学 位 論 文 の 要 旨

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学　位　論　文　名　Gastric Emptying of Liquid and Solid Meals of Various Temperatures

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INTRODUCTION

In patients with functional dyspepsia (FD), abdominal symptoms, such as fullness, are known to be related to delayed gastric emptying, and they are not considered to be easily controlled by various treatments including prokinetics administration. If meal temperature influences gastric emptying, advice regarding the meal temperature may become a possible dietary therapy. Therefore, dietary therapy to accelerate gastric emptying may relieve abdominal symptoms in patients with FD, and the study of the relationship between food temperature and gastric emptying is important. However, little information exists concerning the thermal effect of meals on gastric emptying in human cases. The aim of this study was to determine the thermal effect of liquid and solid meals on gastric emptying.

MATERIALS AND METHODS

Preliminary study: Firstly, to determine the thermal change of liquid and solid meals in the stomach, time-course thermal changes of liquid and solid meals were evaluated in the 37℃ water bath. Two hundred grams of different meals (solid or liquid, 4℃ or 60℃) in an aluminum cup with a good heat conduction rate were submerged in the 37℃ water bath, and their temperatures were measured at various times. These measurements were performed three

times, and the mean values were calculated.

Crossover study: The gastric emptying of liquid and solid test meals was examined in healthy volunteers (liquid, n = 25, mean age = 35.7 ± 9.6 years, M:F ratio = 22:3; solid, n = 25, mean age = 35.2 ± 8.8 years, M:F ratio = 20:5). Gastric emptying after ingestion of liquid or solid meals of 3 different temperatures (4, 37 and 60℃) was investigated with the [^{13}C]-labeled acetate breath test. $T_{max\text{-}calc}$ and $T_{1/2}$ were calculated from the $^{13}CO_2$ breath excretion curve as indices of gastric emptying. After overnight fasting, each subject received a test meal. A caloric liquid meal with 100 mg of [^{13}C]-labeled acetate was used as a liquid test meal. A solid test meal was prepared by adding 4 g agar to 200 mL of the liquid test meal. Both of liquid and solid test meals were ingested as fast as possible within a minute. Breath samples were collected before and after ingestion of the test meal: at baseline, at 5-minute intervals during the first 20 minutes, at 10-minute intervals during the next 40 minutes, and every 15 minutes for the last 60 minutes (0, 5, 10, 15, 20, 30, 40, 50, 60, 75, 90, 105, 120 minutes). The concentration of $^{13}CO_2$ in the collected breath samples was measured by isotope-selective non-dispersive infrared spectrometry. The study protocol was approved by the ethics committee of Shimane University School of Medicine. Before the enrollment, written informed consent was obtained from all of the participants.

RESULTS AND DISCUSSION

Preliminary study: The thermal changes were induced by liquid and solid test meals at 4℃. Shortly after being submerged in a 37℃ water bath, the temperature of hot and cold meals started to change. It takes, however, at least 20 minutes for each meal to reach 37℃. Therefore, the temperature of both liquid and solid test meals may influence gastric function during the earlier phase of the test.

Crossover study: The values of $T_{max\text{-}calc}$ at 60℃ with both the liquid and solid meals were significantly smaller than at 37℃ ($P < 0.05$). However, there was no difference in the $T_{1/2}$ values. In the analysis of % dose/h data with the liquid meal test, significantly larger values were

found at 60℃ in the earlier phase within 30 minutes than at the other temperatures. These findings suggest that a hot meal significantly accelerates gastric emptying.

The mechanism as to how meal temperature influences gastric emptying has not been clearly elucidated. One possible mechanism of temperature-related alteration of gastric emptying is a direct thermal stimulation of the gastric pacemaker in the phase of gastric accommodation, which determines the timing and maximum rate of gastric contractions. Thermal stimulation of the thermoreceptors in the gastrointestinal tract by an ingested meal is considered to be another possible mechanism. Three types of thermoreceptors, which are inactive at normal body temperature, have been demonstrated in the stomach and duodenum of an experimental model. Cold receptors start to respond at temperatures below 36℃, peaking at 10-12℃; warm receptors respond most intensely at 46-49℃; and mixed thermoreceptors respond to both warming and cooling of the mucosal surface. It has been shown that thermoreceptors are distributed along the human gastrointestinal tract and that cold stimuli induce a reflux gastric contraction, whereas warm stimuli evoke a reflux gastric relaxation. Thus, thermoreceptors may play a role in the control of gastric emptying by food of different temperatures.

Gastric emptying disorder may be a main cause of FD, since delayed gastric emptying of both liquid and solid meals is reported to be found frequently in patients with FD. Dietary factors, including the temperature of foods, are well known to be related to symptoms of FD. Therefore, the present study results show that thermal adjustment of an ingested meal as a dietary therapy may be key treatment for patients with FD.

CONCLUSION

The temperature of an ingested meal influences gastric emptying, and a hot meal empties from the stomach faster than a warm one. Accordingly, the adjustment of meal temperature may be useful as a dietary therapy in patients with FD.