Point-by point response to the Reviewers' comments

Reviewer #1:
This is a well-written review about the Superior Mesenteric Artery Syndrome (SMAS). The author involved all the relevant topics and also included personal radiologic imaging with endoscopic imaging. Furthermore, the drafting imaging of the SMAS is extremely well described. The main flaw about this syndrome is the lack of relevant data about the right timing for the surgical approach after conservative treatment fail, which was well described in the text.

> Thank you so much for reviewing our manuscript and your kind words. We hope this article can help clinical managements of SMAS.

Reviewer #2:
What is the meaning of the word " FD" that appears on the page 3, line 85 ?

> We appreciate your careful review and your kind comment. According to your comment, we would define FD as functional dyspepsia and state that acronym has been expanded on the revision (page 3, line 86).

Reviewer #3:
1) Would you please kindly correct all your typos and grammar errors throughout the manuscript.

> Thank you so much for your review and thoughtful comments. According to your suggestion, we corrected all our typos and grammar errors by a native English speaker (Dr. Awoniyi). For major changes, we highlighted changes with yellow color.

2) I would generally suggest to elaborate on more information about possible therapy including surgery. It is well-known that there is no relevant guidelines but it might be nice to gather all the information that might be of importance.

> According to your suggestions, we added more information about possible therapy including surgery. Please see our modifications highlighted by yellow color in the text and the additional table (Table 6). Again thank you so much for your great suggestions.

Opening page:

Superior Mesenteric Artery Syndrome: Diagnosis and Management

Oka A *et al*. SMA syndrome

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Abstract

Superior mesenteric artery syndrome (SMAS, also known as Wilkie's syndrome, cast syndrome, or aorto-mesenteric compass syndrome) is an obstruction of the duodenum caused by extrinsic compression between the superior mesenteric artery (SMA) and the aorta. The median age of patients is 23 years old (range 0-91 years old) and predominant in females over males with a ratio of 3:2. The symptoms are variable, consisting of postprandial abdominal pain, nausea and vomiting, early satiety, anorexia, and weight loss and can mimic anorexia nervosa or functional dyspepsia. Because recurrent vomiting leads to aspiration pneumonia or respiratory depression via metabolic alkalosis, early diagnosis is required. The useful diagnostic modalities are computed tomography as a standard tool and ultrasonography, which has advantages in safety and capability of real-time assessments of SMA mobility and duodenum passage. The initial treatment is usually conservative, including postural change, gastroduodenal decompression, and nutrient management (success rates: 70-80%). If conservative therapy fails, surgical treatment (i.e. laparoscopic duodenojejunostomy) is recommended (success rates: 80-100%).

Key words: Superior mesenteric artery syndrome, Wilkie’s syndrome, Cast syndrome, Aorto-mesenteric compass syndrome.

Core tip:

To summarize, SMA syndrome (SMAS) is a rare condition that occurs when the superior mesenteric artery compresses the third part of the duodenum. This compression can cause obstructive symptoms and weight loss. SMAS can be caused by a variety of factors, including abnormal anatomy, rapid weight loss, and previous abdominal surgery. It is most commonly seen in young, thin females, but can occur in males and people of any age or body type. Treatment may involve dietary modifications, medications, and surgery to correct the underlying cause. If left untreated, SMAS can lead to serious complications, including malnutrition and intestinal damage.

INTRODUCTION

Superior mesenteric artery (SMA) syndrome is a rare cause of duodenal obstruction by extrinsic compression between SMA and the aorta (SMA-Ao) (**Figure 1**), and a morbid entity when the diagnosis is delayed [1–3]. Von Rokitansky first described this entity in his textbook with a case presentation in 1842 [1]. Later, Wilkie described pathological and diagnostic findings in details with 75 cases of his own in 1927 [2], thus SMA syndrome is also known as Wilkie's syndrome. The other names are reported as cast syndrome, aorto-mesenteric compass syndrome, or mesenteric duodenal obstruction [3]. A cast, which is used to treat certain congenital deformities such as scoliosis and hip displacement, is a major cause of SMA syndrome [4–6]. By the year 2022, more than 730 articles with approximately 2,400 cases of SMA syndrome had been reported (author's review in PubMed [7]). Initial conservative therapy occasionally fails, and surgical or, more recently, endoscopic surgical duodenojejunostomy is successfully performed. This review provides clinical information of SMA syndrome in details.

EPIDEMIOLOGY AND ETIOLOGY

SMA syndrome frequently concerns young adult female [2,8–13]. Our review [7] found the median age is 23 years old (inter-quartile range [IQR]: 16-39) but any age can be affected (range 0-91 years old), with increasing trends of elder patients with SMA syndrome in recent literatures (**Figure 2**). The affected age seems to be related to underlying patients' conditions (i.e. congenital scoliosis at children or weight loss due to chemotherapy). Whereas the affected gender is, as reported previously, predominant in females over males with a ratio of 3:2 [7]. The incidence of SMA syndrome in the general population has been estimated at 0.013-0.78% based on radiographic studies [8,14–17], though an accurate prevalence of the disease is unknown, depending on under- or over-diagnosis in clinical practice and each patient's condition [11,18] (**Table 1**) [13,19–35]. A prospective case-control study conducted by Xu et al. found the incidence of SMA syndrome is 2.67% (26/973 admissions for 9 years) [28]. Scoliosis and burn injuries are well-known etiologies of SMA syndrome and clinicians should be aware of this entity. In contrast, in functional dyspepsia patients, the incidence is much higher (10.8%) than in the general population, which is explained by clinicians under-diagnosing.

PATHOPHYSIOLOGY

Decreasing SMA-Ao angle causes compression to the third part of the duodenum (see DIAGNOSIS). Decreases in the SMA-Ao angle can be either congenital or acquired (**Table 2**) [2,4–6,18–20,23,26,31,34–61]. The major causes of SMA syndrome involve body weight loss and resulting loss of mesenteric fat tissue between SMA-Ao, which in turn, makes a narrower angle between the vessels. The reasons for weight loss include several types of dietary conditions (eating disorders and malabsorptive diseases), hypermetabolism (drugs and burns), and cachexia causing conditions (tuberculosis and malignancy). Especially in severe injuries and burns, prolonged bedrest in a supine position increases risk of compression of the duodenum. Scoliosis treatments (surgery and cast) and scoliosis itself are well-known causes of SMA syndrome. The lengthening of the spine during scoliosis surgery is thought to be the underlying pathophysiology. Intestinal surgeries including ileal pouch-anal anastomosis and colectomy are also well-described causes, reducing the SMA-Ao angle due to pulling on the mesentery. Congenitally short or hypertrophic ligament of Treitz is a major cause in children.

Although it is not pure SMA syndrome, aortic artery aneurysm (AAA) and surgery near or around the SMA and 3rd duodenum induces "pseudo-" SMA syndrome. AAA-related SMA syndrome was first reported by Dr. Osler as aortoduodenal syndrome [58–60].

SYMPTOMS

Patients with SMA syndrome suffer from vague and nonspecific symptoms, such as nausea, vomiting, epigastric pain, early satiety and post-prandial discomfort, bloating (abdominal distension), and weight loss, which can mimic anorexia nervosa and functional dyspepsia [9,13,62]. The epigastric pain and discomfort are more severe in a supine position and relieved in the lateral decubitus position (positioning knees to the chest) which reduces tension on the small bowel mesentery [62]. Especially in acute phase, severe duodenal obstruction leads to severe symptoms and life-threatening dilatation of the stomach [9,13,62]. In contrast, in chronic phase, the recurrent nausea and vomiting leads to inadequate food intake, resulting in severe weight loss and thus, aggravation of the syndrome [9,13,62].

COMPLICATIONS AND COMORBIDITIES

Various complications of SMA syndrome have been reported (**Table 3A**) [36,63–87]. Notably, unrecognized or severe cases may progress to life-threatening complications, such as hypovolemic shock, aspiration pneumonia, and sudden death, even in young patients. Mechanisms of sudden death remain unclear, and several hypotheses, however, can be raised based on published cases including autopsies - arrhythmia by severe hypokalemia, severe compression of the inferior vena cava by dilated duodenum, or severe pulmonary depression induced by alkalosis and increased abdominal pressure. Thus, immediate corrections of blood election and volume and early reduction of intestinal pressure should be required in severe cases. The most frequent complication is gastrointestinal injury caused by retained or refluxed peptic acid and bile acid as well as elevated intraluminal pressure. The incidence of mucosal injury has been reported as 25-59% in patients with SMA syndrome [63,74]. Inadequately treated or chronic mucosal injuries may progress to emphysema, necrosis, portal venous gas, and pneumoperitoneum. Elevated intraluminal pressure at the second portion of the duodenum disturbs the flow of pancreatic juice, occasionally resulting in elevated pancreatic enzymes and acute pancreatitis. Vomiting itself can increase serum amylase (mainly from salivary glands), so pancreatic amylase isozyme and lipase should help to recognize pancreatic abnormalities. Recurrent vomiting also leads to aspiration pneumonia, dehydration, electrolyte abnormalities, and severe malnutrition. SMA syndrome sometimes co-exists with other vascular compression diseases (**Table 3B**) [88–91]. Of these, nutcracker phenomenon is the most frequent based on anatomic location to the SMA. It is a condition that occurs when the left renal vein becomes compressed between the aorta and SMA with similar symptoms as SMA syndrome.

DIAGNOSIS

Due to its non-specific symptoms, SMA syndrome might be overlooked in clinical practice [27,92]. Even in radiologists, the duodenum seems to be a neglected segment in the intestine [93]. SMA syndrome requires a high degree of clinical suspicion and few teaching methods have been reported [94,95]. The diagnosis is based on clinical symptoms supported by radiological evidence of duodenal obstruction. Traditional criteria for SMA syndrome are based on barium X-ray studies (**Figure 3**): 1) dilatation of the first and second parts of the duodenum with or without

gastric dilatation, 2) abrupt vertical or oblique compression of the third part of the duodenum, 3) reverse flow of contrast proximal to the obstruction, 4) significant delay (4-6 h) in gastroduodenal transit, and 5) relief of obstruction after postural changes (the prone knee-chest or lateral decubitus position) [18,19,96]. Recently, in addition to barium studies, various imaging modalities have been used to confirm SMA syndrome, such as computed tomography (CT), abdominal ultrasound (US), magnetic resonance imaging (MRI), endoscopy and endoscopic ultrasonography (EUS) etc. (**Table 4**). Many cases are diagnosed by these modalities, which can directly visualize the SMA compression of the duodenum without barium studies. The standard diagnostic modality is CT scan (**Figure 4**) which allows for both diagnosis of SMA syndrome with measurement of the SMA-Ao angle and distance as well as detection of complications, such as gastric necrosis, portal vein gas, acute pancreatitis etc. 3D-CT is more helpful in recognizing the anatomy of SMA, the aorta and duodenum [97]. The normal SMA-Ao angle is between 38 to 65 degrees and has a distance of 10 to 33 mm [5,98]. Unal et al. reported the cutoff value is 22 degrees on the SMA-Ao angle and 8 mm on a distance with a 42.8% sensitivity and 100% specificity [98]. Abdominal US is another modality that provides a convenient, quick, noninvasive tool to diagnose SMA syndrome [98–100]. The sensitivity of abdominal US in diagnosis of SMA syndrome has been confirmed in a comparison study with CT findings [98]. Abdominal US benefits from an improvement of image resolution and can clearly visualize the duodenum and SMA-Ao angle (**Figure 5 and Video**). Endoscopy can detect gastrointestinal complications, such as mucosal injury, bleeding, and bezoar, etc. (**Figures 6A and 6B**). It can also reveal extrinsic compression (by SMA) at the 3rd portion of duodenum (**Figure 6C**). Further, EUS with mini-probes can be used to confirm the compression by SMA and also measure SMA-Ao distance [37,101]. Recently, linear EUS has been used for measuring the SMA-Ao angle and also endoscopic duodenojejunostomy (see TREATMENTS). Laboratory tests are not diagnostic, but they are necessary to identify the presence of electrolytic complications and pancreato-biliary abnormalities. As for differential diagnosis, almost all disorders mimicking SMA syndrome are summarized in **Table 5** [15,27,45,58–60,87,102–128]. Patients with eating disorders, functional dyspepsia, and peptic ulcer disease present non-specific symptoms masquerading as SMA syndrome. In addition, many diseases that potentially involve or compress duodenum should be suspected of and ruled out by CT, abdominal US, or other modalities.

TREATMENTS

The therapeutic options are summarized in **Table 6**. The initial treatment is usually managed conservatively by decompression of dilated stomach and duodenum by postural change and/or nasal gastric tube suction [129,130]. Positioning the patient in the left lateral or sitting position should be helpful [96,131]. However, the best position for each patient may vary because recent studies revealed there is a variation of the SMA position and movement [132–134]. In addition to gastric tube suction, intravenous metoclopramide can enhance gastrointestinal motility and help decompression [135,136]. After decompression therapy, gaining weight to increase adipose tissue between SMA and aorta should be considered. Nasal gastric feeding is effective, but the jejunal tube is more ideal while endoscopic assistant should be considered [137]. Total parenteral nutrition is a useful option for initial nutrient treatment and if the intestinal feedings are impossible. These nutrition managements contribute to the restoration of adipose tissue to increase the angle at the origin of the SMA [29].

Surgical therapy, however, can be recommended if conservative therapies fail especially in elder patients with multiple abdominal operation histories, immobility (bed rest), long history of SMA syndrome and arteriosclerosis of SMA. Surgical therapy might be considered earlier before a patient's conditions worsen and complications occur [130]. The best timing for transition to surgical options is not clear. Shin et al. recommend 6 weeks at least of conservative therapy based on the average response rate to this method [138]. There is currently no randomized study conservative versus surgical therapy. A recent large cohort with 80 patients with SMA syndrome by Lee et al. revealed the overall success and recurrence rates of conservative therapy were 71.3 and 15.8%, respectively [139]. The need for surgical therapy was 18.7% of patients (15/80 cases), which is similar to other recent cohorts 11.5-22.2% [9,140,141]. These recent operation rates are lower than previously reported (70%) in 1974 [142], likely due to advances in nutritional therapies and medications [139]. Various surgical procedures include laparoscopic, laparotomic, or robotic gastrojejunostomy, gastroduodenostomy and duodenojejunostomy, Strong's procedure (a division of the ligament of Treitz), anterior transposition of the third part of duodenum, duodenal lowering, Ladd's procedure, and transabdominal duodenojejunostomy [143–147]. Since 1998, when the first successful laparoscopic duodenojejunostomy was performed, most

surgeons prefer laparoscopic duodenojejunostomy because of its safety and effectiveness (success rates: 80-100%) [143–145]. Laparoscopic approach has been reported to shorten post-operative length of hospital stay [130,144]. Most recently, a new technique of endoscopic gastrojejunostomy (so called lumen-apposing metal stent: LAMS) has also been reported in several case reports as a safe and effective therapeutic option [148–150].

CONCLUSION

In conclusion, superior mesenteric syndrome is a serious condition that requires prompt diagnosis and treatment to prevent long-term complications. Diagnosis can be challenging and may involve imaging studies, such as CT or MR, and upper gastrointestinal endoscopy. Due to the non-specific nature of clinical obstructive presentations, recognition of risk factors such as rapid weight loss, previous abdominal surgery (typically bariatric surgery), trauma or congenital anomalies can predispose patients toward the development of SMA syndrome. These conditions are typically driven by a reduction in the mesenteric fat pad or an abnormal angle between the SMA and duodenum. Early diagnosis and treatment are essential to prevent complications and ensure a successful outcome.

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REFERENCES

1 C R. Handbuch der pathologischen Anatomie 1st Ed. *Vienna Branmuller and Seidel* 1842; **3**: 187-.

2 Wilkie B. Chronic duodenal ileus. *Am J Med Sci* 1927; **173**: 643–650.

3 GRAUER FW. Duodenal ileus (Wilkie's syndrome) arterio-mesenteric ileus. *Bull Vanc Med Assoc* 1948; **24**: 116–8. http://www.ncbi.nlm.nih.gov/pubmed/18914505

4 DORPH MH. The cast syndrome; review of the literature and report of a case. *N Engl J Med* 1950; **243**: 440-442 [PMID: 14775856 DOI: 10.1056/NEJM195009212431203]

5 Hearn JB. Duodenal Ileus with Special Reference to Superior Mesenteric Artery Compression. *Radiology* 1966; **86**: 305-310 [PMID: 14267372 DOI: 10.1148/86.2.305]

6 Berk RN, Coulson DB. The body cast syndrome. *Radiology* 1970; **94**: 303-305 [PMID: 5412795 DOI: 10.1148/94.2.303]

7 Oka A. Nov. 31, 2022. a PubMed search (www.ncbi.nlm.nih.gov/PubMed, 1908 to Nov. 2022) using a combination of the MeSH term "superior mesenteric artery syndrome" "SMA syndrome" Wilkie's syndrome' "Cast syndrome" "aorto-mesenteric compass syndrome".

8 Ylinen P, Kinnunen J, Höckerstedt K. Superior mesenteric artery syndrome. A follow-up study of 16 operated patients. *J Clin Gastroenterol* 1989; **11**: 386-391. http://www.ncbi.nlm.nih.gov/pubmed/2760427

9 Biank V, Werlin S. Superior mesenteric artery syndrome in children: a 20-year experience. *J Pediatr Gastroenterol Nutr* 2006; **42**: 522-525 [PMID: 16707974 DOI: 10.1097/01.mpg.0000221888.36501.f2]

10 Pedoto MJ, O'Dell MW, Thrun M, Hollifield D. Superior mesenteric artery syndrome in traumatic brain injury: two cases. *Arch Phys Med Rehabil* 1995; **76**: 871-875 [PMID: 7668961 DOI: 10.1016/S0003-9993(95)80555-9]

11 BARNER HB, SHERMAN CD. VASCULAR COMPRESSION OF THE DUODENUM. *Int Abstr Surg* 1963; **117**: 103–18. http://www.ncbi.nlm.nih.gov/pubmed/14047737

12 Gustafsson L, Falk A, Lukes PJ, Gamklou R. Diagnosis and treatment of superior mesenteric artery syndrome. *Br J Surg* 1984; **71**: 499-501 [PMID: 6733420 DOI: 10.1002/bjs.1800710706]

13 Mandarry MT, Zhao L, Zhang C, Wei ZQ. A comprehensive review of superior mesenteric artery syndrome. *Eur Surg* 2010; **42**: 229-236 [DOI: 10.1007/s10353-010-0561-y]

14 Nugent FW, Braasch JW, Epstein H. Diagnosis and surgical treatment of arteriomesenteric obstruction of the duodenum. *JAMA* 1966; **196**: 1091-1093. http://www.ncbi.nlm.nih.gov/pubmed/5952480

15 Anderson JR, Earnshaw PM, Fraser GM. Extrinsic compression of the third part of the duodenum. *Clin Radiol* 1982; **33**: 75-81 [PMID: 7067340 DOI: 10.1016/S0009-9260(82)80358-9]

16 Rosa-Jiménez F, Rodríguez González FJ, Puente Gutiérrez JJ, Muñoz Sánchez R,

Adarraga Cansino MD, Zambrana García JL. Duodenal compression caused by superior mesenteric artery: study of 10 patients. *Rev Esp Enferm Dig* 2003; **95**: 485-489, 480-484. http://www.ncbi.nlm.nih.gov/pubmed/12952509

17 GOIN LS, WILK SP. Intermittent arteriomesenteric occlusion of the duodenum. *Radiology* 1956; **67**: 729-737 [PMID: 13370885 DOI: 10.1148/67.5.729]

18 Hines JR, Gore RM, Ballantyne GH. Superior mesenteric artery syndrome. Diagnostic criteria and therapeutic approaches. *Am J Surg* 1984; **148**: 630-632 [PMID: 6496852 DOI: 10.1016/0002-9610(84)90339-8]

19 Lee CS, Mangla JC. Superior mesenteric artery compression syndrome. *Am J Gastroenterol* 1978; **70**: 141–150. http://www.ncbi.nlm.nih.gov/pubmed/717365

20 Munns SW, Morrissy RT, Golladay ES, McKenzie CN. Hyperalimentation for superior mesenteric-artery (cast) syndrome following correction of spinal deformity. *J Bone Joint Surg Am* 1984; **66**: 1175-1177. http://www.ncbi.nlm.nih.gov/pubmed/6436250

21 Zhu Z, Qiu Y, Wang B, Yu Y. Superior mesenteric artery syndrome following scoliosis surgery: its risk indicators and treatment strategy. *Stud Health Technol Inform* 2006; **123**: 610-614. http://www.ncbi.nlm.nih.gov/pubmed/17108497

22 Gore RM, Mintzer RA, Calenoff L. Gastrointestinal complications of spinal cord injury. *Spine (Phila Pa 1976)* 1981; **6**: 538-544 [PMID: 7336276 DOI: 10.1097/00007632-198111000-00002]

23 Ogbuokiri CG, Law EJ, MacMillan BG. Superior mesenteric artery syndrome in burned children. *Am J Surg* 1972; **124**: 75-79 [PMID: 4625377 DOI: 10.1016/0002-9610(72)90172-9]

24 Lescher TJ, Sirinek KR, Pruitt BA Jr. Superior mesenteric artery syndrome in thermally injured patients. *J Trauma* 1979; **19**: 567-571 [PMID: 469969 DOI: 10.1097/00005373-197908000-00004]

25 Reckler JM, Bruck HM, Munster AM, Curreri PW, Pruitt BA Jr. Superior mesenteric artery syndrome as a consequence of burn injury. *J Trauma* 1972; **12**: 979-985 [PMID: 4629265 DOI: 10.1097/00005373-197211000-00008]

26 Watters A, Gibson D, Dee E, Mascolo M, Mehler PS. Superior mesenteric artery syndrome in severe anorexia nervosa: A case series. *Clin Case Rep* 2020; **8**: 185-189 [PMID: 31998513 DOI: 10.1002/ccr3.2577]

298 **27** Kawanishi K, Shojima K, Nishimoto M, Abe H, Kakimoto T, Yasuda Y, Hara T, Kato J.
299 Superior mesenteric artery syndrome may be overlooked in women with functional
300 dyspepsia. *Intern Med* 2017; **56**: 2549-2554 [PMID: 28883239 DOI:
301 10.2169/internalmedicine.8647-16]
302 **28** Xu L, Yu W-K, Lin Z-L, Jiang J, Feng X-B, Li N. Predictors and outcomes of superior
303 mesenteric artery syndrome in patients with constipation: a prospective, nested case-
304 control study. *Hepatogastroenterology* 2014; **61**: 1995-2000.
305 http://www.ncbi.nlm.nih.gov/pubmed/25713901
306 **29** Welsch T, Büchler MW, Kienle P. Recalling superior mesenteric artery syndrome. *Dig*
307 *Surg* 2007; **24**: 149-156 [PMID: 17476104 DOI: 10.1159/000102097]
308 **30** Sinagra E, Raimondo D, Albano D, Guarnotta V, Blasco M, Testai S, Marasà M, Mastrella
309 V, Alaimo V, Bova V, Albano G, Sorrentino D, Tomasello G, Cappello F, Leone A, Rossi
310 F, Galia M, Lagalla R, Midiri F, Morreale GC, Amvrosiadis G, Martorana G, Spampinato
311 MG, Virgilio V, Midiri M. Superior Mesenteric Artery Syndrome: Clinical, Endoscopic,
312 and Radiological Findings. *Gastroenterol Res Pract* 2018; **2018**: 1937416 [PMID: 30224915
313 DOI: 10.1155/2018/1937416]
314 **31** Xia L, Li N, Wang D, Liu M, Li JW, Bao DM, Li P. One-stage Posterior Spinal Osteotomy
315 in Severe Spinal Deformities: A Total of 147 Cases. *Clin Spine Surg* 2017; **30**: E448-E453
316 [PMID: 28437351 DOI: 10.1097/BSD.0000000000000227]
317 **32** Altiok H, Lubicky JP, DeWald CJ, Herman JE. The superior mesenteric artery syndrome
318 in patients with spinal deformity. *Spine (Phila Pa 1976)* 2005; **30**: 2164-2170 [PMID:
319 16205341 DOI: 10.1097/01.brs.0000181059.83265.b2]
320 **33** Zhu ZZ, Qiu Y. Superior mesenteric artery syndrome following scoliosis surgery: its risk
321 indicators and treatment strategy. *World J Gastroenterol* 2005; **11**: 3307-3310 [PMID:
322 15929190 DOI: 10.3748/wjg.v11.i21.3307]
323 **34** Hod-Feins R, Copeliovitch L, Abu-Kishk I, Eshel G, Lotan G, Shalmon E, Anekstein Y,
324 Mirovsky Y, Masharawi Y. Superior mesenteric artery syndrome after scoliosis repair
325 surgery: a case study and reassessment of the syndrome's pathogenesis. *J Pediatr Orthop*
326 *B* 2007; **16**: 345-349 [PMID: 17762674 DOI: 10.1097/BPB.0b013e32826d1d9b]
327 **35** Tsirikos AI, Jeans LA. Superior mesenteric artery syndrome in children and adolescents

with spine deformities undergoing corrective surgery. *J Spinal Disord Tech* 2005; **18**: 263-271.

36 Ko KH, Tsai SH, Yu CY, Huang GS, Liu CH, Chang WC. Unusual complication of superior mesenteric artery syndrome: spontaneous upper gastrointestinal bleeding with hypovolemic shock. *J Chin Med Assoc* 2009; **72**: 45-47 [PMID: 19181598 DOI: 10.1016/S1726-4901(09)70020-6]

37 Lippl F, Hannig C, Weiss W, Allescher HD, Classen M, Kurjak M. Superior mesenteric artery syndrome: diagnosis and treatment from the gastroenterologist's view. *J Gastroenterol* 2002; **37**: 640-643 [PMID: 12203080 DOI: 10.1007/s005350200101]

38 Sun Z, Rodriguez J, McMichael J, Walsh RM, Chalikonda S, Rosenthal RJ, Kroh MD, El-Hayek K. Minimally invasive duodenojejunostomy for superior mesenteric artery syndrome: a case series and review of the literature. *Surg Endosc* 2015; **29**: 1137-1144 [PMID: 25701058 DOI: 10.1007/s00464-014-3775-4]

39 Jain V, Singal AK, Ramu C, Raghunaathan KD. Superior mesenteric artery syndrome: a rare complication in a child with Marfan syndrome. *Arch Dis Child* 2013; **98**: 754-755 [PMID: 23814081 DOI: 10.1136/archdischild-2013-304321]

40 Ortiz C, Cleveland RH, Blickman JG, Jaramillo D, Kim SH. Familial superior mesenteric artery syndrome. *Pediatr Radiol* 1990; **20**: 588-589 [PMID: 2251002 DOI: 10.1007/BF02129061]

41 Iwaoka Y, Yamada M, Takehira Y, Hanajima K, Nakamura T, Murohisa G, Hirai R, Kitagawa M. Superior mesenteric artery syndrome in identical twin brothers. *Intern Med* 2001; **40**: 713–715 [PMID: 11518108 DOI: 10.2169/internalmedicine.40.713]

42 Green P, Swischuk LE, Hernandez JA. Delayed presentation of malrotation and midgut volvulus: imaging findings. *Emerg Radiol* 2007; **14**: 379-382 [PMID: 17710454 DOI: 10.1007/s10140-007-0662-5]

43 Shin J, Shin PJ, Bartolotta RJ. SMA-like syndrome with variant mesenteric venous anatomy. *Clin Imaging* 2018; **48**: 86-89 [PMID: 29055874 DOI: 10.1016/j.clinimag.2017.03.013]

44 Neto NI, Godoy EP, Campos JM, Abrantes T, Quinino R, Barbosa AL, Fonseca CA. Superior mesenteric artery syndrome after laparoscopic sleeve gastrectomy. *Obes Surg*

2007; **17**: 825-827 [PMID: 17879585 DOI: 10.1007/s11695-007-9125-z]

45 Lin JA, Woods ER, Bern EM. Common and emergent oral and gastrointestinal manifestations of eating disorders. *Gastroenterol Hepatol* 2021; **17**: 157-167.

46 Limaye CS, Karande SP, Aher SP, Pati KA. Superior mesenteric artery syndrome secondary to tuberculosis induced cachexia. *J Assoc Physicians India* 2011; **59**: 670-671 http://www.ncbi.nlm.nih.gov/pubmed/22479754

47 Ushiki A, Koizumi T, Yamamoto H, Hanaoka M, Kubo K, Matsushita M. Superior mesenteric artery syndrome following initiation of cisplatin-containing chemotherapy: a case report. *J Med Case Rep* 2012; **6**: 14 [PMID: 22248296 DOI: 10.1186/1752-1947-6-14]

48 Girotra M, Shah HR, Rego RF. An intriguing cause of intractable nausea and vomiting. *Saudi J Gastroenterol* 2013; **19**: 190-191 [PMID: 23828751 DOI: 10.4103/1319-3767.114510]

49 Philip PA. Superior mesenteric artery syndrome: an unusual cause of intestinal obstruction in brain-injured children. *Brain Inj* 1992; **6**: 351-358 [PMID: 1638268 DOI: 10.3109/02699059209034949]

50 Laffont I, Bensmail D, Rech C, Prigent G, Loubert G, Dizien O. Late superior mesenteric artery syndrome in paraplegia: case report and review. *Spinal Cord* 2002; **40**: 88-91 [PMID: 11926421 DOI: 10.1038/sj.sc.3101255]

51 Kwon OY, Lim SG, Park SH. Mitochondrial encephalomyopathy, lactic acidosis, and stroke-like episode leading to recurrent superior mesenteric artery syndrome. *Am J Emerg Med* 2014; **32**: 951.e1-951.e2 [PMID: 24655600 DOI: 10.1016/j.ajem.2014.01.059]

52 Neuman A, Desai B, Glass D, Diab W. Superior mesenteric artery syndrome in a patient with cerebral palsy. *Case Rep Med* 2014; **2014**: 538289 [PMID: 25053950 DOI: 10.1155/2014/538289]

53 Padhan P, Moses V, Moses V, Danda D. Superior mesenteric artery syndrome in an adult rheumatoid arthritis patient. *Int J Rheum Dis* 2012; **15**: e4-e5 [PMID: 22324964 DOI: 10.1111/j.1756-185X.2011.01647.x]

54 Kremers PW, Scholz FJ, Schoetz DJ Jr, Veidenheimer MC, Coller JA. Radiology of the ileoanal reservoir. *AJR Am J Roentgenol* 1985; **145**: 559-567 [PMID: 3895866 DOI: 10.2214/ajr.145.3.559]

55 Gonzalez DO, Nwomeh BC. Complications in children with ulcerative colitis

undergoing ileal pouch-anal anastomosis. *Semin Pediatr Surg* 2017; **26**: 384-390 [PMID: 29126508 DOI: 10.1053/j.sempedsurg.2017.10.008]

56 Kitaura K, Harima K. Superior mesenteric artery syndrome with vascular calcification in a maintenance hemodialysis patient. *Clin Nephrol* 2009; **71**: 228-230 [PMID: 19203523 DOI: 10.5414/cnp71228]

57 Okazaki Y, Higashi Y, Takigawa H. Unusual Complication of Frailty: Superior Mesenteric Artery Syndrome. *Intern Med* 2019; **58**: 2119-2120 [PMID: 30918196 DOI: 10.2169/internalmedicine.2493-18]

58 Osler W. ANEURYSM OF THE ABDOMINAL AORTA. *Lancet* 1905; **166**: 1089-1096 [DOI: 10.1016/S0140-6736(01)69613-2]

59 Saigusa S, Ohi M, Imaoka H, Inoue Y. Aortoduodenal syndrome in a patient receiving maintenance haemodialysis. *BMJ Case Rep* 2014; 2014 [PMID: 25388892 DOI: 10.1136/bcr-2014-206326]

60 Sudo G, Takagi H, Nakahara S, Goto A, Hinoda Y, Nakase H. Gastrointestinal: Abdominal aortic aneurysm caused symptoms mimicking superior mesenteric artery syndrome. *J Gastroenterol Hepatol* 2021; **36**: 43 [PMID: 32627232 DOI: 10.1111/jgh.15149]

61 Lin CY, Lin BY, Kang PL. Duodenal obstruction after elective abdominal aortic aneurysm repair: a case report. *Kaohsiung J Med Sci* 2004; **20**: 501-505 [PMID: 15553810 DOI: 10.1016/s1607-551x(09)70249-9]

62 Marecek GS, Barsness KA, Sarwark JF. Relief of superior mesenteric artery syndrome with correction of multiplanar spinal deformity by posterior spinal fusion. *Orthopedics* 2010; **33**: 519 [PMID: 20608618 DOI: 10.3928/01477447-20100526-26]

63 Anderson WC, Vivit R, Kirsh IE, Greenlee HB. Arteriomesenteric duodenal compression syndrome. Its association with peptic ulcer. *Am J Surg* 1973; **125**: 681-689 [PMID: 4710191 DOI: 10.1016/0002-9610(73)90165-7]

64 Uemura S, Suzuki K, Katayama N, Imai H. Superior mesenteric artery syndrome leading to reversible mucosal gangrene. *Acute Med Surg* 2017; **4**: 375-376 [PMID: 29123896 DOI: 10.1002/ams2.283]

65 Doski JJ, Priebe CJ Jr, Smith T, Chumas JC. Duodenal trichobezoar caused by compression of the superior mesenteric artery. *J Pediatr Surg* 1995; **30**: 1598-1599 [PMID:

8583333 DOI: 10.1016/0022-3468(95)90165-5]

66 Tsai CL, Chen MJ, Tan CK, Chan KS, Cheng KC. Superior mesenteric artery syndrome with hepatic portal venous gas. *Med J Aust* 2007; **186**: 48 [PMID: 17229038 DOI: 10.5694/j.1326-5377.2007.tb00794.x]

67 Lim JE, Duke GL, Eachempati SR. Superior mesenteric artery syndrome presenting with acute massive gastric dilatation, gastric wall pneumatosis, and portal venous gas. *Surgery* 2003; **134**: 840-843 [PMID: 14639366 DOI: 10.1016/S0039-6060(02)21677-3]

68 Kensinger CD, Mukherjee K, Nealon WH, Solorzano CC. Superior mesenteric artery syndrome presenting with pneumoperitoneum and pneumomediastinum. *Am Surg* 2013; **79**: E240-E242 [PMID: 23711260 DOI: 10.1177/000313481307900611]

69 Lee CI, Wu YH. Pneumatosis intestinalis and pneumoretroperitoneum post steroid use in a patient with superior mesenteric artery syndrome. *Am J Emerg Med* 2019; **37**: 1993.e1-1993.e3 [PMID: 31262624 DOI: 10.1016/j.ajem.2019.06.040]

70 Majumder S, Shergill S, Loftus CG. A Young Man With Abdominal Pain, Weight Loss, and Jaundice. *Gastroenterology* 2017; **152**: 1836-1838 [PMID: 28478143 DOI: 10.1053/j.gastro.2016.12.044]

71 Jeune F, d'Assignies G, Sauvanet A, Gaujoux S. A rare cause of obstructive jaundice and gastric outlet obstruction. *World J Gastrointest Surg* 2013; **5**: 192-194 [PMID: 23805363 DOI: 10.4240/wjgs.v5.i6.192]

72 Bohanon FJ, Nunez Lopez O, Graham BM, Griffin LW, Radhakrishnan RS. A Case Series of Laparoscopic Duodenojejunostomy for the Treatment of Pediatric Superior Mesenteric Artery Syndrome. *Int J Surg Res* 2016; **2016**: 1-5. http://www.ncbi.nlm.nih.gov/pubmed/27747293

73 Banerjee A, O'Neil R, Bidstrup H. Adult respiratory distress syndrome caused by superior mesenteric artery syndrome. *Anaesth Intensive Care* 1994; **22**: 602-604 [PMID: 7818068 DOI: 10.1177/0310057x9402200519]

74 Haas PA, Akhtar J, Kobylak L. Compression of the duodenum by the root of the mesentery. *Henry Ford Hosp Med J* 1982; **30**: 85-89. http://www.ncbi.nlm.nih.gov/pubmed/7129947

75 Abu-Zidan FM, Hefny AF, Saadeldinn YA, El-Ashaal YI. Sonographic findings of

superior mesenteric artery syndrome causing massive gastric dilatation in a young healthy girl. *Singapore Med J* 2010; **51**: e184-186. http://sfxhosted.exlibrisgroup.com/galway?sid=EMBASE&issn=00375675&id=doi:&atitle=Sonographic+findings+of+superior+mesenteric+artery+syndrome+causing+massive+gastric+dilatation+in+a+young+healthy+girl&stitle=Singapore+Med.+J.&title=Singapore+Medical+Journ

76 Mohammad Kazmin NE, Kamaruzaman L, Wong Z, Fong VK, Mohd R, Mustafar R. Acute Kidney Injury Caused by Superior Mesenteric Artery Syndrome. *Case Rep Nephrol* 2020; **2020**: 8364176 [PMID: 32328326 DOI: 10.1155/2020/8364176]

77 Shajani-Yi Z, Lee HK, Cervinski MA. Hyponatremia, Hypokalemia, Hypochloremia, and Other Abnormalities. *Clin Chem* 2016; **62**: 898 [PMID: 27235468 DOI: 10.1373/clinchem.2015.249292]

78 THIEME ET, POSTMUS R. Superior mesenteric artery syndrome. *Ann Surg* 1961; **154(6)Suppl**: 139-143 [PMID: 13920640 DOI: 10.1097/00000658-196112000-00017]

79 Iko BO, Monu JU, Orhue A, Sarkar SK. The superior mesenteric artery syndrome in pregnancy: a case resulting in recurrent pregnancy loss. *Eur J Obstet Gynecol Reprod Biol* 1986; **21**: 233-236 [PMID: 3709922 DOI: 10.1016/0028-2243(86)90021-3]

80 Sato H, Tanaka T. Acute gastric dilatation due to a superior mesenteric artery syndrome: an autopsy case. *BMC Gastroenterol* 2014; **14**: 37 [PMID: 24555911 DOI: 10.1186/1471-230X-14-37]

81 Ratjen E. Concomitant arterio-mesenteric obstruction of the duodenum and chronic oesophagitis; case report. *Acta radiol* 1952; **37**: 369-373 [PMID: 14933218 DOI: 10.3109/00016925209139893]

82 Hamdeh S, Haddad TM, Kabach A. A rare case of superior mesenteric artery syndrome causing upper gastrointestinal bleeding. *Am J Gastroenterol* 2015; **110**: 1653 [PMID: 26673491 DOI: 10.1038/ajg.2015.141]

83 Murakami C, Irie W, Sasaki C, Nakamaru N, Sakamoto M, Nagato J, Satoh F. Extensive gastric necrosis secondary to acute gastric dilatation: A case report. *Leg Med* 2019; **36**: 85-88 [PMID: 30448603 DOI: 10.1016/j.legalmed.2018.11.007]

84 Moyer K, Thompson GH, Poe-Kochert C, Splawski J. Superior Mesenteric Artery

Syndrome Complicated by Gastric Mucosal Necrosis Following Congenital Scoliosis Surgery: A Case Report. *JBJS Case Connect* 2019; **9**: e0380 [PMID: 31584907 DOI: 10.2106/JBJS.CC.18.00380]

85 Rod J, Sarnacki S, Petit T, Ravasse P. Portal venous gas and thrombosis complicating superior mesenteric artery syndrome (Wilkie's syndrome) in a child. *J Pediatr Surg* 2010; **45**: 826-829 [PMID: 20385295 DOI: 10.1016/j.jpedsurg.2010.01.007]

86 Petrosyan M, Estrada JJ, Giuliani S, Williams M, Rosen H, Mason RJ. Gastric perforation and pancreatitis manifesting after an inadvertent nissen fundoplication in a patient with superior mesenteric artery syndrome. *Case Rep Med* 2009; **2009**: 426162 [PMID: 19730743 DOI: 10.1155/2009/426162]

87 Amadi C, Anderson S. Refractory coeliac disease: or is it? *BMJ Case Rep* 2017; **2017** [PMID: 28928249 DOI: 10.1136/bcr-2017-219271]

88 Oh MJ. Superior Mesenteric Artery Syndrome Combined with Renal Nutcracker Syndrome in a Young Male: A Case Report. *Korean J Gastroenterol* 2017; **70**: 253-260 [PMID: 29161795 DOI: 10.4166/kjg.2017.70.5.253]

89 Diab S, Hayek F. Combined superior mesenteric artery syndrome and nutcracker syndrome in a young patient: A case report and review of the literature. *Am J Case Rep* 2020; **21**: e922619 [PMID: 32772039 DOI: 10.12659/AJCR.922619]

90 Farina R, Gozzo C, Foti PV, Conti A, Vasile T, Pennisi I, Venturini M, Basile A. A man with the rare simultaneous combination of three abdominal vascular compression syndromes: median arcuate ligament syndrome, superior mesenteric artery syndrome, and nutcracker syndrome. *Radiol Case Rep* 2021; **16**: 1264-1270 [PMID: 33854661 DOI: 10.1016/j.radcr.2021.02.065]

91 Tseng CK, Su WB, Lai HC, Chou JW, Feng CL, Peng CY, Chen YF. Superior mesenteric artery syndrome caused by celiac axis compression syndrome: a case report and review of the literature. *Eur J Gastroenterol Hepatol* 2008; **20**: 578-582 [PMID: 18467920 DOI: 10.1097/MEG.0b013e3282f172fa]

92 Elbadaway MH. Chronic superior mesenteric artery syndrome in anorexia nervosa. *Br J Psychiatry* 1992; **160**: 552-554 [PMID: 1571759 DOI: 10.1192/bjp.160.4.552]

93 Reghunath A, Kabilan K, Mittal MK. Exploring the neglected segment of the intestine:

the duodenum and its pathologies. *Pol J Radiol* 2020; **85**: e230-e244 [PMID: 32612721 DOI: 10.5114/pjr.2020.95477]

94 Han F, Cheng H, Hou M, Liu R. Application of the "Hand as Foot" teaching method in superior mesenteric artery syndrome. *Asian J Surg* 2021; **44**: 1562-1563 [PMID: 34635413 DOI: 10.1016/j.asjsur.2021.08.070]

95 Yongqing N, Chen D, Rui L, Linlin L. The "Hand as Foot" teaching method in superior mesenteric artery syndrome. *Asian J Surg* 2022; **45**: 618-619 [PMID: 34895954 DOI: 10.1016/j.asjsur.2021.10.008]

96 Neri S, Signorelli SS, Mondati E, Pulvirenti D, Campanile E, Di Pino L, Scuderi M, Giustolisi N, Di Prima P, Mauceri B, Abate G, Cilio D, Misseri M, Scuderi R. Ultrasound imaging in diagnosis of superior mesenteric artery syndrome. *J Intern Med* 2005; **257**: 346-351 [PMID: 15788004 DOI: 10.1111/j.1365-2796.2005.01456.x]

97 Raman SP, Neyman EG, Horton KM, Eckhauser FE, Fishman EK. Superior mesenteric artery syndrome: spectrum of CT findings with multiplanar reconstructions and 3-D imaging. *Abdom Imaging* 2012; **37**: 1079-1088 [PMID: 22327421 DOI: 10.1007/s00261-012-9852-z]

98 Unal B, Aktaş A, Kemal G, Bilgili Y, Güliter S, Daphan C, Aydinuraz K. Superior mesenteric artery syndrome: CT and ultrasonography findings. *Diagn Interv Radiol* 2005; **11**: 90-95. http://www.ncbi.nlm.nih.gov/pubmed/15957095

99 Le D, Stirparo JJ, Magdaleno TF, Paulson CL, Roth KR. Point-of-care ultrasound findings in the diagnosis and management of Superior Mesenteric Artery (SMA) syndrome. *Am J Emerg Med* 2022; **55**: 233.e1-233.e4 [PMID: 35241297 DOI: 10.1016/j.ajem.2022.02.018]

100 Chin LW, Chou MC, Wang HP. Ultrasonography diagnosis of superior mesenteric artery syndrome in the ED. *Am J Emerg Med* 2007; **25**: 864.e5-864.e6 [PMID: 17870516 DOI: 10.1016/j.ajem.2005.09.012]

101 Gottlieb K. Doppler-endosonography with the GF-UE 160 electronic radial echoendoscope - Current use and future potential. *J Gastrointest Liver Dis* 2007; **16**: 455-461.

102 Su MC, Lee CH, Wang CC. Education and Imaging. Gastrointestinal: Superior mesenteric artery syndrome initially presenting like reflux esophagitis. *J Gastroenterol*

Hepatol 2010; **25**: 645 [PMID: 20370735 DOI: 10.1111/j.1440-1746.2010.06259.x]

103 Dimopoulou A, Zavras N, Alexopoulou E, Fessatou S, Dimopoulou D, Attilakos A. Superior mesenteric artery syndrome mimicking cyclic vomiting syndrome in a healthy 12-year-old boy. *J Paediatr Child Health* 2020; **56**: 168-170 [PMID: 31408239 DOI: 10.1111/jpc.14592]

104 Arbell D, Gross E, Koplewitz BZ, Vromen A, Bar-Ziv J, Udassin R. Superior mesenteric artery syndrome masquerading as recurrent biliary pancreatitis. *Isr Med Assoc J* 2006; **8**: 441-442. http://www.ncbi.nlm.nih.gov/pubmed/16833180

105 Shah D, Naware S, Thind S, Kuber R. Superior mesenteric artery syndrome: an uncommon cause of abdominal pain mimicking gastric outlet obstruction. *Ann Med Health Sci Res* 2013; **3**: S24-S26. [PMID: 24349841 DOI: 10.4103/2141-9248.121214]

106 Sisodiya R, Ramachandra L. Tubercular duodenal, jejunal and ileocecal stricture in a patient. *BMJ Case Rep* 2013; **2013** [PMID: 24334467 DOI: 10.1136/bcr-2013-200347]

107 Upadhyaya VD, Kumar B, Lal R, Sharma MS, Singh M, Rudramani. Primary duodenal tuberculosis presenting as gastric-outlet obstruction: Its diagnosis. *Afr J Paediatr Surg* 2013; **10**: 83-86 [PMID: 23860052 DOI: 10.4103/0189-6725.115028]

108 Fromm S, Cash JM. Superior mesenteric artery syndrome: an approach to the diagnosis and management of upper gastrointestinal obstruction of unclear etiology. *S D J Med* 1990; **43**: 5-10. http://www.ncbi.nlm.nih.gov/pubmed/2263953

109 Harada T, Machida H, Ito S, Aihara Y, Yokota S. Henoch-Schönlein purpura presenting duodenal involvement similar to superior mesenteric artery syndrome in a girl. *Eur J Pediatr* 2007; **166**: 489-490 [PMID: 17009000 DOI: 10.1007/s00431-006-0254-5]

110 Harada T, Ito S, Mori M, Yokota S. Anatomical condition mimicking superior mesenteric artery syndrome might cause duodenal involvement in Henoch-Schönlein purpura. *Pediatr Int* 2012; **54**: 579 [PMID: 22830554 DOI: 10.1111/j.1442-200X.2012.03659.x]

111 Fujii Y, Kino M, Kimata T, Kaneko K. Abdominal pain in Henoch-Schönlein purpura and its association with superior mesenteric artery syndrome. *Pediatr Int* 2012; **54**: 313 [PMID: 22507166 DOI: 10.1111/j.1442-200X.2012.03582.x]

112 Lourenço LC, Martins A, Oliveira AM, Horta DV, Reis J. Wilkie Syndrome behind Crohn Disease? Superior Mesenteric Artery Syndrome Mimicking and Complicating Crohn

Disease of the Upper Gastrointestinal Tract. *GE Port J Gastroenterol* 2017; **24**: 50-52 [PMID: 28848781 DOI: 10.1159/000450873]

113 Cicero G, D'Angelo T, Bottari A, Costantino G, Visalli C, Racchiusa S, Marino MA, Cavallaro M, Frosina L, Blandino A, Mazziotti S. Superior Mesenteric Artery Syndrome in Patients with Crohn's Disease: A Description of 2 Cases Studied with a Novel Magnetic Resonance Enterography (MRE) Procedure. *Am J Case Rep* 2018; **19**: 431-437 [PMID: 29643328 DOI: 10.12659/ajcr.908273]

114 Verma R, Abraham DT, Joseph P, Nayak S, Agarwal S. Ectopic pancreas mimicking superior mesenteric artery syndrome. *Indian J Gastroenterol* 2003; **22**: 105-106. http://www.ncbi.nlm.nih.gov/pubmed/12839387

115 LAMBERT CJ, FITTS FO Jr, TURK R. Duodenal diverticula. An unusual cause of "secondary superior mesenteric artery syndrome". *Am J Surg* 1961; **101**: 808-811 [PMID: 13758444 DOI: 10.1016/0002-9610(61)90732-2]

116 Goto S, Ookawara S, Sugai M. Superior mesenteric artery syndrome due to duodenal edema in a chronic renal failure patient: a case report. *CEN Case Rep* 2014; **3**: 14-17 [PMID: 28509237 DOI: 10.1007/s13730-013-0076-z]

117 Gopal M, Fisher R. A case report of B-cell lymphoma masquerading as superior mesenteric artery syndrome. *J Pediatr Surg* 2007; **42**: 1926-1927 [PMID: 18022448 DOI: 10.1016/j.jpedsurg.2007.07.026]

118 Basu S, Srivastava V, Singh PK, Srivastava A, Shukla VK. Duodenojejunal junction web masquerading as Wilkie's syndrome: report of a case. *Surg Today* 2011; **41**: 409-411 [PMID: 21365426 DOI: 10.1007/s00595-010-4258-4]

119 Chung SC, Leung JW, Li AK. Phytobezoar masquerading as the superior mesenteric artery syndrome: successful endoscopic treatment using a colonoscope. *J R Coll Surg Edinb* 1991; **36**: 405-406. http://www.ncbi.nlm.nih.gov/pubmed/1774711

120 Cho YP, Ahn JH, Jang HJ, Kim YH, Lee SG. Superior Mesenteric Artery Syndrome after Successful Coil Embolization of a Ruptured Pancreaticoduodenal Artery Aneurysm: Report of a Case. *Surg Today* 2004; **34**: 276-278 [PMID: 14999545 DOI: 10.1007/s00595-003-2681-5]

121 Shen A, Tabello D, Merchant N, Portereiko JV, Croteau A, Gates JD. Functional Superior

598 Mesenteric Artery Syndrome Induced by an Optional IVC Filter. *Case Rep Surg* 2019;
599 **2019**: 6543934 [PMID: 31485366 DOI: 10.1155/2019/6543934]
600 **122** Blouhos K, Boulas KA, Paraskeva A, Triantafyllidis A, Kariotis I, Hatzigeorgiadis A. A
601 misdiagnosed cause of early postoperative bowel obstruction. *Clin Case Rep* 2019; **7**: 832-
602 833 [PMID: 30997096 DOI: 10.1002/ccr3.2052]
603 **123** Hussain Ashraf T, Chandra A, Jauhari RK, Kumar Singh S, Noushif M. Rosai-Dorfman
604 disease with exclusive intra-abdominal lymphadenopathy masquerading as Wilkie's
605 syndrome. *Arab J Gastroenterol* 2014; **15**: 40-41 [PMID: 24630515 DOI:
606 10.1016/j.ajg.2013.10.005]
607 **124** Siddiqui MN, Ahmad T, Jaffary A. Retroperitoneal fungal abscess presenting as superior
608 mesenteric artery syndrome. *Postgrad Med J* 1996; **72**: 433-434 [PMID: 8935607 DOI:
609 10.1136/pgmj.72.849.433]
610 **125** Reed JK, McGiin RF, Gorman JF, Thomford NR. Traumatic mesenteric arteriovenous
611 fistula presenting as the superior mesenteric artery syndrome. *Arch Surg* 1986; **121**: 1209
612 [PMID: 3767653 DOI: 10.1001/archsurg.1986.01400100121023]
613 **126** Moreno MA, Smith MS. Anorexia in a 14-year-old girl: why won't she eat? *J Adolesc*
614 *Health* 2006; **39**: 936-938 [PMID: 17116532 DOI: 10.1016/j.jadohealth.2006.05.017]
615 **127** Jinnouchi T, Sakurai Y, Miyoshi K, Koizumi C, Waki H, Kubota N, Yamauchi T. Chronic
616 Intestinal Pseudo-obstruction with Mitochondrial Diseases. *Intern Med* 2022; **61**: 469-474
617 [PMID: 34393166 DOI: 10.2169/internalmedicine.7714-21]
618 **128** Guthrie RH Jr. Wilkie's syndrome. *Ann Surg* 1971; **173**: 290-293 [PMID: 5100100 DOI:
619 10.1097/00000658-197102000-00017]
620 **129** Lee TH, Lee JS, Jo Y, Park KS, Cheon JH, Kim YS, Jang JY, Kang YW. Superior
621 Mesenteric Artery Syndrome: Where Do We Stand Today? *J Gastrointest Surg* 2012; **16**:
622 2203-2211 [DOI: 10.1007/s11605-012-2049-5]
623 **130** Merrett ND, Wilson RB, Cosman P, Biankin AV. Superior mesenteric artery syndrome:
624 diagnosis and treatment strategies. *J Gastrointest Surg* 2009; **13**: 287-292 [PMID: 18810558
625 DOI: 10.1007/s11605-008-0695-4]
626 **131** Evarts CM, Winter RB, Hall JE. Vascular compression of the duodenum associated with
627 the treatment of scoliosis. Review of the literature and report of eighteen cases. *J Bone*

Joint Surg Am 1971; **53**: 431-444. http://www.ncbi.nlm.nih.gov/pubmed/5580004

132 Dounas GD, Cundy TP, Smith ML, Gent R, Antoniou G, Sutherland LM, Cundy PJ. The coronal aorto-mesenteric orientation theory for post-operative nausea and vomiting following scoliosis surgery in children: a pilot study. *ANZ J Surg* 2021; **91**: 174-178 [PMID: 33244810 DOI: 10.1111/ans.16438]

133 Khan H, Al-Jabbari E, Shroff N, Barghash M, Shestopalov A, Bhargava P. Coexistence of superior mesenteric artery syndrome and nutcracker phenomenon. *Radiol Case Rep* 2022; **17**: 1927-1930 [PMID: 35401899 DOI: 10.1016/j.radcr.2022.03.063]

134 Miyata J, Eshak ES, Yoshioka T, Iso H. Movement of the superior mesenteric artery in patients with superior mesenteric artery syndrome: A case-reference study. *Clin Anat* 2022; **35**: 891-898 [PMID: 35417615 DOI: 10.1002/ca.23885]

135 Applegate GR, Cohen AJ. Dynamic CT in superior mesenteric artery syndrome. J. Comput. Assist. Tomogr. 1988; **12**: 976-980.

136 Ahmed AR, Taylor I. Superior mesenteric artery syndrome. *Postgrad Med J* 1997; **73**: 776-778 [PMID: 9497945 DOI: 10.1136/pgmj.73.866.776]

137 Kim J, Yang S, Im YC, Park I. Superior mesenteric artery syndrome treated successfully by endoscopy-assisted jejunal feeding tube placement. *BMJ Case Rep* 2021; **14** [PMID: 34785514 DOI: 10.1136/bcr-2021-245104]

138 Shin MS, Kim JY. Optimal duration of medical treatment in superior mesenteric artery syndrome in children. *J Korean Med Sci* 2013; **28**: 1220-1225 [PMID: 23960451 DOI: 10.3346/jkms.2013.28.8.1220]

139 Lee TH, Lee JS, Jo Y, Park KS, Cheon JH, Kim YS, Jang JY, Kang YW. Superior Mesenteric Artery Syndrome: Where Do We Stand Today? *J Gastrointest Surg* 2012; **16**: 2203-2211 [PMID: 23076975 DOI: 10.1007/s11605-012-2049-5]

140 Wan S, Zhang L, Yang J, Gao X, Wang X. Superior Mesenteric Artery Syndrome Improved by Enteral Nutritional Therapy: A Retrospective Case-Series Study in a Single Institution. *Ann Nutr Metab* 2020; **76**: 37-43 [PMID: 32172254 DOI: 10.1159/000506620]

141 Shiu JR, Chao HC, Luo CC, Lai MW, Kong MS, Chen SY, Chen CC, Wang CJ. Clinical and nutritional outcomes in children with idiopathic superior mesenteric artery syndrome. *J Pediatr Gastroenterol Nutr* 2010; **51**: 177-182 [PMID: 20601910 DOI:

10.1097/MPG.0b013e3181c7bdda]

142 Burrington JD. Vascular compression of the duodenum. *Surgery* 1976; **80**: 655. http://www.ncbi.nlm.nih.gov/pubmed/982286

143 Pottorf BJ, Husain FA, Hollis HW Jr, Lin E. Laparoscopic management of duodenal obstruction resulting from superior mesenteric artery syndrome. *JAMA Surg* 2014; **149**: 1319-1322 [PMID: 25353279 DOI: 10.1001/jamasurg.2014.1409]

144 Fredericks C, Alex G, Kumar V, Luu M. Laparoscopic Duodenojejunostomy for Superior Mesenteric Artery Syndrome. *Am Surg* 2016; **82**: e176-e177 [PMID: 27457852 DOI: 10.1177/000313481608200719]

145 Jain N, Chopde A, Soni B, Sharma B, Saini S, Mishra S, Mishra S, Gupta R, Bhojwani R. SMA syndrome: management perspective with laparoscopic duodenojejunostomy and long-term results. *Surg Endosc* 2021; **35**: 2029-2038 [PMID: 32342220 DOI: 10.1007/s00464-020-07598-1]

146 Bing L, Shun-Lin X, Ji-Hua O, Wei-Bing C, Ye-Bo W. Laparascopic Ladd's procedure as treatment alternative, when parenteral or prolonged hospital nutrition is not an option for superior mesenteric artery syndrome. *J Pediatr Surg* 2020; **55**: 554-557 [PMID: 30376960 DOI: 10.1016/j.jpedsurg.2017.07.004]

147 STRONG EK. Mechanics of arteriomesentric duodenal obstruction and direct surgical attack upon etiology. *Ann Surg* 1958; **148**: 725-730 [PMID: 13595530 DOI: 10.1097/00000658-195811000-00001]

148 Kouanda A, Watson R, Binmoeller KF, Nett A, Hamerski C. EUS-guided gastroenterostomy for duodenal obstruction secondary to superior mesenteric artery syndrome. *VideoGIE* 2021; **6**: 14-15 [PMID: 33490746 DOI: 10.1016/j.vgie.2020.09.008]

149 Bronswijk M, Fransen L, Vanella G, Hiele M, van der Merwe S. Successful treatment of superior mesenteric artery syndrome by endoscopic ultrasound-guided gastrojejunostomy. *Endoscopy* 2021; **53**: 204-205 [PMID: 32559775 DOI: 10.1055/a-1190-3228]

150 Kawabata H, Sone D, Yamaguchi K, Inoue N, Okazaki Y, Ueda Y, Hitomi M, Miyata M, Motoi S. Endoscopic Gastrojejunostomy for Superior Mesenteric Artery Syndrome Using Magnetic Compression Anastomosis. *Gastroenterology Res* 2019; **12**: 320-323 [PMID:

31803313 DOI: 10.14740/gr1229]

Figure Legends

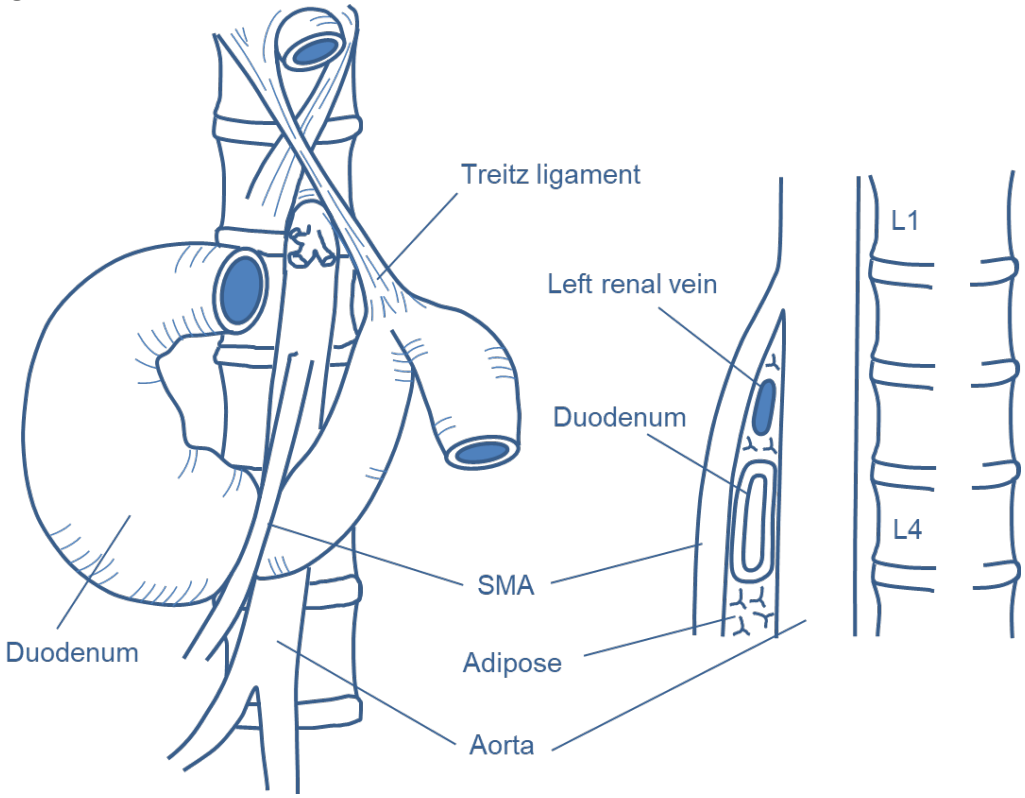
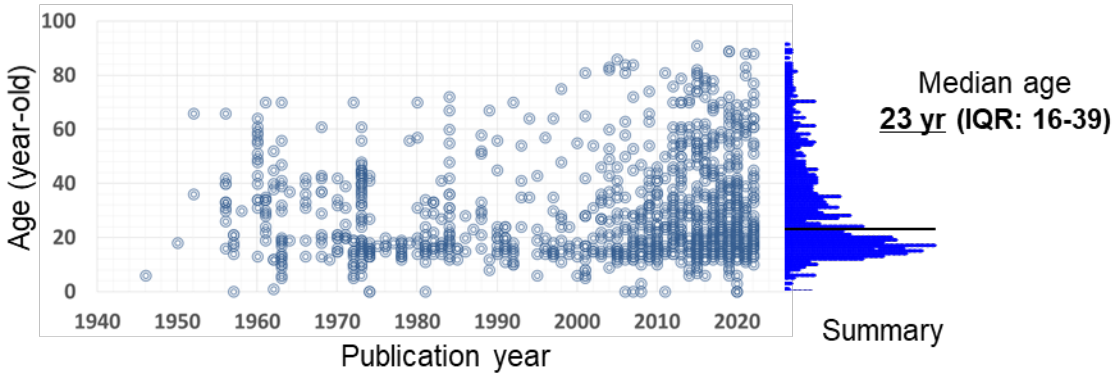


Figure 1 Anatomy related to superior mesenteric artery syndrome. SMA: superior mesenteric artery.



694

695 **Figure 2 Published patient age**. IQR: inter-quartile range. Dot indicates an individual case. The
696 data is based on our review [7].

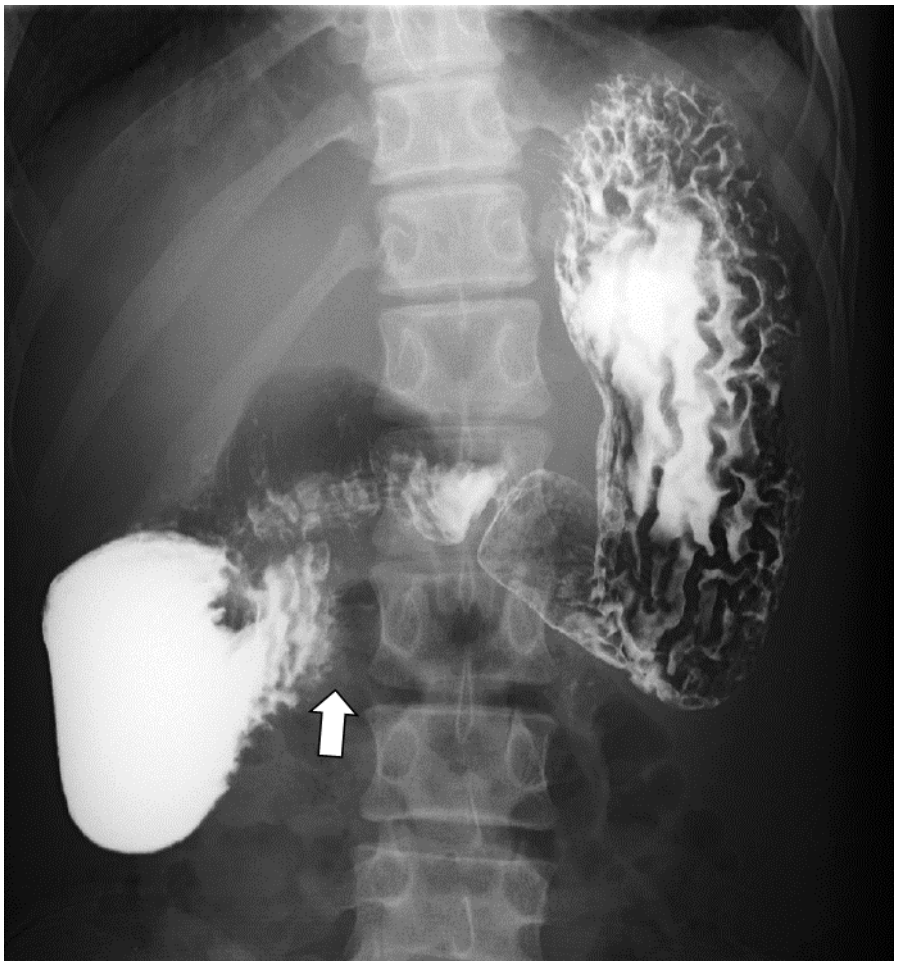


Figure 3 Upper gastrointestinal series (barium X-ray) of a 16-year-old male with superior mesenteric artery syndrome. Arrow indicates obstructive compression of the third portion of the duodenum.

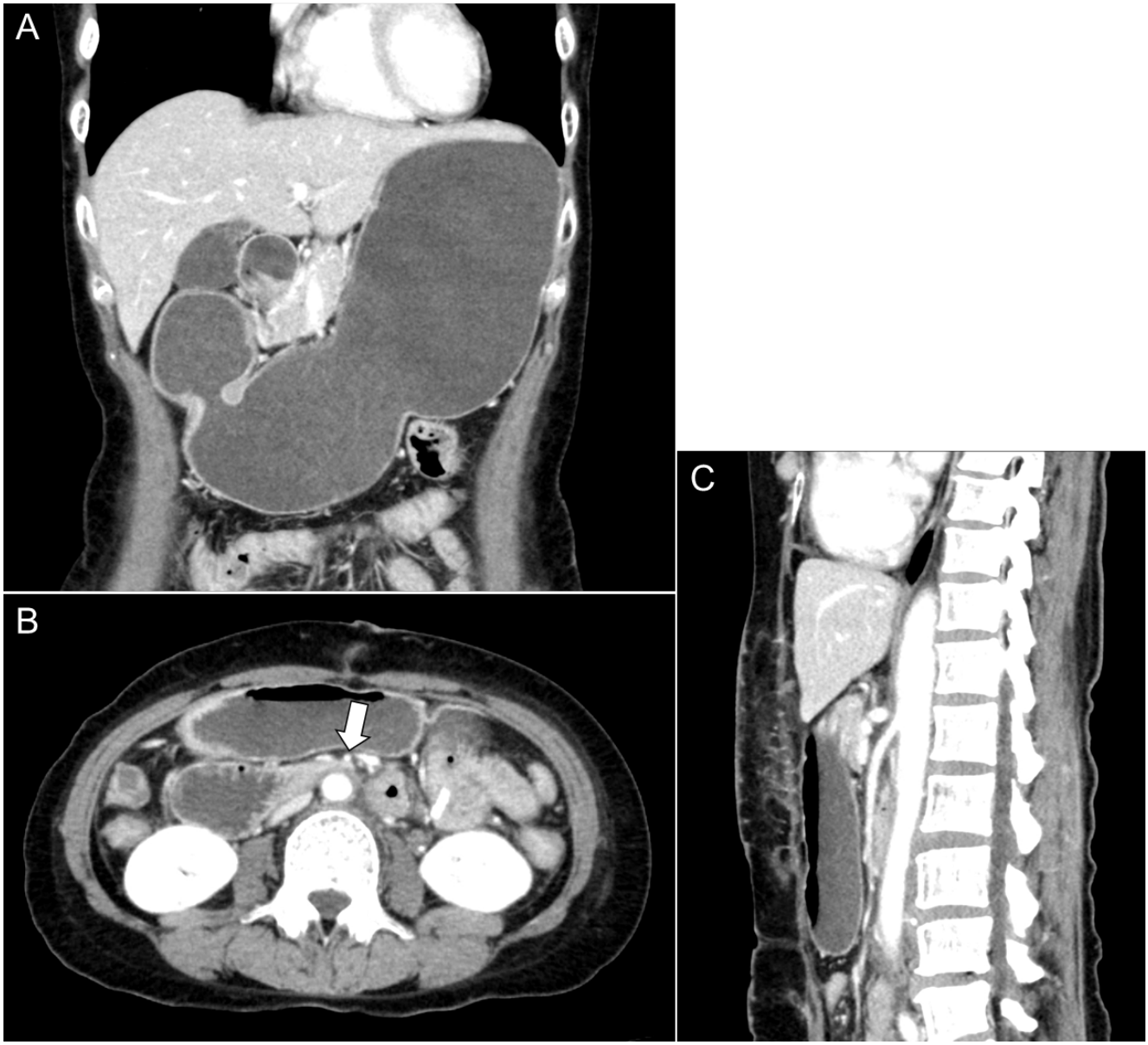


Figure 4 Enhanced computed tomography images of a 56-year-old female with superior mesenteric artery syndrome. Computed tomography images (A: coronal, B: axial, C: sagittal) show a markedly distended stomach and proximal duodenum by extrinsic compression between the superior mesenteric artery (arrow in panel B) and aorta.

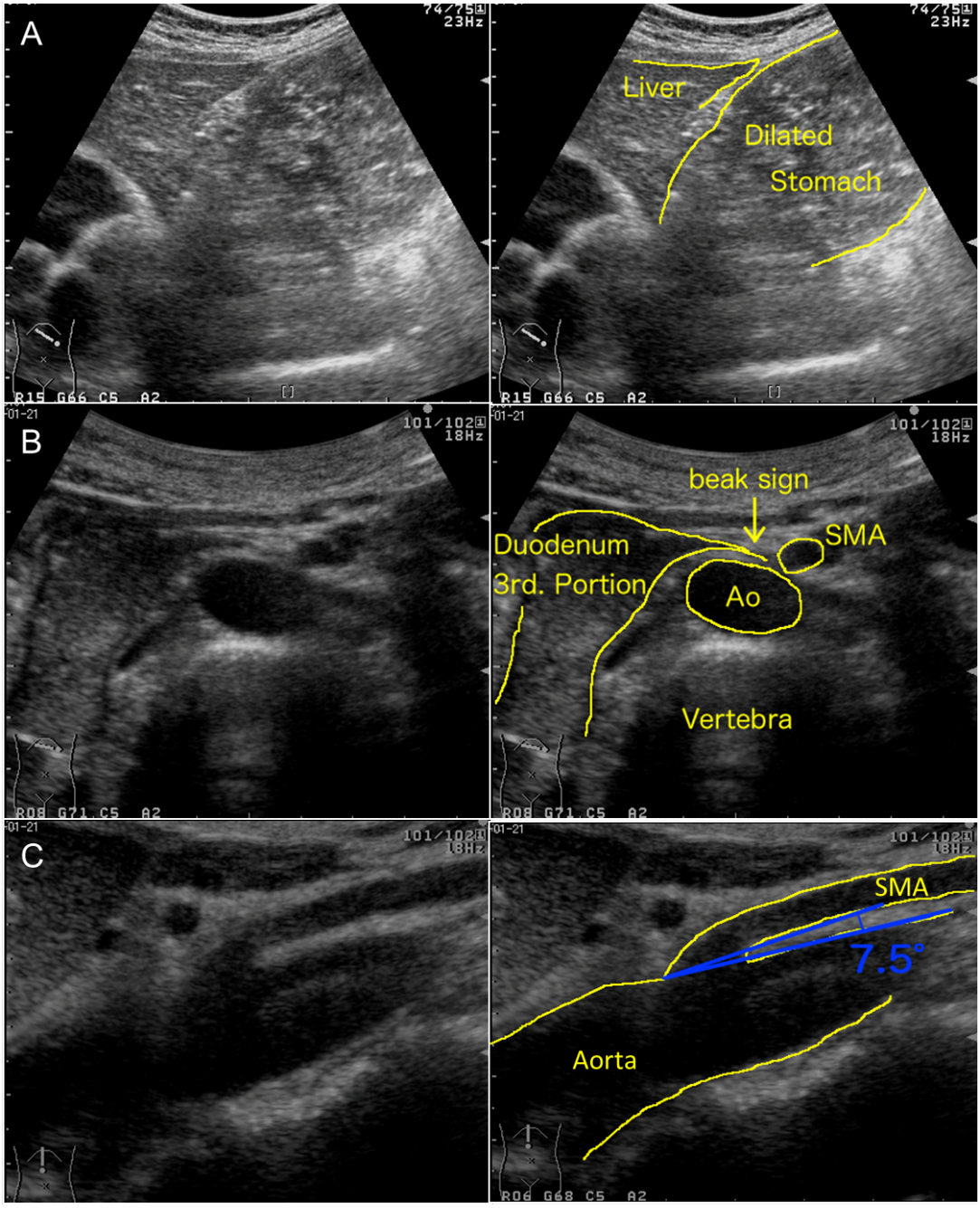
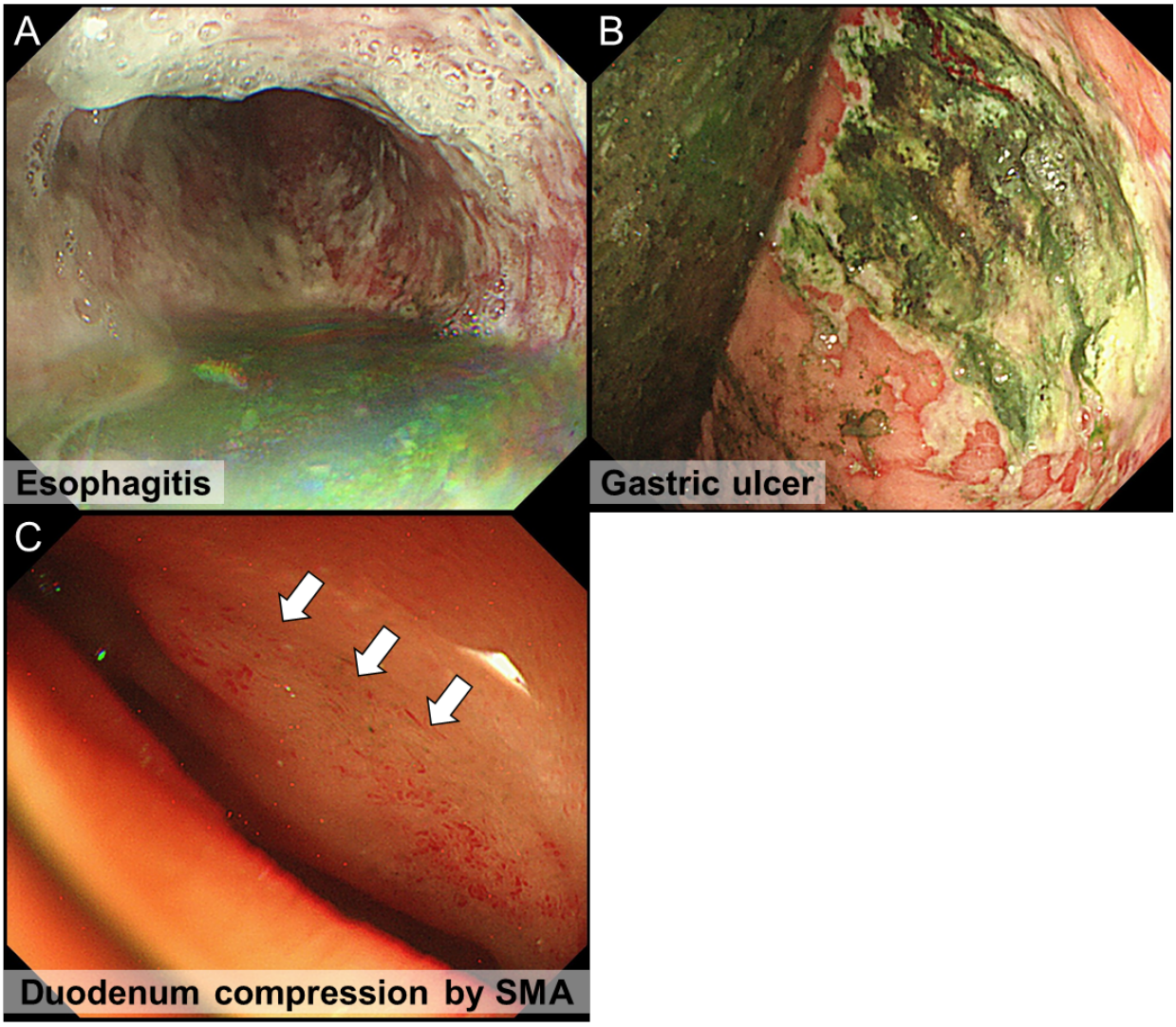


Figure 5 Abdominal ultrasonographic images of a 53-year-old female with superior mesenteric artery syndrome. Upper abdominal ultrasonography shows a markedly dilated stomach (A) and obstruction of duodenum (which looks like beak, beak sign) by extrinsic compression between the superior mesenteric artery (SMA) and aorta (Ao). C: The SMA-Ao angle (7.5 degree) and distance (5 mm) are decreased.



715

716 **Figure 6 Endoscopic findings of patients with superior mesenteric artery syndrome**.
717 Esophagitis (A) and gastric ulcer (B) with retained luminal contents. C: compression area in the
718 third portion of the duodenum.

719

TABLE 1. Incidence of SMA syndrome in several populations

Population	Incidence (%)	References
Acute general hospitals	0.001-0.0052	19
Chronic-care hospital	0.097	19
Hospital admissions	0.05-2.67	13,28,29
Upper gastrointestinal endoscopy	0.48	30
Post-scoliosis surgery + cast	0.5-3.4	20,31-35
Spinal cord injury	0.53	22
Burn injury	1.0-1.12	23-25
Anorexia nervosa (admitted)	2.73	26
Functional dyspepsia	10.8	27

SMA: superior mesenteric artery

TABLE 2. Etiology of SMA syndrome

Etiology	References
Congenital	
Short or high insersion of Treitz ligament	61
Low origin of the SMA	36
Spinal deformity (Scoliosis, Marfan etc.)	37,38
Familial	39,40
Malrotation of SMA and SMV	41,42
Malrotation of intestine	2
Body weight loss	
Diet and obesity surgery (sleeve surgery)	5,43
Eating disorders (anorexia nervosa, anorexia bulimia)	26,37
Malabsorption	18
Malignancy	18,19,36
Tuberculosis	45
Chemotherapy	46,47
Trauma (Burn injury, brain injury, spinal cord injuries etc.)	23,48,49
Neural disorders (ALS, MELAS, paraplegia, cerebral palsy etc.)	50,51
Drug or alcohol abuse	37
Rheumatoid arthritis	52
Scoliosis surgery	20,31-35
Intestinal surgery (IPAA, colectomy etc.)	37,53,54
Aging (bed rest, frail, vascular calcification etc.)	55,56
Body cast	4-6
"Pseudo-" SMA syndrome	
Aortic artery aneurysm (Aortoduodenal syndrome)	57-59
Surgery near or around the SMA and 3rd duodenum	60

SMA: superior mesenteric artery, SMV: superior mesenteric vein, ALS: amyotrophic lateral sclerosis, MELAS: mitochondrial myopathy, encephalopathy, lactic acidosis, and stroke-like episodes, IPAA: ileal pouch-anal anastomosis

TABLE 3. Complications and comobidities of SMA synddrome

A. Complications	**References**
Gastrointestinal complications 25-59% in SMA syndrome	63,74
Esophageal inflammation, bleeding, and ulcer	61,81,82
Gastric inflammation, ulcer, emphysema, ischemia, necrosis, perforation, and bezoar	83-86
Duodeneal inflammation, ulcer, mucosal necrosis, emphysema, and bezoar	64,65,87
Portal venous gas and thrombosis	66,67,85
Pneumoperitoneum and pneumomediastinum	68,69
Pancreato-biliary complications	
Elevated serum pancreatic and/or biliary enzymes	70
Acute and chronic pancreatitis	86
Jaundice	71
Pulmonary complications	
Aspiration pneumonia	72
Adult respiratory distress syndrome	73
Dehydration	
Low blood pressure	76
Acute kidney injury	76
Shock	76
Electrolytes and gas abnormalities	
Hypokalemia	77
Hyponatremia	77
Metabolic alkalosis	77
Severe malnutrition	78
Recurrent pregnancy loss	79
Sudden death	83

B. Comobidities related to SMA syndrome	**References**
Nutcracker phenomenon	88,89
Celiac axis compression syndrome (Median arcuate ligament syndrome)	90,91

SMA: superior mesenteric artery

TABLE 4. Diagnostic modalities for SMA synddrome

Modalities
Plain film X-ray
Barium X-ray
Angiogram
CT
Plain
Enhanced (3D-CT)
Abdominal ultrasound
B-mode
Doppler-mode
MRI
MR angiography
MR enterography
Endoscopy
White liight imaging
Ultrasonography (EUS)
Gastric-emptying scintigraphy
Multi-channel manometory

SMA: superior mesenteric artery, CT: computed tomography, 3D: 3-demension, MRI: magnetic resonance imaging, EUS: endoscopic ultrasonography

TABLE 5. Differential diagnoses of SMA syndrome

Disorders mimicking SMA syndrome	References
Similar symptoms by...	
Eating disorder	
Anorexia nervosa, Anorexia bulimia	126
CIPO	127
Peptic ulcer disease	128
Reflux esophagitis	102
Functional dyspepsia	27
Cyclic vomiting syndrome	103
Pancreatitis	104
Gastric outlet obstruction	105
Involvement of duodenum by... (other disorders)	
Tubercular infection	106,107
Megaduodenum (localized CIPO)	108
Henoch-Schönlein purpura	109-111
Crohn's disease	112,113
Celiac disease	87
Ectopic pancreas	114
Duodenal diverticula	115
Duodenal edema	116
Tumor	
Primary or metastatic duodenal cancer, pancreatic cancer, lymphoma etc.	15,117
Anatomical abnormality (web, diaphragm)	118
Foreign body (bezoar etc.)	119
Extrinsic compression by... (non-SMA)	
Aortic artery aneurysm (Aortoduodenal syndrome)	57-59
Stent or filter	
Mesenteric artery, aorta, IVC etc.	120,121
Horseshoe kidney	122
Lymphnode	123
Abscess	124
Traumatic false aneurysm	125

SMA: superior mesenteric artery, CIPO: chronic idiopathic intestinal pseudo-obstruction, IVC: inferior vena cava

TABLE 6. Treatments for SMA syndrome

Therapeutic methods
Conservative therapy
Decompression of dilated stomach and duodenum by
Postural change (left lateral, sitting position)
Nasal gastric tube suction
Medication (metoclopramide)
Gaining weight by
Giving multiple small feeds
Feeding tube (nasal gastric or jejunal)
Total parenteral nutrition
Surgecal therapy
Anterior transposition of the third part of duodenum
Gastroduodenostomy
Gastrojejunostomy
Duodenojejunostomy
Strong's procedure (a division of the ligament of Treitz)
Duodenal lowering
Ladd's procedure
Endoscopic therapy
Lumen-apposing metal stent* by
EUS-guided gastrojejunostomy

SMA: superior mesenteric artery, *LAMS: potential option based on case reports, EUS: endoscopic ultrasonography

731

Video Legends

Abdominal ultrasonographic images of a 53-year-old female with superior mesenteric artery syndrome. Upper abdominal ultrasonography shows a markedly dilated stomach and proximal duodenum as well as obstructive compression of the third portion of the duodenum between the superior mesenteric artery and aorta.