Ischemic Gastroparesis: Resolution After Revascularization

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Patients with chronic nausea and vomiting frequently present challenging diagnostic and therapeutic problems. In such patients, gastroparesis of unknown cause, or "idiopathic" gastroparesis, may be the only objective finding. Two middle-aged women with nausea, vomiting, and weight loss of 10 and 26 kg over 6 and 18 months, respectively, were evaluated. Routine laboratory and barium study results were normal. Solid-phase gastric emptying studies showed severe gastroparesis in both patients. Upper endoscopies excluded gastric outlet obstruction. Gastric dysrhythmias (4-cpm and 1-cpm patterns) were recorded using cutaneous electrodes. An abdominal bruit was auscultated in one patient. Abdominal arteriograms in both patients showed total occlusion of all three major mesenteric vessels with collaterals supplied via hemorrhoidal arteries. Bypass grafting procedures of the celiac and superior mesenteric arteries in one patient and of the celiac artery in the other patient were performed. Six months after mesenteric artery revascularization, upper gastrointestinal symptoms had resolved and original weights were regained. Furthermore, normal 3-cpm gastric myoelectrical activity and normal gastric emptying of solids were restored in both patients. In these patients, chronic mesenteric ischemia resulted in a novel and reversible cause of gastroparesis, gastric dysrhythmias, and accompanying symptoms. In this entity, which the cause remains unexplained, i.e. idiopathic gastroparesis (1), remains.

Herein we report on two patients with nausea, vomiting and idiopathic gastroparesis in whom three-vessel mesenteric artery occlusions were discovered. Chronic mesenteric ischemia usually occurs in elderly individuals with abdominal pain and weight loss (2-6). Our patients were middle-aged and had symptoms compatible with their documented gastroparesis. Furthermore, after mesenteric revascularization, upper gastrointestinal symptoms and gastroparesis resolved in both patients. Recognition of this entity is important because symptoms and gastroparesis are reversible with corrective vascular surgery.

Materials and Methods

Gastric Emptying Test

Patients fasted for at least 8 hours before solid-phase gastric emptying tests were performed. No medications that might affect gastric emptying were allowed for 48 hours before the studies. The standard meal consisted of two eggs mixed thoroughly with 500 μCi of technetium 99m sulfur colloid and then cooked until done. A large-field-of-view camera with a parallel hole collimator was used. The energy range for technetium 99m was preset with a 20% window, and the preset stop was set for 60 seconds. Immediately after ingestion of the eggs, scintigraphic images were obtained in the supine position. This procedure continued with 1-minute scans 15, 30, 45, 60, 75, 90, 105, and 120 minutes after ingestion of the eggs. In studies from 10 healthy control subjects, the t1/2 averaged 75 minutes and the percentage

Abbreviations used in this paper: EGG, electrogastrogram; RSA, running spectral analysis; SMA, superior mesenteric artery. © 1990 by the American Gastroenterological Association 0016-5085/90/$3.00
emptied at 120 minutes averaged 83%. Patients with pro-
longed $t_{1/2}$ or percentage emptied $>2$ SD above the mean at
120 minutes, i.e., $<60\%$ emptied, were considered normal.

Electrogastrography

Standard electrodes (Miniature Skin Electrodes, Sen-
sorMedics Corp., Anaheim, CA) were positioned on the
abdomen to record the electrogastrogram (EGG). Three
electrodes were placed in the left upper quadrant and
epigastic regions: the first electrode was positioned below
the left rib margin in the midclavicular line, the third
electrode was placed equidistant between the xiphoid pro-
cess and the umbilicus, and the second electrode was
positioned along a line between the first and third electrode.
The fourth electrode served as a reference electrode and
was positioned in the right upper quadrant along the line
formed by the other three electrodes. The skin beneath the
electrodes was abraded gently before attaching the elec-
trodes. The electrodes were connected to a rectilinear
recorder (RS11, SensorMedics) through direct nystagmus
couplers (9859, SensorMedics). The low-frequency cutoff
was 0.016 Hz, and the high-frequency cut off was 0.30 Hz.
The EGG signals were recorded simultaneously on magnetic
tape (Honeywell 101, Honeywell Instruments, Denver, CO)
for computer analysis.

Each patient ate a 200-kcal breakfast (juice and toast) 2
hours before the EGG recording. After a 20-minute baseline
recording, the patients ingested 240 mL of water in a 2-
minute period. The recording channel with the clearest
EGG signal was chosen for visual and computer analysis.
Approximately 3-cpm EGG waves [2.5–3.5 cpm] were consid-
ered normal; 4–9-cpm waves were considered tachyarrhyth-
rias/tachygastrias; and from 0–2.5-cpm waves were consid-
ered bradygastrias (7–9). Visual inspection of the EGG
recording was used to determine the predominant gastric
rhythm. Computer analysis representing approximately 40
minutes of EGG signals recorded from each subject were
compared with the visual interpretation of the EGG signal to
confirm the predominant frequency peaks and to ascertain
shifts in EGG frequency that were not appreciated by visual
inspection. Computer analysis of EGG records using analog
to digital transformation, Fourier analysis, and running
spectral analyses has been described previously (10).

Case 1

A 56-year-old white woman presented with a 6-
month history of nausea, vomiting of undigested foods, and
occasional crampy epigastric to right lower quadrant pain.
During this period, she lost 10 kg. Diagnostic studies in-
cluded a normal upper gastrointestinal series with small
bowel follow-through, normal abdominal ultrasound, and
normal computed tomographic scan of the abdomen. She
reported no relief of symptoms after antacids, ranitidine,
and empiric trials of metronidazole for suspected giardiasis.
She had a 40-pack-year smoking history and reported no
alcohol use. Review of systems was remarkable for Raynaud’s
phenomenon. She was referred to the gastroenterology
clinic to consider a drug trial for chronic unexplained
nausea and vomiting.

Physical examination was notable for weight of 35 kg and
right upper abdominal and right femoral bruits that had not
been appreciated previously. Blood count, liver enzymes,
protein, albumin, serum electrolytes, and glucose were
normal. A 0.5 $\times$ 0.5-cm superficial antral ulceration was
found by esophagogastroduodenoscopy; the pylorus was
patent and the duodenum was normal. Solid-phase gastric
emptying time was markedly delayed, with $t_{1/2} > 120$ minutes
and 32% emptied 2 hours after ingestion. A Doppler study of
the mesenteric arteries failed to define vascular flow. An
arteriogram showed total occlusion of the celiac artery,
superior mesenteric artery (SMA), and inferior mesenteric
artery (Figure 1) with collaterals supplied by the left middle
hemorrhoidal artery.

The patient underwent abdominal revascularization
with an antegrade bifurcated graft from the aorta to the celiac
axis and SMA. After surgery, her symptoms resolved, and by
6 months after revascularization her weight had increased 6
kg and gastric emptying was normal; $t_{1/2}$ improved from
>120 minutes to 75 minutes, and the percentage emptied at
120 minutes improved from 32% to 80% (Figure 2).

Electrogastrograms and the running spectral analysis
(RSA) of the EGG signal from this patient before revascular-
ization are shown in Figure 3. The EGG shows rhythmic
waves at 4 cpm (inset); the RSA also indicates that the
predominant frequency is near 4 cpm. After ingestion of
water, the amplitude of the EGG waves increases and the
frequency remains 4 cpm; the RSA also shows that the
predominant EGG rhythm is near 4 cpm. Smaller peaks are
also seen in the <2-cpm and >4-cpm ranges. Figure 4 shows
the EGGs and RSA recorded from 6 months after revascular-
ization when the patient was symptom-free. The EGG shows
rhythmic waves at 3–3.5 cpm, and the RSA also indicates
regular peaks at 3–3.5 cpm, a frequency slightly slower than
the preoperative rates and now within the normal range.

Case 2

A 55-year-old white woman with a surgical history of
cholecystectomy, appendectomy, and removal of a Meckel’s
diverticulum had an 18-month history of nausea, vomiting
of undigested food, and constant “nagging” discomfort in the
right upper quadrant that was sometimes relieved by vomit-
ing. She lost approximately 26 kg during this period. Diagno-
stic studies included a normal upper gastrointestinal examina-
tion with small bowel series, barium enema, abdominal
ultrasound, and computed tomographic scan. Fecal fat and
24-hour urine collections for 5-HIAA were negative. Several
esophagogastroduodenoscopies showed varying degrees of
mild superficial gastric and pyloric channel ulcerations but
no evidence of pyloric or duodenal obstruction. Results of an
endoscopic retrograde cholangiopancreatoangiogram (ERCP)
were normal. Symptoms did not improve with ranitidine, famoti-
dine, sucralfate, or metoclopramide. She had a 30-pack-year
history of smoking. She was referred to the gastroenterology
clinic for treatment of idiopathic nausea and vomiting.

Physical examination showed a cachectic woman weigh-
ing 34 kg. Results of her examination were otherwise
normal, and no abdominal bruits were ascultated. Routine
laboratory studies were within normal limits. A solid-phase
gastric emptying study was abnormal with $t_{1/2} > 120$ minutes,
and only 44% of the meal emptied 2 hours after ingestion (Figure 5).

Vague lower abdominal discomfort developed and abdominal arteriograms were obtained. The radiographic findings were similar to those in case 1 and showed occlusion of the celiac artery, SMA, and inferior mesenteric artery with collaterals supplied by the middle hemorrhoidal artery. During surgery the celiac axis was absent and a calcified plaque was found at the origin of the SMA. The splenic and hepatic arteries arose from the proximal SMA. An aorto-SMA Dacron bypass graft was placed.

Six months after revascularization, the patient was symptom-free and had gained 17 kg. Figure 5 shows the solid-phase gastric emptying results after mesenteric revascularization: $t_{1/2}$ improved from 120 minutes to 85 minutes, and the percentage emptied at 120 minutes improved from 44% to 82% after revascularization.

Figure 6 shows the patient’s EGGs and RSA before revascularization. The baseline EGG shows large 1-cpm waves (inset). The RSA shows predominant EGG frequen-
Figure 4. Postoperative EGGs (insets) and RSA (case 1) show predominantly rhythmic EGG waves at 3-3.5 cpm and corresponding peaks at 3 cpm in the RSA.

cycles near 1 cpm; no 3 cpm waves or peaks are seen. After ingestion of water, the EGG waves and the RSA show no changes in frequency and no evidence of normal 3-cpm rhythms. Electrogastrograms obtained six months after revascularization (Figure 7) show rhythmic EGG waves within the normal range at 3-3.5 cpm; the RSA shows some 1-2-cpm peaks and many regular peaks at the normal 3-cpm range.

In both patients, follow-up Doppler studies have shown continued graft patency and normal flow patterns.

Discussion

An association between chronic mesenteric ischemia and gastroparesis has not been described previously. Thus, the major new findings provided by these studies are that (a) chronic mesenteric ischemia is a pathophysiological mechanism that may result in gastroparesis, and (b) ischemia-related gastroparesis, gastric dysrhythmias, and upper gastrointestinal symptoms are reversible after mesenteric artery bypass graft surgery.

Ingestion of meals normally stimulates a fed pattern of 3/min gastric peristalses that mix and empty the chyme into the small intestine where a fed pattern of segmental contractions continues the digestive and absorptive process. Our patients had abnormal preoperative solid-phase gastric emptying, but emptying
returned to normal after mesenteric revascularization. Thus, these findings suggest that mesenteric ischemia inhibits gastric contractility and results in delayed gastric emptying. The incidence of chronic mesenteric ischemia in patients with idiopathic nausea, vomiting, and gastroparesis is unknown, but in patients at risk for vascular diseases the possibility should be considered.

Slow waves are generated by oxygen-requiring metabolic activity of smooth muscle cells located in the pacemaker region of the stomach (11). In healthy subjects, normal slow wave frequency is approximately 3 cpm (7–13). However, our patients with ischemic gastroparesis had gastric dysrhythmias. Bradygastrias and tachygastrias are associated with symptoms of nausea (7–11,13,14) and may also contribute to gastroparesis by interfering with normal gastric contractile activity (14,15). Gastric dysrhythmias reflect a disruption of normal gastric myoelectrical activity, but the underlying mechanisms of gastric dysrhythmias in humans are poorly understood. However, normal slow wave activity in the small bowel is reduced or abolished by ischemia and hypoxia resulting from chronic decreases in mesenteric blood flow (16). The normal postoperative slow wave signals reported here suggest that chronic ischemia is one mechanism that disrupts normal gastric myoelectrical activity.

Blood flow increases immediately and transiently in canine celiac artery after meals, whereas the increase in blood flow is sustained in the SMA for several hours after a meal (17,18). As recorded in Doppler studies in humans, blood flow in the SMA increases significantly 10 minutes after ingestion of a nutrient meal (19). Postprandial increases in celiac blood flow were not detected; selective increases in flow to the stomach could not be excluded by this technique (19). Increases in blood flow to the stomach after meals in our patients were apparently insufficient to support normal gastric motility, as evidenced by delayed gastric emptying. Any increase in blood flow in the SMA after ingestion of meals also may have reduced the limited blood flow to the stomach, thereby creating a potential "steal" in blood flow to the stomach after meals in our patients were apparently insufficient to support normal gastric ischemia in patients with idiopathic nausea, vomiting, and gastroparesis. This putative effects of chronic ischemia on gastric emptying and myoelectrical activity are supported by the fact that gastroparesis and gastric dysrhythmias resolved or improved after revascularization.

The resected arteries in cases 1 and 2 showed organized thrombus and an isolated arteriosclerotic plaque, respectively. Chronic mesenteric ischemia is commonly caused by atherosclerotic processes; more unusual causes of arterial occlusion include embolism, external compression, thromboangiitis obliterans, aortitis, chronic aortic dissection, and congenital abnormalities of the vessels (20). Potential risk factors for arterial lesions in our patients were their smoking histories. Cigarette smoking and nicotine alter intestinal blood flow and platelet aggregation (21–24) and increase vascular resistance (23), events that may contribute to atherosclerosis and thrombosis. Thus, it is conceivable that cigarette smoking contributed to the vascular lesions found in these two patients.

The possibility of mesenteric ischemia should be considered in patients with idiopathic gastroparesis, nausea, and vomiting, particularly if the patients are middle-aged women with marked weight loss, smoking histories, or other risk factors for vascular disease. Identification of such patients is important because symptoms, gastric dysrhythmias, and gastroparesis are potentially reversible with vascular bypass graft surgery.

References


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