-0811, Japan

^b Department of Neurology, Graduate School of Medical Sciences, Kumamoto University, 1-1-1 Honjo, Kumamoto 860-0811, Japan

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SUMMARY

Background & aims: Early high nasogastric tube feeding (NTF) is effective for improving the nutritional status of critical illness. However, potential complications of NTF in tetanus include aspiration pneumonia because of dysphagia and gastrointestinal dysfunction induced by over-activity of autonomic nervous system.

Methods: We serially evaluated gastric myoelectrical activities using electrogastrogram (EGG) recorder in 4 elderly severe tetanus patients, and assessed its potential as a marker to increase volume and calorie of NTF. **Results:** Although dominant frequencies of EGG in all patients (1.8 ± 0.6 cycle/min (cpm)) were lower than those in healthy volunteers (2.9 ± 0.2 cpm) at least until 12th hospital day, it tended to improve from 14–24th hospital day and reached the same levels in healthy volunteers at least until 28th hospital day. We transferred total NTF along their metabolic costs when the timing of dominant frequency tended to improve in each patient (17–24th hospital day). No aspiration pneumonia and malnutrition occurred in their hospital days.

Conclusion: EGG data may be a useful marker to know the level of over-activity of autonomic nervous system and to guess the best timing to increase volume and calorie of NTF especially in elderly severe tetanus.

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1. Introduction

Early high nasogastric tube feeding (NTF) initiation is well tolerated, and effective for improving the nutritional status of critical illness.^{1,2} However, it is very difficult to guess the best timing to increase the volume and calorie of the feeding in patients with tetanus. Tetanus is now a rare disease in developed world. However, it remains an important cause of death worldwide and is associated with a high case fatality, particularly in the developing world.³ Mortality from tetanus is as high as 45%.⁴ Especially, a total of 75% of deaths occur within the first week because of aspiration or pulmonary infection in these patients. In addition, the oral sensorimotor function for feeding in tetanus is severely compromised.⁵ Moreover, it is well known that gastrointestinal dysfunction induced by over-activity of the autonomic nervous system, such as abdominal bloating and constipation with the development of paralytic ileus, affects the

prognosis of the patients.⁶ These symptoms often disturb the successful enteral feeding. Thus, physicians need to be aware of special needs concerning the feeding in patients with tetanus.

Recently, electrogastrogram (EGG) has received attention as a useful non-invasive tool for gastric functional testing.⁷ Numerous EGG studies have been performed in several gastric disorders, such as functional dyspepsia, achalasia, Parkinson's disease, multiple system atrophy, familial amyloidotic polyneuropathy and diabetic gastropathy.^{8–12} However, EGG study in tetanus has not been performed yet.

In this study, we evaluated gastric myoelectrical activities quantitatively in severe tetanus using cutaneous EGG during the course of illness, and assessed its potential as a marker to increase the volume and calorie of NTF in these patients.

2. Subjects and methods

2.1. Subjects

2.1.1. Patients

Four elderly severe tetanus patients (2 men and 2 women, mean age 83 ± 8.3 years old) who had been investigated at Arao City

Abbreviations: NTF, nasogastric tube feeding; EGG, electrogastrogram; cpm, cycles/minute.

* Corresponding author. Tel./fax: +81 96 373 5281.

E-mail address: konen@fc.kuh.kumamoto-u.ac.jp (K. Obayashi).

Hospital and Kumamoto University Hospital, Japan from April 2003 to November 2009 were available for the study (Table 1). Although blood cultures were negative for *Clostridium tetani* in these patients, we diagnosed from the clinical manifestations, such as difficulty in opening mouth, opisthotonic posturing followed by generalized convulsion, tachycardia, and severe hypertension. Anti-tetanus toxoid immunoglobulin, antibiotics, mechanical ventilation, anesthetics, muscle relaxants, and anti-hypertensive drugs were used in all patients during the course of illness. However, all patients did not receive a percutaneous endoscopic gastrostomy for enteral nutrition because of their severe gastrointestinal dysfunction induced by over-activity of the autonomic nervous system.

2.1.2. Controls

As control group, we recruited 4 healthy subjects (2 men and 2 women, mean age 74 ± 7 years old) who had no medication and no symptoms of cardiovascular or autonomic disorders.

2.2. Initial feeding

We initiated 1640 kcal/day of parenteral nutrition and 400–800 ml (0.4 kcal/ml) of NTF immunonutrition in each patient from their 1st hospital day.

2.3. Data collection

2.3.1. EGG measurements

We serially evaluated gastric myoelectrical activity using a portable four-channel EGG recorder (Nipro EG; Nipro, Japan) from 1st to 28th day after hospitalization for all patients. Five surface electrodes (Vitrode J; Nihon Kohden, Japan) were placed on the abdominal skin surface. The EGG data were analyzed using EGS2 Ver.1.31 software (Gram, Japan). Two-hour segments from 9:00 to 11:00 were assessed, and we compared with the gastric slow wave between tetanus patients and healthy controls. All subjects were studied after more than 6 h fast. In addition, we performed power spectral analysis for each patient's EGG segment using a fast Fourier transform with an analysis range 1.0–6.0 cycle/min (cpm). The frequency at which the overall power spectrum displayed peak power in the range 2.0–4.0 cpm was defined as the dominant frequency. The frequency ranges were classified into low (1.0–2.0 cpm), normal (2.0–4.0 cpm), and high (4.0–6.0 cpm) frequency ranges. We calculated the ratios of low frequency range, normal frequency range, and high frequency range components as percentages of total power. As movement artifacts and noises from various sources can result in abdominal frequency spectra with significant power in the low frequency and high frequency range in EGG,^{13,14} our patients were placed in dark, soundproofed rooms after diagnosing tetanus. In addition, mechanical ventilation was initiated with a muscle relaxant and anesthetics to avoid opisthotonic posturing in these patients.

Table 1
Profiles in patients with tetanus.

	Case 1	Case 2	Case 3	Case 4
Age, Sex	82, male	88, male	91, female	71, male
Onset	April, 2003	January, 2007	January, 2007	Sep, 2007
Symptoms				
Difficulty in opening mouth	(+)	(+)	(+)	(+)
Opisthotonic posturing	(+)	(+)	(+)	(+)
Tachycardia	(+)	(+)	(+)	(+)
Hypertension	(+)	(+)	(+)	(+)
Mechanical ventilation	(+)	(+)	(+)	(+)

2.3.2. Nutritional status

Percent change in body weight and serum albumin level for each patient compared with 1st to 28th day after hospitalization were used to evaluate their nutritional status.

2.3.3. Complications and managements

Complications, such as dysphagia, vomiting, abdominal bloating, paralytic ileus, and aspiration pneumonia, were recorded according to the timing of its occurrence. Duration of mechanical ventilation and changes of feeding were also recorded.

2.4. Statistical methods

All data are expressed as mean \pm SD. Differences between groups were analyzed by Mann–Whitney *U* test. Statistical significance was considered when $p < 0.05$.

3. Results

3.1. EGG measurements

All 4 tetanus patients showed irregular gastric slow wave, and the dominant frequencies of EGG in all tetanus patients (1.8 ± 0.6 cpm) were lower than those in healthy volunteers (2.9 ± 0.2 cpm) at least until 12th hospital day (Fig. 1). At that time, the ratio of low frequency range in all patients was significantly higher than those in healthy controls ($p < 0.01$, Fig. 2A), and the ratio of high frequency range in all patients was significantly lower than those in healthy controls ($p < 0.05$, Fig. 2C). However, the dominant frequency tended to improve from 17th hospital day, and reached the same levels in healthy controls at least until 28th hospital day in all patients (Fig. 1).

3.2. Feeding and nutritional status

We transferred total NTF when the timing of dominant frequencies tended to improve (more than 2.6 cpm) in each patient (17–24th hospital day). At least until 28th hospital day, 2250–2450 ml (0.8 kcal/ml) of NTF nutrition was administered in all patients. Moreover, all 4 patients could prevent the decrease of body weight during 28 hospital days, and their serum albumin levels of 28th hospital day were not also decreased compared with those of 1st hospital day (Table 2).

3.3. Complications and prognosis

Although abdominal bloating and/or constipation with the development of paralytic ileus were shown at least until 10th hospital day in all 4 patients, no vomiting and aspiration pneumonia occurred during the course of illness except for Case 2, who already contacted aspiration pneumonia before admission (Table 2). Mechanical ventilation could be weaned smoothly in all patients, and they were all discharged from our hospital to start dysphagia rehabilitation at least by 45th hospital day.

4. Discussion

This is the first report to demonstrate the changes in gastric myoelectrical activities in patients with severe tetanus throughout the course of illness.

In elderly tetanus, at least 80% of cases are the generalized form.¹⁵ The prognosis of these patients mainly depends on how effectively the spasm can be managed and lethal complications, such as aspiration pneumonia and malnutrition, prevented.¹⁶ Beale et al. reported that early tube feed pharmaconutrition and

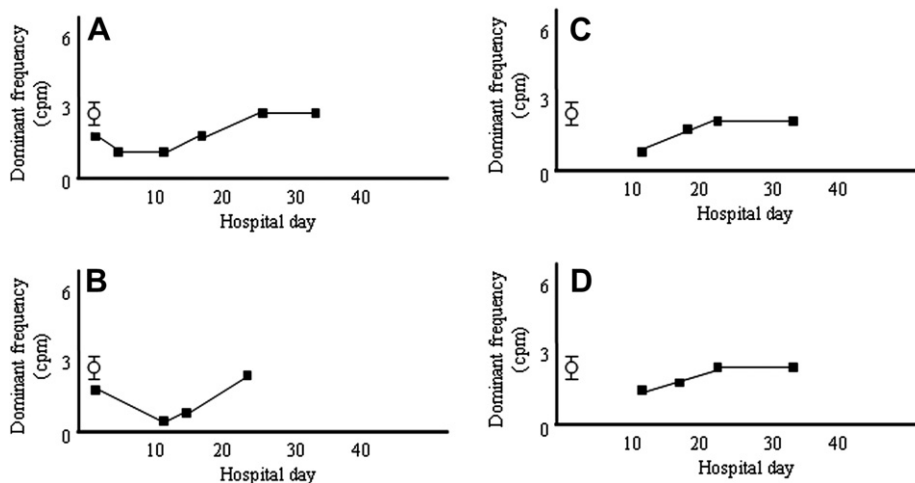


Fig. 1. Changes in dominant frequencies of EGG during the course of illness A: Case 1, B: Case 2, C: Case 3 and D: Case 4 Open circle: The data of healthy controls ($n = 4$, mean \pm SD).

immunonutrition, results in significantly faster recovery of organ function in patients with severe infectious diseases, compared with disease control patients.¹ But on the other hand, Emilia et al. reported that mortality after NTF initiation was high, mainly due to infectious complications and refeeding syndrome.¹⁷ Moreover, Charvát et al. reported that 18% of the patients admitted to intensive care unit with life threatening disease and indication for enteral nutrition had to be replaced for parenteral one due to complications.² In this study, we had successful outcomes of NTF in all patients. We could prevent the complications, such as vomiting, aspiration pneumonia, malnutrition, and refeeding syndrome, using EGG data to guess the best timing to increase volume and calorie of the feeding. Moreover, mechanical ventilation could be weaned at the best time to avoid ventilation complications and start physical rehabilitation as fast as possible in these patients, because the changes in EGG data constantly preceded the variations in clinical manifestations. These results suggest that the

knowledge regarding this technique may facilitate the next step for considering a suitable treatment throughout the course of illness.

Many factors influence gastric electroactivity and motility, such as medications, gastric emptying, aging, activity of the autonomic nervous system, particularly the parasympathetic vagus nerve, and enteric peptides.^{18–22} All our patients were administered anti-hypertensive drugs, anesthetics for mechanical ventilation, and muscle relaxants for opisthotonic posturing throughout the course of illness. However, gastric myoelectrical abnormalities appeared in these patients not only after but also before starting these drugs. Thus, the effects of medications may be limited. As we initiated 400–800 ml (0.4 kcal/ml) of NTF immunonutrition in each patient from their 1st hospital day, all patients did not show gastric emptiness throughout the course of illness. These findings suggest that aging and over-activity of the autonomic nervous system caused by tetanus are more closely related to abnormalities of gastric myoelectrical activities in those patients. Thus, EGG may also be a helpful tool to diagnose tetanus in a very early stage and to quantify the progression and disease severity.

EGG technique, measuring electrical waves in the stomach muscle wall, is theoretically usable in combination with other examination, such as gastric reflux monitoring or measurement of residual gastric volume.⁷ However, as these methods are invasive, we could not try the tests in our severe patients. On the other hand, EGG is a non-invasive tool. Thus, we only evaluated gastric myoelectrical activities using cutaneous EGG during the course of illness in this study.

In conclusion, EGG data may be a useful marker to know the level of over-activity of the autonomic nervous system and to guess

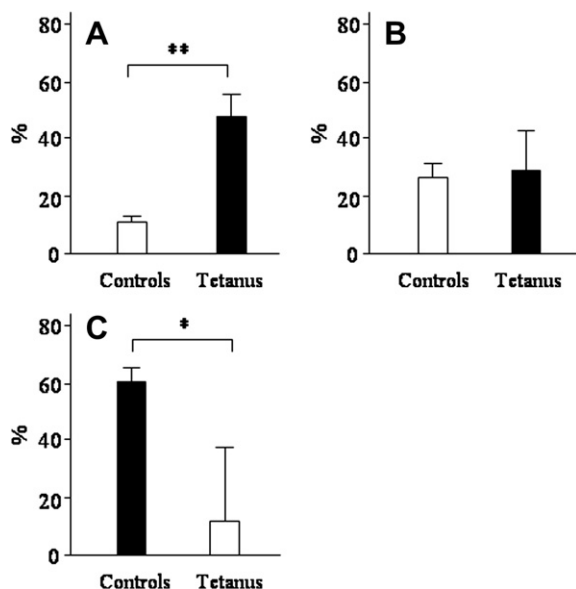


Fig. 2. Comparison with 2-h segments averages for dominant frequency between 4 tetanus patients in 12th hospital day and 4 healthy controls. A: Ratio of low frequency range components as percentages of total power. B: Ratio of normal frequency range components as percentages of total power. C: Ratio of low frequency range components as percentages of total power. The data were collected from 9:00–11:00. All subjects were studied after more than 6 h fast. * $p < 0.05$, ** $p < 0.01$.

Table 2
Outcomes of all patients.

	Case 1	Case 2	Case 3	Case 4
Abdominal bloating	(+)	(+)	(+)	(+)
Paralytic ileus	(+)	(-)	(-)	(+)
Serum albumin level (g/dl)				
1st hospital day	3.5	3.2	3.0	2.9
28th hospital day	4.1	3.3	3.2	3.5
Body weight (kg)				
1st hospital day	56.5	40.3	39.0	63.2
28th hospital day	58.8	43.4	40.4	64.7
Vomiting	(-)	(-)	(-)	(-)
Aspiration pneumonia (before admission)	(-)	(+)	(-)	(-)
Transferred total NTF (hospital day)	13	26	22	28
Discharge our hospital (hospital day)	48	49	66	71

the best timing to increase volume of NTF especially in elderly severe tetanus.

Conflict of interest

All authors of the manuscript have no conflict of interest.

Statement of authorship

Obayashi K was responsible for data collection, data interpretation and manuscript writing and reviewing.

Ueda M, Yamashita T, Misumi Y, Hirahara T, Tasaki M, and Ohshima T were responsible for patients' evaluation and data collection.

Uchino M and Ando Y were responsible for manuscript writing and reviewing.

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