Contribution of Ascites to Impaired Gastric Function and Nutritional Intake in Patients With Cirrhosis and Ascites

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Background & Aims: **Protein calorie malnutrition and weight loss are common among patients with cirrhosis and ascites. The cause of these symptoms is unclear, with several putative mechanisms proposed. The primary aims of this study were to compare gastric volumes and accommodation between patients with cirrhosis complicated by ascites and healthy controls, and to evaluate the effect of large-volume paracentesis in the patient group.** ***Methods:*** **Patients with cirrhosis and ascites underwent assessment of gastric volumes as measured by single-photon emission computed tomography, gastric sensation assessed by a validated nutrient drink test, and a 3-day assessment of caloric intake before and after large-volume paracentesis. Age- and sex-adjusted linear regression models were used to compare gastric volumes and accommodation ratios between patients and healthy volunteers. Paired Wilcoxon rank-sum tests were used to compare gastric measures before and after paracentesis among the patient group.** ***Results:*** **Fifteen patients (median age, 54 y) were compared with 112 healthy (age- and sex-matched) controls. Median postprandial gastric volumes (627 mL patients vs 721 healthy controls) and gastric accommodation were reduced significantly in patients compared with healthy controls ($P = .02$ and .006, respectively). After paracentesis: (1) fasting gastric volumes were increased (median 312 mL post- vs 241 mL pre-, $P = .04$), (2) patients tolerated ingestion of larger maximum volumes (median 964 mL post- vs 738 mL pre-, $P = .04$), and (3) caloric intake was increased (median 34% kcal post- vs 3110 kcal pre-, $P = .005$).** ***Conclusions:*** **Postprandial gastric volumes and accommodation ratios are reduced in patients with cirrhosis and ascites compared with healthy controls. In addition, large-volume paracentesis increases fasting gastric volumes, volumes ingested until maximal satiation, and caloric intake.**

Patients with cirrhosis and ascites frequently complain of dyspeptic symptoms such as early satiety, nausea, and postprandial fullness.[1] These symptoms have been associated with decreased oral intake and clinically significant weight loss. Although several putative mechanisms have been proposed, the main cause of these symptoms in these patients is not known. One hypothesis is that delayed gastric emptying results in the sensation of satiety.[2–6] However, in a prospective Mayo Clinic study of patients with cirrhosis and ascites, no differences in gastric emptying between patients and healthy controls were identified.[7] In addition, despite improvements in satiety and caloric intake after large-volume paracentesis, no changes in gastric emptying were identified.

Gastric accommodation is a vagally mediated reflex that results in reduced gastric tone and increased gastric compliance, thereby facilitating the ingestion of large volumes of solids or liquids without inducing symptoms or the vomiting reflux. Impaired gastric accommodation has been associated with early satiety and other postprandial upper-gut symptoms in a variety of gastrointestinal disorders such as functional dyspepsia, rumination syndrome, postvagotomy/gastric surgery, and diabetes mellitus when associated with vagal neuropathy.[8–17] As a result of increased wall tension and stimulation of visceral afferents or alteration of cerebral perception, patients may develop gastric hypersensitivity while fasting or postprandially.[15,18–21]

Recently, it was shown that fasting gastric volumes are associated with food intake and postprandial symptoms.[22,23] Furthermore, pharmacologic manipulation leading to relaxation of the stomach has been shown to decrease sensitivity to gastric distention and meal-induced symptoms,[14,15,20,24,25] with one study suggesting a direct effect on gastric tension mechanoreceptors.[26] These findings suggest that the measurement of gastric volumes and their relationship with regard to accommodation after a meal may facilitate our understanding of

Abbreviation used in this paper: SPECT, single-photon emission computed tomography.

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upper-gastrointestinal symptoms in the postprandial period.

Previously, the only reliable measurement of proximal gastric volumes and accommodation involved the placement of a polyethylene balloon into the stomach while linking it to a barostat device. More recently, a noninvasive method to measure fasting and postprandial volumes of the entire stomach using single-photon emission computed tomography (SPECT) was developed[27] and validated.[28] This novel approach, which requires no oral or nasogastric intubation, provides the opportunity to examine safely patients with cirrhosis and portal hypertension who may have esophageal or gastric varices.

The primary aim of this prospective study was to evaluate gastric volumes and accommodation in patients with cirrhosis and ascites compared with healthy controls. We also wished to examine the impact of large-volume paracentesis in these patients while assessing satiety and nutritional intake.

Materials and Methods

Study Participants

The Mayo Clinic institutional review board approved all protocols, and all participants signed informed consent forms. Fifteen patients, aged 18–70 years, with cirrhosis and ascites and symptoms of early satiety, nausea, and/or postprandial fullness who were presenting for large-volume paracentesis were included. Patients with a prior history of abdominal or gastric surgery, vagotomy, diabetes mellitus, confirmed diagnosis of autonomic neuropathy, or who were on medications that may alter gastrointestinal motility were excluded. Control data from 112 healthy age- and sex-matched controls previously studied using identical imaging techniques were used for comparison.[28]

Experimental Design

After an initial screen, review of the study, and informed consent the participants completed a 3-day caloric assessment. Patients then presented to the study unit after an overnight fast where they underwent SPECT scanning of gastric volumes before and after a test meal. Subsequently patients completed a nutrient drink test and underwent large-volume paracentesis. Preparacentesis and postparacentesis weights and abdominal girth measurements were obtained. Within 24–48 hours after paracentesis the patients returned to the research unit after an overnight fast where they underwent repeat SPECT and nutrient drink tests. Measurements of weight and abdominal girth were obtained again. For 3 days after the paracentesis, patients underwent a repeat caloric assessment and review with a dietician.

Measurement of Gastric Volumes and Accommodation

A noninvasive method developed at the Mayo Clinic and validated against the standard gastric barostat was used to measure the fasting and postprandial gastric volumes after an intravenous injection of technetium-99m pertechnetate and imaging with SPECT.[27,28] This technique has reproduced the gastric volumes reported in response to pharmacologic treatments and in patients with dyspepsia as measured by the barostat technique.[14,29–31] All tomographic studies were acquired on a large field of view, dual-head, gamma camera system (ADAC Phillips, Milpitse, CA) equipped with low-energy, high-resolution collimators. Patients were positioned supine on the imaging table with the detectors over the upper and midabdomen to ensure imaging of the stomach and small bowel.

Gastric volumes were measured using the SPECT-Analyze PC 2.5 (Biomedical Imaging Resource, Mayo Foundation, Rochester, MN) software system. The gastric mucosa is able to take up the administered technetium-99m pertechnetate from the circulating blood pool. Starting 10 minutes after the intravenous injection of 10 mCi technetium-99m pertechnetate, SPECT imaging was performed while fasting and for a total of 20 minutes after ingestion of 300 mL of Ensure (1 kcal/mL; Ross Nutrition, Abbott Laboratories, Columbus, OH). Gastric volumes were assessed during 2 postprandial periods: 0–10 minutes and 10–20 minutes after the meal. Transaxial images of the stomach were rendered with Analyze to reconstruct 3-dimensional images of the stomach and to measure gastric volumes during the fasting and postprandial periods. Extraneous structures such as the upper duodenum or a kidney in close proximity to the stomach, which had not been removed in the segmentation algorithm, were removed manually. The volume ratio between the postprandial and fasting volumes (gastric accommodation ratio = postprandial volume/fasting volume) was calculated.

Nutrient Drink Test

All patients underwent 2 standardized nutrient drink tests,[32,33] 1 before large-volume paracentesis and another within 48 hours after paracentesis. Patients reported to the research unit on an empty stomach. Ensure (1 kcal/mL, 11% fat, 73% carbohydrate, 16% protein) was poured into a cup at a constant rate (30 mL/min), and patients were requested to maintain intake at the poured rate until a maximum tolerated volume was reached. Patients scored their satiation (feeling of fullness) at 5-minute intervals by using a graphic rating scale that combined verbal descriptors on a scale graded 0–5 (0 = no symptoms, 5 = maximal satiety). Patients stopped meal intake when a score of 5 was reached. Total volume ingested was recorded.

Caloric Assessment

All enrolled patients completed a written food diary for 3 consecutive days before and after paracentesis. Caloric