Effects of aging and gastric lipolysis on gastric emptying of lipid in liquid meal

YASUYUKI NAKAE1, HATSUMI ONOUCHI2, MIEKO KAGAYA3, and TAKAHARU KONDO1

1Research Center of Health, Physical Fitness and Sports, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8601, Japan
2Department of Home Economics, Aichi Bunkyo Women’s College, Inazawa, Japan
3Department of Food and Nutrition, Sugiyama Jogakuen University School of Life Studies, Nagoya, Japan

Abstract: Lipid delays gastric emptying, and aging is associated with changes in gastric motor function and transit. However, little is known about the effect of lipid on gastric emptying time in the elderly. To determine the effect of aging on lipid gastric emptying, we used electrical impedance tomography (EIT) to study gastric emptying of liquid meals with or without lipid in five young (23.0 ± 0.6 years, mean ± SEM) and six elderly (73.3 ± 1.6 years) healthy male volunteers. These subjects drank 400 ml of non-lipid soup (triglycerides, 0 g) or lipid soup (triglycerides, 24.6 g) in liquid test meals. To study the effect of lipolysis in the stomach, a liquid test meal containing 240 mg of lipase in the lipid soup was also administered. Plasma cholecystokinin (CCK) concentration was measured by specific radioimmunoassay before and 30 min after the ingestion of a test meal. The gastric emptying time of the lipid soup was longer in the elderly than in the young subjects, and the time was significantly longer for lipid soup than for non-lipid soup (P < 0.05) in both the young and elderly subjects. Gastric emptying time for non-lipid soup was not significantly different between the elderly and young subjects. The administration of lipase shortened the gastric emptying time for lipid in both the elderly and the young subjects. Basal CCK concentration was significantly higher in the elderly than in the young subjects. However, there was no relationship between gastric emptying time and plasma CCK concentration after the ingestion of a test meal in the subjects overall. In conclusion, the delaying effect of lipid on gastric emptying is increased in the elderly, and the administration of lipase accelerates the emptying of lipid from the stomach.

Key words: gastric emptying, lipid, aging, lipase, cholecystokinin, electrical impedance tomography (EIT)

Introduction

Satiation occurs after the ingestion of fat-rich food, and an increase in this satiation is commonly experienced with aging. Dietary fat delays gastric emptying,1 which is regulated by small-intestine nutrient-mediated feedback, such as by the duodenal receptor to the hydrolytic products of triglycerides2 and release of cholecystokinin (CCK).3 Aging is associated with changes in gastric motor4 or neural function5 that have effects on gastric emptying. Therefore, an aging effect on gastric emptying of lipid has been considered, but the relationship between them remains controversial.3,6-8

Lipase plays an important role in the digestion of fat. Recent studies have indicated the importance of gastric and pancreatic lipases in the regulation of gastric emptying.9,10 In these studies, a lack of lipase accelerated gastric emptying in a pancreatic insufficiency model. Clinically, lipase is administered to improve satiation after the eating of fat-rich foods even in subjects without diseases; however, the effect of lipase administration on gastric emptying time in these subjects is unclear.

In this study, we used the non-invasive method of electrical impedance tomography (EIT) to measure gastric emptying of liquid meals with and without lipid in young and elderly healthy subjects to determine the age-associated effect of lipid on gastric emptying. Lipase was also administered to both age groups with the lipid meal to study the effect of lipolysis in the stomach.
Patients and Methods

Subjects

We studied five young healthy men (mean age, 23.0 ± 0.6 years; range, 21–24 years; height, 175.0 ± 1.67 cm; weight, 64.6 ± 2.86 kg; body mass index (BMI), 21.1 ± 0.82 kg/m² [mean ± SEM]) and six elderly healthy men (mean age, 73.3 ± 1.6 years; range, 69–80 years; height, 162.5 ± 0.7 cm; weight, 58.5 ± 1.5 kg; BMI, 22.2 ± 0.6 kg/m²); all subjects were volunteers. The young subjects were taller than the elderly subjects, but the weight and BMI in the two groups were not significantly different. None of the subjects had any history of major gastrointestinal disease, diabetes mellitus, or surgery, nor were any taking drugs that influence gastrointestinal motility. All subjects gave their fully informed consent for the studies, and the protocol was approved by the Ethical Committee of the Research Center of Health, Physical Fitness and Sports, Nagoya University.

Protocol

After the subjects fasted overnight, their gastric secretion was inhibited by the oral administration of 200 mg cimetidine (Tagamet; Smith Kline Beecham, Tokyo, Japan) 1 h before the test for EIT images. EIT images of gastric emptying were measured by applied potential tomography (APT; University of Sheffield, UK). EIT images were collected over 15-s periods at 1-min intervals. The images were collected for 5 min before and 60 min after the ingestion of test meals. Subjects were asked to sit during the study. All subjects drank 400 ml of each of three kinds of liquid meals (Table 1). Gastric emptying time for lipid soup in both young and elderly subjects (5.3 ± 0.9 vs 5.8 ± 1.1 min for T1/4 and 15.2 ± 2.9 vs 15.8 ± 6.3 min for T1/2; Table 1). Gastric emptying time for the lipid soup was longer than that for the non-lipid soup in both the young and elderly subjects. In the elderly subjects, the percentage of remaining lipid soup was significantly greater from 10 to 22 min than that of non-lipid soup (P < 0.05; Fig. 1), and both T1/4 (13.2 ± 3.5 min) and T1/2 (28.0 ± 6.1 min) for lipid soup were significantly greater than the corresponding values for non-lipid soup (P < 0.05; Table 1). T1/2 for lipid soup was longer in elderly subjects (28.0 ± 6.1 min) than in young subjects (19.1 ± 3.3 min), but the difference was not significant. The addition of lipase shortened the gastric emptying time for lipid soup in both young and elderly subjects (Table 1).

Analysis of results

To obtain a profile of gastric emptying by EIT, the gastric region was outlined, using an integrated image of the first three frames obtained after ingestion, and the resistivity of this region was calculated by computer for all images. The percentage of the meal remaining in the stomach was calculated by expressing each value as a percentage of the minimum value after ingestion, and this was plotted against time. The times taken for a quarter (T1/4) and for half the meal to empty (T1/2) were calculated from the percentage plots.

Statistical analysis

Data values are expressed as means ± SEM. Comparison of gastric emptying time and plasma CCK concentration between the young and elderly groups was done with a Mann-Whitney U-test, and comparisons between the non-lipid soup test, lipid soup test, and lipid soup with lipase test were done with the paired t-test after adjusting for equal variance. Correlation between gastric emptying time and plasma CCK concentration was analyzed by Spearman rank correlation. The P values computed were two-tailed, and P < 0.05 was considered significant.

Results

There were no significant differences in the gastric emptying time of the non-lipid soup between the young and elderly subjects (5.3 ± 0.9 vs 5.8 ± 1.1 min for T1/4 and 15.2 ± 2.9 vs 15.8 ± 6.3 min for T1/2; Table 1). Gastric emptying time for the lipid soup was longer than that for the non-lipid soup in both the young and elderly subjects. In the elderly subjects, the percentage of remaining lipid soup was significantly greater from 10 to 22 min than that of non-lipid soup (P < 0.05; Fig. 1), and both T1/4 (13.2 ± 3.5 min) and T1/2 (28.0 ± 6.1 min) for lipid soup were significantly greater than the corresponding values for non-lipid soup (P < 0.05; Table 1). T1/2 for lipid soup was longer in elderly subjects (28.0 ± 6.1 min) than in young subjects (19.1 ± 3.3 min), but the difference was not significant. The addition of lipase shortened the gastric emptying time for lipid soup in both young and elderly subjects (Table 1).

Basal (before ingestion of test meal) plasma CCK concentration was significantly higher in elderly subjects (10.9 ± 0.5 pg/ml) than in young subjects (8.5 ± 0.5 pg/ml; P < 0.01). However, there were no differences between young and elderly subjects in Δ plasma CCK concentration 30 min after ingestion for all test meals (Table 2).

There was no significant relationship between plasma CCK concentration 30 min after ingestion and gastric