

# World Journal of *Gastrointestinal Surgery*

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*WJGS* mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, etc.

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## Retrospective Study

**Causes of epigastric pain and vomiting after laparoscopic-assisted radical right hemicolectomy - superior mesenteric artery syndrome**

Juan Xie, Jiao Bai, Ting Zheng, Jian Shu, Ma-Li Liu

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Superior mesenteric artery syndrome (SMAS) is a rare condition causing functional obstruction of the third portion of the duodenum. Postoperative SMAS following laparoscopic-assisted radical right hemicolectomy is even less prevalent and can often be unrecognized by radiologists and clinicians.

**AIM**

To analyze the clinical features, risk factors, and prevention of SMAS after laparoscopic-assisted radical right hemicolectomy.

**METHODS**

We retrospectively analyzed clinical data of 256 patients undergoing laparoscopic-assisted radical right hemicolectomy in the Affiliated Hospital of Southwest Medical University from January 2019 to May 2022. The occurrence of SMAS and its countermeasures were evaluated. Among the 256 patients, SMAS was confirmed in six patients (2.3%) by postoperative clinical presentation and imaging features. All six patients were examined by enhanced computed tomography (CT) before and after surgery. Patients who developed SMAS after surgery were used as the experimental group. A simple random sampling method was used to select 20 patients who underwent surgery at the same time but did not develop SMAS and received preoperative abdominal enhanced CT as the control group. The angle and distance between the superior mesenteric artery and abdominal aorta were measured before and after surgery in the experimental group and before surgery in the control group. The preoperative body mass index (BMI) of the experimental group and the control group was calculated. The type of lymphadenectomy and surgical approach in the experimental and control groups were recorded. The differences in angle and distance were compared preoperatively and postoperatively in the experimental group compared. The differences in angle, distance, BMI, type of lymphadenectomy and surgical

approach between the experimental and control groups were compared, and the diagnostic efficacy of the significant parameters was assessed using receiver operating characteristic curves.

## RESULTS

In the experimental group, the aortomesenteric angle and distance after surgery were significantly decreased than those before surgery ( $P < 0.05$ ). The aortomesenteric angle, distance and BMI were significantly higher in the control group than in the experimental ( $P < 0.05$ ). There was no significant difference in the type of lymphadenectomy and surgical approach between the two groups ( $P > 0.05$ ).

## CONCLUSION

The small preoperative aortomesenteric angle and distance and low BMI may be important factors for the complication. Over-cleaning of lymph fatty tissues may also be associated with this complication.

**Key Words:** Right hemicolectomy; Superior mesenteric artery syndrome; X-ray computed tomography

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**Core Tip:** This study retrospectively analyzed 256 patients undergoing laparoscopic-assisted radical right hemicolectomy, and six patients developed superior mesenteric artery syndrome (SMAS). The preoperative and postoperative aortomesenteric angle and distance were compared in the six patients, and 20 patients without postoperative SMAS were randomly selected for comparative analysis with 6 patients developed SMAS. The results and literature review suggest possible reasons and preventative measures for SMAS after right hemicolectomy.

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## INTRODUCTION

A series of symptoms may occur after right hemicolectomy. They include nausea, bilious vomiting, epigastric pain, and postprandial abdominal fullness and distension. A total of 256 cases of laparoscopic-assisted radical right hemicolectomy was performed between January 2019 and May 2022 at the Affiliated Hospital of Southwestern Medical University, with six cases of postoperative complications of persistent upper gastrointestinal obstruction and a final diagnosis of superior mesenteric artery syndrome (SMAS). Several factors have been identified that have an impact on the occurrence of SMAS. The most common is significant weight loss, which leads to loss of retroperitoneal fat. These predisposing factors include wasting diseases (burns, cancer, and endocrine disorders), severe injuries (head or spinal trauma, and application of a body cast), dietary disorders (anorexia nervosa and malabsorptive diseases), and postoperative states (treatment for scoliosis, and abdominal surgery)[1]. Postoperative SMAS following intra-abdominal procedures is extremely rare. In this paper, we analyze cases and review the relevant literature to discuss the possible causes and preventative measures of SMAS after right hemicolectomy.

## MATERIALS AND METHODS

### Patients

Among the 256 patients in this group who underwent laparoscopic-assisted radical right hemicolectomy, including 130 men and 126 women, aged 19–84 years (median  $61.8 \pm 13.8$  years), postoperative SMAS occurred in six patients (2.3%), including four men and two women, aged 29–64 years (median  $50.3 \pm 13.0$  years).

### Clinical manifestations

Patients developed upper gastrointestinal obstruction symptoms after 5–10 d postoperatively. In patients with postoperative gastric tube drainage, the drainage continuously exceeded 500–800 mL/d. The patients experienced epigastric distention, eructation, and vomiting after meals or removal of the gastric tube. The vomiting volume was large, similar to pyloric obstruction. The vomit contained bile, partially excluding pyloric obstruction and gastric emptying disorder. Two cases displayed an associated 10%–18% weight loss and electrolyte disturbances. The prominent feature of this group of cases was that the obstructive symptoms were position-related. The symptoms decreased or disappeared when patients were in the left lateral or prone position.

### Imaging

All six patients underwent abdominal contrast-enhanced computed tomography (CT) before surgery. After surgery, three of the patients were simultaneously examined by abdominal contrast-enhanced CT and an upper gastrointestinal series. The other three patients received abdominal contrast-enhanced CT only. [Figure 1A–1E](#) shows the image of a patient with postoperative SMAS.

### Management

Based on the clinical and radiological findings, a diagnosis of SMAS was suspected. All six cases were initially treated conservatively with gastric tube placement, fasting, and increased rehydration. These patients were gradually introduced to enteral feeding. In one case, endoscopic nasojejunal tube feeding was performed. Two cases did not improve with conservative treatment and were treated with duodenojejunostomy or gastrojejunostomy. Electrolyte abnormalities were carefully treated. All six patients showed weight gain and symptom resolution, corroborating our diagnosis.

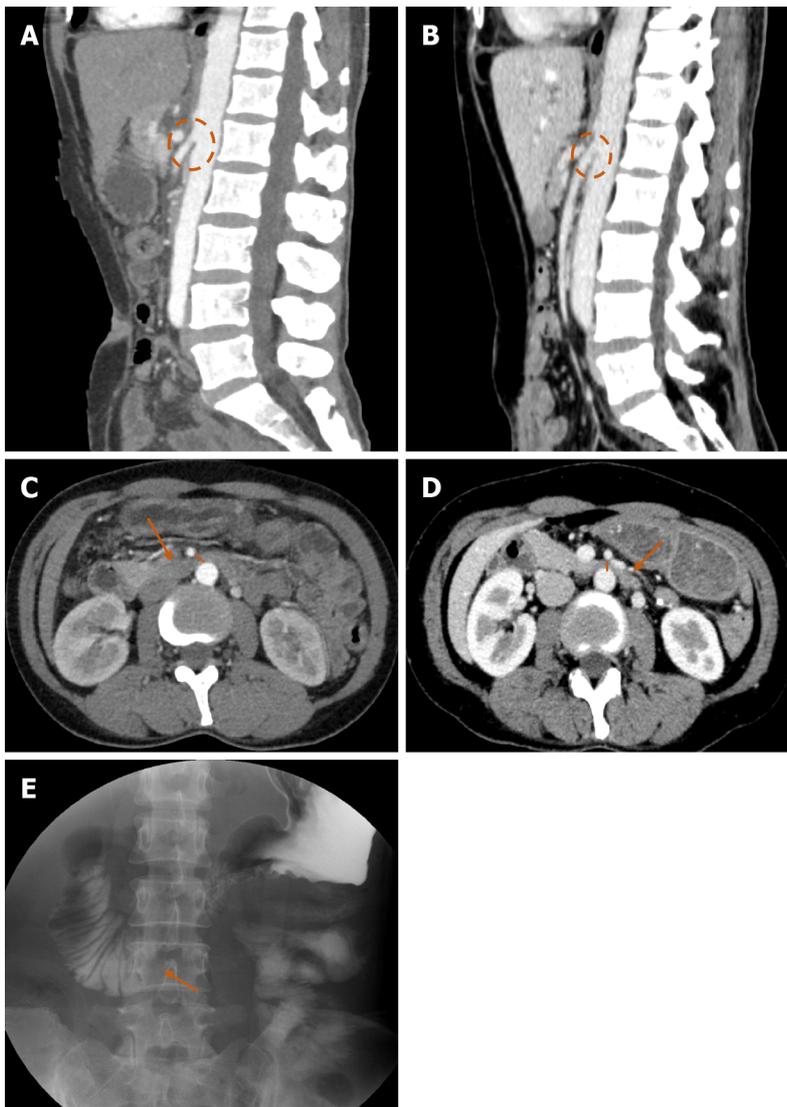
### Statistical analysis

Of the six patients, five had ascending colon cancer and one had ascending colon lymphoma. All six patients were examined by CT before and after surgery. The median age of patients with postoperative SMAS was  $50.3 \pm 13.0$  years, including 130 men and 126 women, and the median age of all patients in the same period was  $61.8 \pm 13.8$  years, including four men and two women.

There was little difference in sex and age between patients with postoperative SMAS and all surgical patients in the same period. It seemed that sex and age were not risk factors for SMAS. Patients who developed SMAS after surgery were used as the experimental group. A simple random sampling method was used to select a control group of 10 male and 10 female patients who underwent surgery at the same time but did not develop SMAS and received preoperative abdominal enhanced CT. Arterial phase images of both groups were reconstructed by sagittal multiplanar reformation. The angle and distance between the superior mesenteric artery (SMA) and abdominal aorta (AA) were measured before and after surgery in the experimental group and before surgery in the control group. The preoperative body mass index (BMI) of the experimental and control groups was calculated. The type of lymphadenectomy and surgical approach in the experimental group and the control group were recorded. Types of lymphadenectomy include D3 lymphadenectomy and D2 lymphadenectomy. There were three surgical approaches, the lateral approach, intermediate and caudal approach. SPSS 23.0 software was used for statistical analyses of the above risk factors. The Kolmogorov–Smirnov method was used to test whether the measurement data conformed to the normal distribution. The data conforming to the normal distribution was expressed as mean  $\pm$  standard deviation. The *t* test was used to compare the differences in angle and distance preoperatively and postoperatively in the experimental group. The differences in angle, distance and BMI between the experimental and control groups were compared by independent sample *t* test, and the differences in type of lymphadenectomy and surgical approach between the two groups were compared by  $\chi^2$  test. Receiver operating characteristic curves were used to analyze the optimal diagnostic threshold and diagnostic efficiency of statistically significant parameters. The difference was statistically significant at  $P < 0.05$ .

## RESULTS

In the experimental group of six cases, the angle between the SMA and AA was  $18^\circ$ – $29^\circ$  (mean  $23.50^\circ \pm 4.23^\circ$ ) in the preoperative period and  $10^\circ$ – $18^\circ$  (mean  $14.67^\circ \pm 3.08^\circ$ ) in the postoperative period. The distance between the SMA and the AA was 7–11 mm (mean  $9.33 \pm 1.37$  mm) in the preoperative period and 3–8 mm (mean  $5.17 \pm 1.72$  mm) in the postoperative period. Preoperative BMI ranged from 16.8 to 25.1 kg/m<sup>2</sup> (mean  $18.82 \pm 3.13$  kg/m<sup>2</sup>). Five patients received D3 lymphadenectomy and one D2 lymphadenectomy. There were three surgical approaches: Lateral in two cases, intermediate in one, and caudal approach in three. In the control group, the angle between the SMA and AA of the 20 patients ranged from  $19^\circ$  to  $49^\circ$  (mean  $36.35^\circ \pm 8.13^\circ$ ). The distance between SMA and AA ranged from 7 to 25 mm (mean  $14.45 \pm 4.44$  mm). BMI ranged from 18.7 to 27.2 kg/m<sup>2</sup> (mean  $22.85 \pm 2.33$  kg/m<sup>2</sup>). Fifteen patients received D3 lymphadenectomy and five D2 lymphadenectomy. There were three surgical



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**Figure 1** Imaging of a patient with postoperative superior mesenteric artery syndrome. A: Abdominal enhanced computed tomography (CT) in the preoperative period showing the angle between the superior mesenteric artery (SMA) and abdominal aorta (AA) was 19°; B: Abdominal enhanced CT in the postoperative period showing the altered anatomical position of the SMA and the aortomesenteric angle was 10°; C: Abdominal enhanced CT in the preoperative period showing the distance between the SMA and AA in the third portion (large arrow) of the duodenum was 7 mm (short thin line); D: Abdominal enhanced CT in the postoperative period showing the reduced aortmesenteric distance in the third portion (large arrow) was 4 mm (short thin line); E: Representative image from upper gastrointestinal series showing abrupt cutoff of oral contrast in the third portion of the duodenum (arrow) and slight dilation of the proximal duodenum, suggestive of superior mesenteric artery syndrome.

approaches: Lateral in five cases, intermediate in eight, and caudal approach in seven. In the experimental group, the angle and distance after surgery were significantly decreased than those before surgery ( $P < 0.05$ ) (Table 1). The angle, distance and BMI were significantly higher in the control group than in the experimental ( $P < 0.05$ ) (Table 2). There was no significant difference in the type of lymphadenectomy and surgical approach between the two groups ( $P > 0.05$ ). The area under receiver operating characteristic curve for aortomesenteric angle, distance and BMI was 0.913, 0.888, 0.867, and cutoff of the aortomesenteric angle, distance and BMI to identify the control and experimental groups was 29.50°, 11.50 mm, 18.45 kg/m<sup>2</sup> respectively (Table 3).

## DISCUSSION

SMAS is a rare medical condition that describes the clinical symptoms resulting from vascular compression of the third part of the duodenum in the angle between the SMA and AA. This syndrome is also known as aortomesenteric artery compression, arteriomesenteric duodenal compression, Wilkie's syndrome, and cast syndrome. The incidence of SMAS reported in previous studies has ranged from 0.13%–0.78% [2]. The symptoms of SMAS can be vague, chronic, and significantly overlap with more

**Table 1 Comparison of preoperative and postoperative angle and distance in the experimental groups**

	Preoperative	Postoperative	t	P value
Angle (°)	23.50 ± 4.23	14.67 ± 3.08	12.562	0.000
Distance (mm)	9.33 ± 1.37	5.17 ± 1.72	6.934	0.001

**Table 2 Comparison of risk factors between the two groups**

Risk factor	Experimental group (n = 6)	Control group (n = 20)	t/χ <sup>2</sup>	P value
Angle (°)	23.50 ± 4.23	36.35 ± 8.13	3.686 <sup>b</sup>	0.001
Distance (mm)	9.33 ± 1.37	14.45 ± 4.44	4.491 <sup>b</sup>	0.000
BMI (kg/m <sup>2</sup> )	18.82 ± 3.13	22.85 ± 2.33	3.436 <sup>b</sup>	0.002
Type of lymphadenectomy			0.000 <sup>a</sup>	1.000
	D3	5	15	
	D2	1	5	
Surgical approach			1.219 <sup>a</sup>	0.544
	Lateral approach group	2	5	
	Intermediate group	1	8	
	Caudal approach group	3	7	

<sup>a</sup>χ<sup>2</sup> test.<sup>b</sup>t test.

BMI: Body mass index.

**Table 3 Receiver operating characteristic results**

Risk factor	AUC	SE	P value	95%CI	Cut off	Sensitivity	Specificity
Angle	0.913	0.056	0.003	0.803–1.000	29.50°	0.800	1.000
Distance	0.888	0.065	0.005	0.760–1.000	11.50 mm	0.750	1.000
BMI	0.867	0.123	0.007	0.625–1.000	18.45 kg/m <sup>2</sup>	1.000	0.833

AUC: Area under curve; SE: Standard error; BMI: Body mass index.

common gastrointestinal disorders, such as gastritis, peptic ulcer disease, irritable bowel syndrome, and gastroparesis[3]. Chief complaints of patients with SMAS include early satiety, postprandial pain or discomfort, nausea and bilious emesis that often develop after a meal, bloating, eructation, and reflux. The latter is classically relieved by lying in the left lateral decubitus position or follows an episode of emesis[4-6]. Death in SMAS is due to aspiration pneumonia, acute gastric rupture, severe electrolyte imbalance, hypokalemia, and cardiovascular collapse[7]. The normal anatomical aortomesenteric angle and aortomesenteric distance is 25°–60° and 10–28 mm, respectively. An aortomesenteric angle of 22°–25° and distance of 8 mm correlates with symptoms of SMAS[3,8]. The diagnosis of SMAS must be based on clinical symptomatology correlated with radiographic information[9]. Once diagnosed, SMAS can be safely treated conservatively, including by nasogastric decompression and correction of electrolytes and intravenous hydration, followed by enteral nutrition through a nasojejunal tube or parenteral nutrition if necessary. Operative management is indicated only when conservative management fails[10]. The multiple surgical approaches include lysis of the ligament of Treitz, gastrostomy tube placement, or proximal bypass of the common channel to the distal stomach or duodenum (i.e., duodenojejunostomy and/or gastrojejunostomy)[11]. Once the third portion of the duodenum is bypassed, the symptoms resolve quickly.

Postoperative SMAS following intra-abdominal procedures is extremely rare, but has previously been reported following colectomy[12], proctoright hemicolectomy[13], retroperitoneal sarcoma resection[14] and Roux-en-Y gastric bypass[15]. Corrective spinal surgery for scoliosis, which requires relative lengthening of the spine and results in the narrowing of the aortomesenteric angle, is the most frequently cited cause of postoperative SMAS with an estimated incidence of 1%–4.7%[16].

Many previous studies have described the common causes for the occurrence of SMAS, but further research will be needed to investigate the etiopathogenesis of SMAS after right hemicolectomy. In this study, we discussed the cases of SMAS occurring after right hemicolectomy and reviewed the relevant literature to suggest five possible reasons and preventative measures.

First, the unifying theme for most cases of postoperative SMAS is a sudden major rearrangement of intra-abdominal anatomy[14]. The postoperative CT in this group showed that the position of intestinal structures in the abdominal cavity was changed. The right hemicolectomy disrupted the suspension of the transverse colon from the hepatic region of the colon, resulting in prolapse of the anastomosed colonic segment and excessive pulling of the colonic mesenteric root, resulting in the compression of the duodenal root. The six patients had no clinical manifestation of SMAS before the surgery. Postoperative visceral prolapse and further depletion of mesenteric fat resulted in reduction of the aortomesenteric angle and distance significantly. Six patients with postoperative SMAS were selected as the study subjects. The control group comprised 20 patients who had undergone surgery at the same time but who did not have postoperative SMAS. All patients underwent abdominal contrast-enhanced CT before surgery. The statistical results showed that the aortomesenteric angle and distance were smaller in the experimental group than in the control group. Thus, the pre-existing small preoperative aortomesenteric angle and distance were anatomical factors leading to SMAS. Further reductions in angle and distance after right hemicolectomy led to the development of SMAS symptoms.

Second, careful analysis of the surgical data of all patients revealed over-cleaning of lymph fatty tissues in the six patients. Five patients who underwent D3 clearance and the other who underwent D2 clearance also had a partially dissected naked surface of the SMA. Over-cleaning of lymph fatty tissues may have contributed to the postoperative SMAS in this group of patients. However, the type of lymphadenectomy in the experimental and control groups did not differ significantly, which may be due to the small sample size, leading to the lack of strict statistical significance of the conclusions. More evidence needs to be accumulated and observed in more cases.

Third, during right hemicolectomy, the electric knife dissociated the second and third part of the duodenum, resulting in injury of the duodenal intestinal plexus. This may affect peristalsis and tone of the duodenum, inducing the development of SMAS[17].

Fourth, intestinal peptides influence gastric function. Reduced sources of intestinal peptides after right hemicolectomy may inhibit the movement of the duodenum and affect its digestion and absorption, inducing the development of SMAS. Finally, local mesenteric traction of tissue near the SMA due to confined abdominal exudate and peritoneal adhesions after right hemicolectomy may be a contributing factor to SMAS.

Patients with an angle between the SMA and AA  $< 29.50^\circ$ , distance  $< 11.50$  mm, and especially those with BMI  $< 18.45$  kg/m<sup>2</sup> are at greater risk of developing SMAS after right hemicolectomy. To reduce the incidence, early nutrition should be enhanced to reduce visceral fat consumption. Intraoperative preservation of some peritoneal structures to enhance the support of mesenteric vessels as much as possible is prudent. Other important aspects are: To reduce SMAS to prevent postoperative adhesions by standardizing surgery; to ensure that the anastomosis is tension-free and has good blood flow; correctly placing the drainage tube; accelerating healing of the anastomosis; reducing the occurrence of peri-anastomotic infection; and avoiding adhesions that can form a mass that pulls the superior mesenteric vessels. Reduction of the number of intraoperative electrocautery procedures can reduce damage to the intestinal wall plexus. Finally, the use of pro-gastrointestinal drugs postoperatively can increase propulsive gastrointestinal motility.

## CONCLUSION

SMAS is an uncommon phenomenon. Postoperative SMAS following right hemicolectomy is rarer. We reported six cases of SMAS after laparoscopic-assisted radical right hemicolectomy and reviewed the literature to analyze potential risk factors or determining factors for the occurrence of SMAS. Some suggestions were put forward to reduce the occurrence of SMAS. Future studies should explore whether the occurrence of obstruction can be reduced in patients prone to SMAS after right hemicolectomy by improving reconstruction of the anastomotic colonic segment to reduce its pull on the superior mesenteric vessels or by prophylactic release of the ligament of Treitz.

## ARTICLE HIGHLIGHTS

### Research background

Superior mesenteric artery syndrome after laparoscopic-assisted radical right hemicolectomy is a rare complication and can often be unrecognized by radiologists and clinicians.

**Research motivation**

Help people understand postoperative superior mesenteric artery syndrome.

**Research objectives**

Potential risk factors for the development of superior mesenteric artery syndrome were analyzed through case discussions and review of the literature.

**Research methods**

The preoperative and postoperative aortomesenteric angle and distance were compared in the experimental group of 6 patients, and 20 patients without postoperative SMAS in the 256 patients were randomly selected for comparative analysis with 6 patients developed SMAS.

**Research results**

In the experimental group, the aortomesenteric angle and distance after surgery were significantly decreased than those before surgery. The aortomesenteric angle, distance and BMI were significantly higher in the control group than in the experimental. There was no significant difference in the type of lymphadenectomy and surgical approach between the two groups.

**Research conclusions**

The small preoperative aortomesenteric angle and distance and low BMI may be important factors for the complication. Over-cleaning of lymph fatty tissues may also be associated with this complication.

**Research perspectives**

Future studies should explore whether the occurrence of obstruction can be reduced in patients prone to SMAS after right hemicolectomy by improving reconstruction of the anastomotic colonic segment to reduce its pull on the superior mesenteric vessels or by prophylactic release of the ligament of Treitz.

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**FOOTNOTES**

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**Author contributions:** Xie J, Bai J, Zheng T, Shu J, and Liu ML designed and performed the research; Xie J analyzed the data and wrote the manuscript.

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