Superior Mesenteric Artery Syndrome Improved by Enteral Nutritional Therapy according to the Controlling Nutritional Status Score

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Abstract
Superior mesenteric artery syndrome (SMAS) is a relatively rare disease that involves bowel obstruction symptoms, such as vomiting and gastric distension, owing to the compression of the third portion of the duodenum from the front by the superior mesenteric artery (SMA) and from the rear by the abdominal aorta and the spine. SMAS is diagnosed on the basis of an upper gastrointestinal examination series indicating the obstruction of the third portion of the duodenum or a computed tomography scan indicating the narrowing of the branch angle between the aorta and the SMA (i.e., the aorta-SMA angle). Here, we report the case of a 78-year-old woman diagnosed with SMAS after a laparoscopic right hemicolectomy for cecal cancer, whose condition was improved by enteral nutritional therapy. We used her controlling nutritional status (CONUT) score as a nutrition assessment and noted the changes in the aorta-SMA angle over the course of the disease. This patient appeared to develop SMAS, on
the basis of a worsened CONUT score and a decreased aorta-SMA angle, owing to the in-
flammation resulting from the intraoperative dissection of the tissues around the SMA and
prolonged postoperative fasting. After the initiation of enteral nutritional therapy, the patient
exhibited body weight gain and an improved aorta-SMA angle and CONUT score. Hence,
assessment of the aorta-SMA angle and CONUT score is an important preoperative consid-
eration.

Introduction

Superior mesenteric artery syndrome (SMAS) is a relatively rare disease that involves
bowel obstruction symptoms, such as vomiting and gastric distension, owing to compression
of the horizontal portion of the duodenum in the front by the superior mesenteric artery
(SMA) and from the rear by the abdominal aorta. SMAS is diagnosed on the basis of an upper
gastrointestinal (GI) examination series indicating the obstruction of the third portion of the
duodenum or a computed tomography (CT) scan indicating the narrowing of the branch
angle between the aorta and the SMA (i.e., the aorta-SMA angle). The aorta-SMA angle in
healthy persons has been reported to be 25–60°, whereas that of patients with SMAS is 6–22° [1–3]. For patients with SMAS, conservative treatment is considered the first strategy.
Drainage of the gastric contents with a nasogastric tube and the administration of prokinetic
agents or erythromycin, a motilin receptor agonist, have been reported to ameliorate the
symptoms. Furthermore, hyperalimentation is also performed to improve the nutritional
status. Enteral nutrition therapy with a feeding tube that is passed through the narrow se-
gment and placed into the jejunum may be required to increase weight gain and the mass of
fat and lymphatic tissue around the origin of the SMA, which consequently increases the
aorta-SMA angle and relieves the duodenal obstruction. Parenteral nutrition therapy is use-
ful when enteral nutrition is not tolerated [2, 4, 5]. Surgical treatment is indicated for pa-
tients whose symptoms are not relieved by conservative treatment and for patients with
recurrent symptoms due to duodenal obstruction. As operative procedures, duodenojeju-
nostomy, gastrojejunostomy, mobilization of the duodenum with transection from the liga-
tament of Treitz, and anterior transposition of the duodenum have been reported. Recently,
the number of reports on laparoscopic operations has increased [2, 3, 6, 7].

In the current study, the controlling nutritional status (CONUT) score was a convenient
and useful tool to assess nutritional status. The CONUT score evaluates the nutritional status
by calculating the total score for albumin (Alb), the total lymphocyte count, and the total
cholesterol, which are common items in blood tests and objective nutrition indices. The mal-
nutrition level was graded using a 4-point scale (normal, mild, moderate, and severe), where
the total score ranges from 0 to 1, 2 to 4, 5 to 8, and 9 to 12 were judged as normal, mild
abnormal, moderate abnormal, and severe abnormal, respectively. A higher CONUT score
can reflect not only the state of hypoalimentation but also systemic inflammation and an
impaired immune response [8–11].

For our patient, we noted the CONUT score as a nutrition assessment and the changes in
the aorta-SMA angle over the course of the disease.
Case Report

A 78-year-old woman had infective endocarditis (IE), as detected by a close systemic examination before surgery for cecal cancer. This patient underwent mitral valve repair, aortic valve replacement, and tricuspid valve replacement at the Department of Cardiovascular Surgery. After 1 month of administration of antibiotics at the Department of Cardiovascular Medicine (sulbactam/ampicillin 12 g/day; gentamicin 180 mg/day; and micafungin 150 mg/day), she underwent a laparoscopic right hemicolectomy with a D3 node dissection for cecal cancer. Additionally, her weight was 50.0 kg at admission and decreased to 46.1 kg at the time of surgery for cecal cancer.

Oral intake was initiated on postoperative day (POD) 3. However, it was discontinued because chylous ascites were detected in a drain tube. Although oral intake was initiated again on POD 10 after the chylous ascites were relieved, the patient was unable to tolerate oral intake owing to high gastric residual volumes and vomiting on POD 12. An abdominal X-ray revealed gastric dilation. After a nasogastric tube was inserted for drainage of the gastric contents, the patient was managed conservatively. However, the amount of drainage from the nasogastric tube did not decrease for more than 1 week.

On POD 21, an upper GI series examination with Gastrografin™ administered via the nasogastric tube revealed an obstruction at the third portion of the duodenum and dilation of the proximal duodenum (Fig. 1). In addition, we performed an endoscopic examination. We observed an extrinsic compression of the duodenum wall, which was the narrow segment detected by the upper GI series examination. Poor distension was revealed despite the air insufflated from the endoscope (Fig. 2). An abdominal CT scan revealed that the aorta-SMA angle was decreased to 21° (Fig. 1). These findings were suggestive of SMAS. Clinically, the patient exhibited stable vital signs. Blood tests revealed a white blood cell count of 7,600/μL and a C-reactive protein level of 0.1 mg/dL. However, the patient exhibited body weight loss (from 50.0 to 41.3 kg) and a body mass index decrease (from 22.5 to 18.6) after admission. Her Alb level was 2.4 g/dL, and her CONUT score was 6 on the nutrition index, thus indicating that the patient was in a state of hypoalimentation.

Nutritional management with hyperalimentation was first adopted as a conservative treatment strategy. We chose enteral nutrition therapy to avoid catheterization of the vein because of postoperative IE. For enteral nutrition therapy, we used a feeding tube that was passed through the narrow segment and placed into the jejunum. Enteral nutrition therapy was initiated on POD 21 and was combined with an orally administered liquid diet starting on POD 30. Finally, the administration of nutrients was set at 1,800 kcal/day. The obstruction of the third portion of the duodenum disappeared on the upper GI series, and good patency of this part of the lumen was ascertained on endoscopic examination (Fig. 2).

The feeding tube was removed on POD 41. After the initiation of treatment, the patient exhibited body weight gain (from 41.3 to 48.7 kg), an improved aorta-SMA angle (from 21 to 38°) was observed on a CT scan, and an improved Alb level (from 2.4 to 3.8 g/dL) and CO-NUT score (from 6 to 2) on the nutrition index were observed. Although her normal diet intake gradually increased after removal of the feeding tube, the patient experienced no recurrence of the SMAS and was discharged on POD 64 (Fig. 3).
Discussion

SMAS is caused by compression of the third portion of the duodenum from the front by the SMA and from the rear by the abdominal aorta and is accompanied by bowel obstruction symptoms, including abdominal pain, vomiting, and gastric distension. These symptoms are aggravated by eating [12, 13]. The SMA arises from the anterior aspect of the aorta at the level of the L1 vertebral body. In healthy persons, the mass of fat and lymphatic tissue around the origin of the SMA provides adequate protection against compression of the duodenum [1, 4, 12, 13]. The decrease in the aorta-SMA angle results in vascular compression of the third portion of the duodenum, thus contributing to SMAS. The potential causes are as follows: (1) a decrease in the mass of fat and lymphatic tissue around the origin of the SMA due to anorexia nervosa, hyperthyroidism, or long-term lying in bed; (2) hyperextension of the spine, due to body corset or body height increase at puberty; and (3) caudal traction of the mesentery, due to visceraloptosis, malrotation of the intestine, inflammatory thickening of the mesenteric root, or adhesion after abdominal surgery. Detachment of the physiological adhesion and the traction of the mesentery, due to intestinal resection and reconstruction or abdominal adhesion, are considered factors that cause the postoperative development of SMAS [2–4, 14]. In our patient, the surgery involved sites near the SMA (i.e., the surgical trunk that was exposed by the D3 lymph node dissection and the detachment of the mesentery of the colon from the retroperitoneum). Mesenteric traction, which was associated with thickening of the mesenteric tissue because of the effects of inflammation, temporary edema of the duodenal wall, and mobilization from the retroperitoneum of the mesentery of the colon, was regarded as the cause of SMAS.

The diagnosis of SMAS is based on an upper GI series examination indicating obstruction in the third portion of the duodenum and dilation of the proximal duodenum. Decreases in the aorta-SMA angle and in the aorta-SMA distance on an abdominal CT scan are also important for the diagnosis [1, 14]. Our patient exhibited both an obstruction of the third portion of the duodenum on an upper GI series examination and a decrease in the aorta-SMA angle on an abdominal CT scan.

In our patient, conservative treatment was first adopted. Nutritional management with hyperalimentation was considered, but we chose enteral nutrition therapy to avoid catheterization of the vein because of postoperative IE. At the initiation of enteral nutrition therapy, the basic energy expenditure was calculated with the Harris-Benedict equation on the basis of patient’s height, weight, and age at admission. After the activity factor was defined as 1.2 and the stress factor as 1.4, the total energy expenditure was calculated and defined for the daily administration of calories [4, 15].

For our patient, we noted the CONUT score as a nutrition assessment, and the changes in the aorta-SMA angle were recorded over the course of the disease. From the time of hospitalization, our patient exhibited a CONUT score of 7, which indicated moderate abnormality. Between the cardiac surgery and the surgery for cecal cancer, her cancer remained untreated. Her CONUT score did not improve, because her caloric intake was insufficient. Subsequently, she underwent surgery for cecal cancer. It was thought that her continuously high CONUT score reflected a decrease in the mass of fat and lymphatic tissue around the origin of the SMA. Her aorta-SMA angle also decreased from 36° at admission to 21°. She appeared to develop SMAS because of a further worsened CONUT score and a decrease in the aorta-SMA angle, which resulted from the effects of inflammation arising from the intraoperative dissection of the tissues around the SMA and a prolonged fasting period due to postoperative chylous ascites. After the diagnosis of SMAS, the patient received optimal caloric intake via
enteral nutrition therapy. Consequently, on the basis of her nutrition assessment, her aorta-SMA angle increased to 38°, and her CONUT score improved to 2. Generally, although her weight decreased to 41.3 kg, it increased back to 48.7 kg before discharge. The good passage of the third portion of the duodenum was maintained, and she never experienced a recurrence of SMAS, even after her dietary intake increased.

In conclusion, SMAS was thought to be triggered by the preoperative hypoalimentation state, intraoperative dissection of the tissues around the SMA, and postoperative fasting. Our findings reaffirm the importance of checking the aorta-SMA angle and assessing the nutritional status before surgery. Preoperative confirmation of the aorta-SMA angle and CONUT score might lead to an assessment of the risk of SMAS in operative procedures in which intraoperative dissection is performed on the tissues around the SMA.

**Statement of Ethics**

This case report followed the principles of the Declaration of Helsinki and was approved by the ethics review board of Juntendo University (Ethical Committee Approval No. JHS 17-0004). When obtaining informed consent for the surgical procedure, general consent for publication and presentation was also obtained from the patient.

**Disclosure Statement**

The authors declare that they have no competing interests.

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Fig. 1. a An upper gastrointestinal series examination with Gastrografin™ administered via the nasogastric tube on postoperative day (POD) 21 revealed an obstruction of the third portion of the duodenum and dilation of the proximal duodenum (arrow). b Sagittal slices from the abdominal computed tomography scan on POD 13 revealed that the branch angle between the aorta and the superior mesenteric artery (i.e., the aorta-SMA angle) was 21°.
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**Fig. 2.** a A feeding tube was passed through the narrow segment (arrow) and placed into the jejunum. b, c An endoscopic examination revealed the extrinsic compression of the duodenal wall, which was the narrow segment detected in the upper gastrointestinal (GI) series examination. The poor distension was insufflated with air from the endoscope. d, e An upper GI series examination and endoscopic examination on POD 47 revealed that the third portion of the duodenum exhibited good patency (arrow).

**Fig. 3.** Clinical course of the patient. We observed improvements in the aorta-SMA angle and nutritional status. WBC, white blood cells; CRP, C-reactive protein; Alb, albumin; BW, body weight; CONUT, controlling nutritional status; SBT/ABPC, sulbactam/ampicillin; GM, gentamicin; MCFG, micafungin; ND, normal diet; LD, liquid diet; ED, elemental diet; N.P.O., nothing per oral; Ope, operation; IE, infective endocarditis; POD, postoperative day; SMAS, superior mesenteric artery syndrome.