

CASE REPORT

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# McKeown esophagectomy with concomitant median arcuate ligament release in a case of esophageal cancer with celiac artery stenosis

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## Abstract

**Background:** The celiac artery stenosis due to compression by median arcuate ligament (MAL) has been reported in many cases of pancreaticoduodenectomy, but not in cases of esophagectomy. Recently, the celiac artery stenosis due to MAL or arteriosclerosis has been reported to be associated with the gastric tube necrosis or anastomotic leakage following Ivor–Lewis esophagectomy. Herein, we present the first reported case of esophageal cancer with celiac artery stenosis due to compression by the MAL successfully treated by McKeown esophagectomy and gastric tube reconstruction following prophylactic MAL release.

**Case presentation:** A 72-year-old female patient was referred to our department for esophagectomy. The patient had received two courses of neoadjuvant chemotherapy with 5-FU and cisplatin for T2N0M0 squamous cell carcinoma of the middle esophagus. Preoperative contrast-enhanced computed tomography (CECT) showed celiac artery stenosis due to compression by the MAL. The development of collateral arteries around the pancreatic head was observed without evidence of aneurysm formation. The patient reported no abdominal symptoms. After robot-assisted esophagectomy with mediastinal lymphadenectomy, gastric mobilization, supra-pancreatic lymphadenectomy, and preparation of the gastric tube were performed under laparotomy. Subsequently, the MAL was cut, and released to expose the celiac artery. Improved celiac artery blood flow was confirmed by decreased pulsatility index on intraoperative Doppler sonography. The operation was completed with the cervical esophagogastric anastomosis following cervical lymphadenectomy. Postoperative CECT on postoperative day 7 demonstrated increased celiac artery patency. The patient had an uncomplicated postoperative course thereafter.

**Conclusions:** Prophylactic MAL release may be considered in patients with celiac artery stenosis due to compression by the MAL on preoperative CECT for esophagectomy.

**Keywords:** Esophageal cancer, Esophagectomy, Celiac artery stenosis, Median arcuate ligament, Doppler ultrasonography

## Background

Esophagectomy is one of the most invasive gastrointestinal surgical procedures and is associated with a range of postoperative morbidities [1]. Of these, anastomotic leakage remains an important complication with a reported incidence between 10 and 21.2% in large-scale studies [2, 3]. Long-term fasting is required once anastomotic leakage is identified, leading to prolonged hospital

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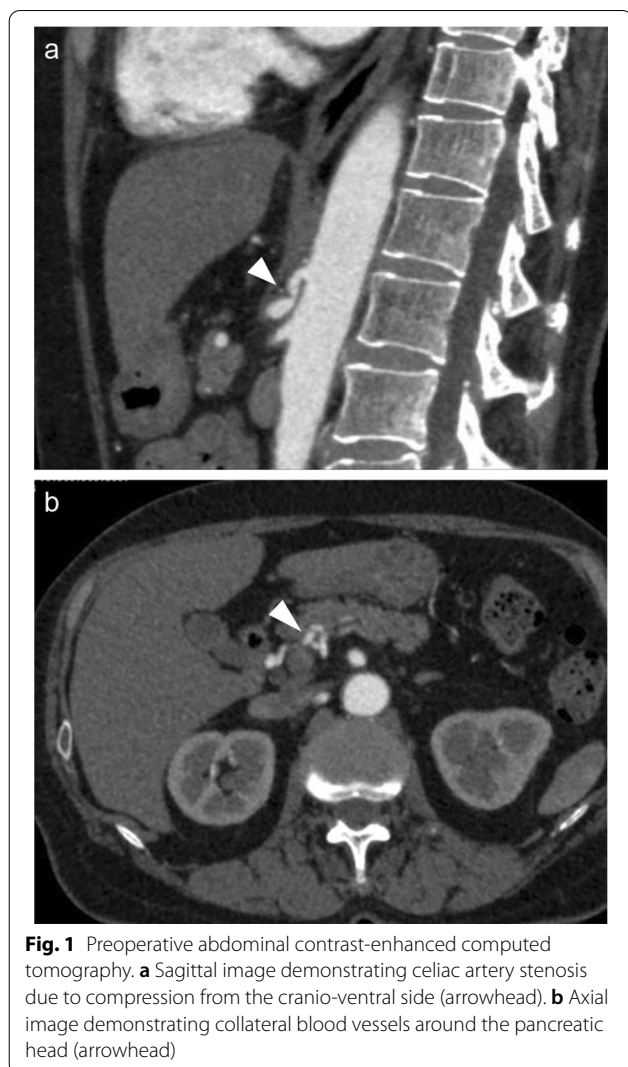
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stays. In addition, anastomotic strictures may develop [4, 5] and impact on patient quality of life for many years postoperatively. Moreover, anastomotic leakage is a prognostic factor in patients undergoing esophagectomy for esophageal cancer [6, 7]. Therefore, the prevention of anastomotic leakage is a clinical priority for esophageal surgeons. Many factors, including gastric tube blood flow, nutrition, anastomosis method, and anastomotic location reportedly influence anastomotic outcomes [8, 9]. Recently, celiac artery stenosis due to arteriosclerosis has been reported to be associated with anastomotic leakage following Ivor–Lewis esophagectomy [10, 11]. Lainas et al. reported celiac artery stenosis due to compression by the median arcuate ligament (MAL), in addition to atherosclerotic celiac artery stenosis, was associated with necrosis of the gastric tube following Ivor–Lewis esophagectomy [12]. However, the management of the celiac artery stenosis due to MAL in patients with esophageal cancer undergoing gastric tube reconstruction has not been reported. Herein, we present the first reported case of esophageal cancer with celiac artery stenosis due to compression by the MAL successfully treated by McKeown esophagectomy and gastric tube reconstruction following prophylactic MAL release.

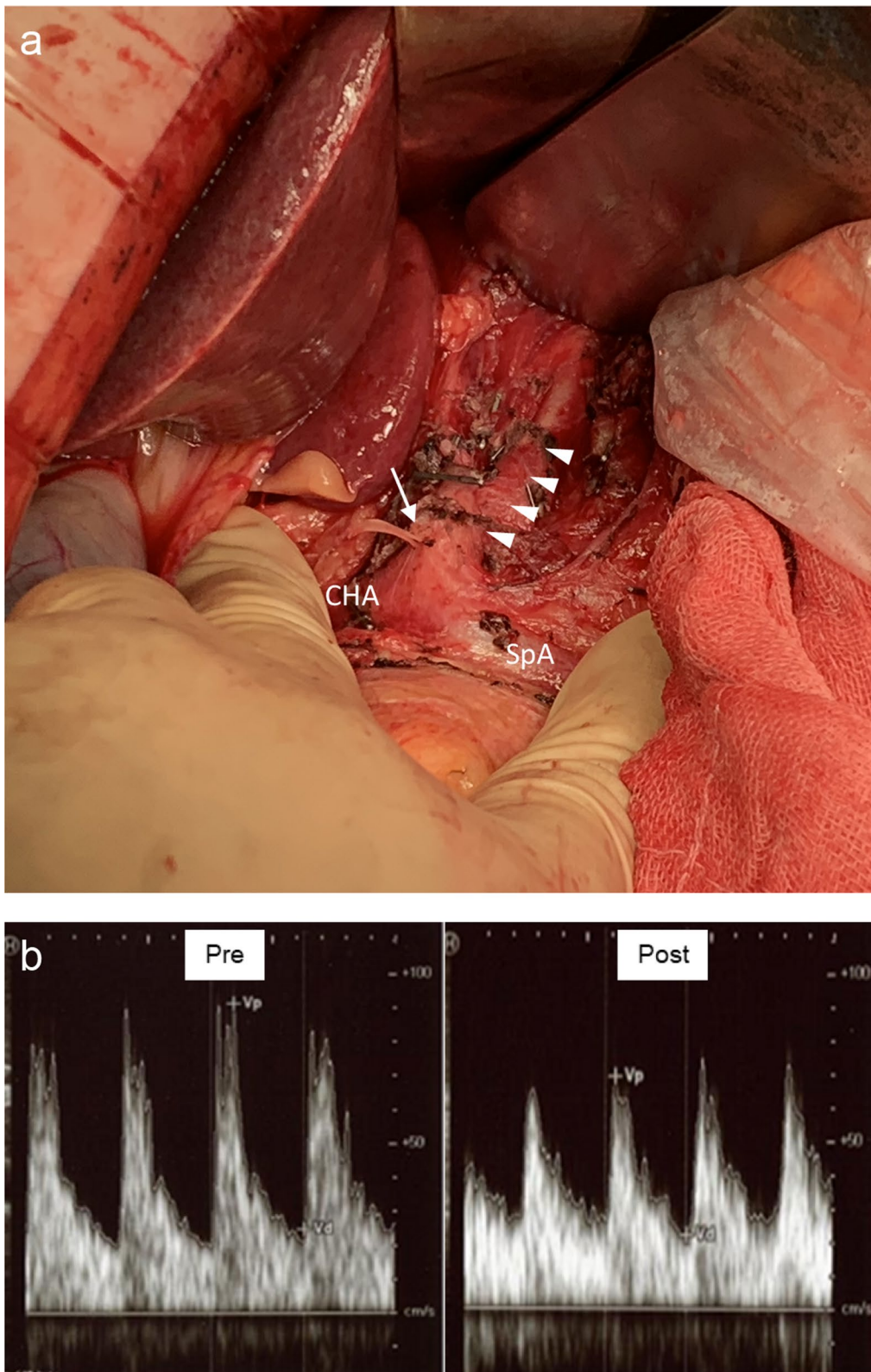
### Case presentation

A 72-year-old female patient with a history of radical hysterectomy and postoperative irradiation for cervical cancer 25 years prior was referred to our department for esophagectomy. The patient had received two courses of neoadjuvant chemotherapy with 5-FU and cisplatin for T2N0M0 squamous cell carcinoma of the middle esophagus. Preoperative contrast-enhanced computed tomography (CECT) showed celiac artery stenosis due to cranio-ventral compression, a finding typical of MAL syndrome (Fig. 1a). No aortic or celiac artery calcification was observed. The development of collateral arteries around the pancreatic head (i.e., arcade vessel from the superior mesenteric artery through the inferior pancreaticoduodenal artery to the gastroduodenal artery) was observed (Fig. 1b) without evidence of aneurysm formation. The patient reported no abdominal symptoms.

Robot-assisted thoracoscopic esophagectomy [13] with mediastinal lymphadenectomy [14] was performed in the prone position, followed by gastric mobilization and supra-pancreatic lymphadenectomy by open laparotomy in the supine position. Then, a gastric tube was created using linear staplers and the lesion was excised en bloc. Subsequently, the MAL was cut and released to expose the celiac artery (Fig. 2a). Celiac artery blood flow was assessed by the pulsatility index (PI), which provides information pertaining to down-stream vascular resistance, calculated from the



difference between systolic and diastolic flow velocities divided by the mean velocity using intraoperative Doppler sonography [15, 16]. The PI decreased from 1.54 to 1.18 after the MAL release, indicating decreased vascular resistance and improved celiac artery patency (Fig. 2b). Perfusion of the gastric tube was evaluated in a non-quantitative way using an indocyanine green (ICG) fluorescence imaging system as our routine practice. In the present case, it was as good as usual even before the MAL release and there was no apparent difference observed between before and after the MAL release. The cervical esophagogastric anastomosis was performed using the triangulating stapling technique [17] following cervical lymphadenectomy. CECT imaging on postoperative day (POD) 7 showed improved celiac artery patency (Fig. 3). The postoperative course was uneventful except for Clavien–Dindo [18] Grade



**Fig. 2** Intraoperative findings. **a** Median arcuate ligament (MAL) release was performed under laparotomy. Arrowheads indicate the celiac artery. The arrow indicates the stump of the left gastric artery. *CHA* common hepatic artery, *SpA* splenic artery. **b** Evaluation of celiac artery blood flow using Doppler sonography pre (left) and post (right) MAL release. *Vp* indicates systolic flow velocity. *Vd* indicates diastolic flow velocity



**Fig. 3** Abdominal contrast-enhanced computed tomography on postoperative day 7. Sagittal image demonstrating improved celiac artery patency

I left recurrent nerve palsy and the patient was discharged on POD 21. No recurrence was observed up to 2 years postoperatively.

## Discussion

The MAL is a band of fibrous tissue that connects the bilateral diaphragmatic crura surrounding the aortic hiatus. Individuals with a high origin of the celiac artery or lower insertion of the diaphragm are more prone to compression of the celiac artery [19]. It is reported that in 10% to 24% of the population, the MAL crosses the aorta at a lower level, resulting in compression of the celiac artery [20]. Although the incidence of MAL syndrome in the population is not well understood, it is more prevalent in women (4:1 ratio) between the ages of 30 to 50 years and in patients with a thin body habitus [21]. In the present case, we successfully performed subtotal esophagectomy with prophylactic MAL release for esophageal cancer with celiac artery stenosis. This is the first report of prophylactic MAL release for celiac artery stenosis in a patient undergoing gastric tube reconstruction following esophagectomy.

The gastric tube blood flow is predominantly from the right gastroepiploic artery through the gastroduodenal artery, with little contribution from the right gastric artery [22]. The gastroduodenal artery normally receives its blood flow from the celiac artery through the common hepatic artery; however, in the presence of celiac artery stenosis, it receives its blood flow from the

superior mesenteric artery [23, 24]. Therefore, in cases of gastric tube reconstruction following esophagectomy for patients with celiac artery stenosis, correction of celiac artery stenosis is controversial. Regarding this issue, Lammerts et al. reported the use of preoperative percutaneous stent angioplasty followed by Ivor–Lewis esophagectomy for esophageal cancer with atherosclerotic celiac artery stenosis [25]. Therapeutic intervention for celiac artery stenosis is frequently reported in cases of pancreaticoduodenectomy [26, 27]. Sugae et al. classified celiac artery stenosis due to MAL into three types according to the degree and length of stenosis based on CT angiography findings in patients undergoing pancreaticoduodenectomy [27]. They concluded MAL release was required in cases of moderate stenosis (50–80% stenosis and 3–8 mm stenosis length), and collateral preservation or arterial reconstruction was required in cases of severe stenosis (>80% stenosis and >8 mm stenosis length). In the present case, CECT showed 75% stenosis with a stenosis length of 4.5 mm, which corresponded to moderate stenosis. Accordingly, MAL release was expected to improve celiac artery blood flow. Recently, celiac artery stenosis due to MAL or arteriosclerosis has been reported to be associated with necrosis of the gastric tube or anastomotic leakage following Ivor–Lewis esophagectomy [10–12]. Among these reports, Chang et al. reported that the mean degree of celiac artery stenosis in patients with anastomotic leakage was 44.4% [10], and Brinkmann et al. reported that the median degree of celiac artery stenosis in patients with anastomotic leakage was 50.0% [11]. Moreover, McKeown esophagectomy with three fields' lymph node dissection, which is standard procedure in Japan [28], requires a higher anastomosis than Ivor–Lewis esophagectomy. Taken together, the risk of postoperative anastomotic complication would be higher in the present case. In addition, as the present case had already developed collateral arteries around the pancreatic head, we performed prophylactic MAL release to ensure favorable short-term anastomotic outcomes and prevent future aneurysmal rupture leading to gastric tube necrosis.

As for the operative strategy for a case of esophageal cancer with celiac artery stenosis, if the initial ICG fluorescence imaging of the gastric tube is satisfactory, the MAL release would be the prophylactic procedure anyway. On the contrary, if there are any discrepancies between the decrease of the PI and the change of the ICG fluorescence images even after thorough dissection of the MAL in a patient with poor initial ICG imaging, the sufficient perfusion of the gastric tube would not be guaranteed. In such case, we consider either revascularization of the gastric tube at the neck or two-stage reconstruction.

In elective cases with MAL syndrome, we typically use the laparoscopic approach in a hybrid operating room to confirm hemodynamic alterations using concomitant angiography [29], and our team has sufficient experience of laparoscopic gastrectomy even in patients with a history of previous laparotomy [30]. Therefore, we considered laparoscopic gastric mobilization and MAL release to be feasible in the present case. However, considering the operative duration and limited choice of operating rooms for robotic surgery, we opted to use an open approach and evaluate celiac artery flow using Doppler sonography, which represents a method of real-time intraoperative monitoring [31].

## Conclusions

In patients with celiac artery stenosis due to compression by the MAL on preoperative CECT for esophagectomy, preservation of gastric tube blood flow should be ensured prior to reconstruction. Prophylactic MAL release may be considered in cases, where celiac artery stenosis may increase risk of anastomotic complications.

## Abbreviations

MAL: Median arcuate ligament; CECT: Computed tomography; PI: Pulsatility index; POD: Postoperative day.

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## Authors' contributions

KH drafted the manuscript. ST, TN, SH, and KO contributed to interpretation of the data and the critical revision of the manuscript for important intellectual content. SO contributed to the data collection and interpretation and critically reviewed the manuscript. All authors read and approved the final manuscript.

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## Availability of data and materials

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## Declarations

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Written, informed consent was obtained from the patient for publication of this case report.

### Competing interests

The authors declare that they have no competing interests.

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## References

1. Kakeji Y, Takahashi A, Hasegawa H, Ueno H, Eguchi S, Endo I, National Clinical Database, et al. Surgical outcomes in gastroenterological surgery in Japan: report of the National Clinical Database 2011–2018. *Ann Gastroenterol Surg.* 2020;4:250–74.
2. Chevally M, Jung M, Chon SH, Takeda FR, Akiyama J, Mönig S. Esophageal cancer surgery: review of complications and their management. *Ann NY Acad Sci.* 2020;1482:146–62.
3. Takeuchi H, Miyata H, Gotoh M, Kitagawa Y, Baba H, Kimura W, et al. A risk model for esophagectomy using data of 5354 patients included in a Japanese nationwide web-based database. *Ann Surg.* 2014;260:259–66.
4. Petrin G, Ruol A, Battaglia G, Buin F, Merigliano S, Constantini M, et al. Anastomotic stenoses occurring after circular stapling in esophageal cancer surgery. *Surg Endosc.* 2000;14:670–4.
5. van Heijl M, Gooszen JA, Fockens P, Busch OR, van Lanschot JJ, van Berge Henegouwen MI. Risk factors for development of benign cervical strictures after esophagectomy. *Ann Surg.* 2010;251:1064–9.
6. Markar S, Gronnier C, Duhamel A, Mabrut JY, Bail JP, Carrere N, et al. The impact of severe anastomotic leak on long-term survival and cancer recurrence after surgical resection for esophageal malignancy. *Ann Surg.* 2015;262:972–80.
7. Andreou A, Biebl M, Dadras M, Struecker B, Sauer IM, Thuss-Patience PC, et al. Anastomotic leak predicts diminished long-term survival after resection for gastric and esophageal cancer. *Surgery.* 2016;160:191–203.
8. Messenger M, Warlaumont M, Renaud F, Marin H, Branche J, Piessen G, et al. Recent improvements in the management of esophageal anastomotic leak after surgery for cancer. *Eur J Surg Oncol.* 2017;43:258–69.
9. Jansen SM, de Bruin DM, van Berge Henegouwen MI, Strackee SD, Veelo DP, van Leeuwen TG, et al. Optical techniques for perfusion monitoring of the gastric tube after esophagectomy: a review of technologies and thresholds. *Dis Esophagus.* 2018;1:31.
10. Chang DH, Brinkmann S, Smith L, Becker I, Schroeder W, Hoelscher AH, et al. Calcification score versus arterial stenosis grading: comparison of two CT-based methods for risk assessment of anastomotic leakage after esophagectomy and gastric pull-up. *Ther Clin Risk Manag.* 2018;14:721–7.
11. Brinkmann S, Chang DH, Kuhr K, Hoelscher AH, Spiro J, Bruns CJ, et al. Stenosis of the celiac trunk is associated with anastomotic leak after Ivor-Lewis esophagectomy. *Dis Esophagus.* 2019;1:32.
12. Lainas P, Fuks D, Gaujoux S, Machroub Z, Fregeville A, Perniceni T, et al. Preoperative imaging and prediction of oesophageal conduit necrosis after oesophagectomy for cancer. *Br J Surg.* 2017;104:1346–54.
13. Tsunoda S, Obama K, Hisamori S, Nishigori T, Okamura R, Maekawa H, et al. Lower incidence of postoperative pulmonary complications following robot-assisted minimally invasive esophagectomy for esophageal cancer: propensity score-matched comparison to conventional minimally invasive esophagectomy. *Ann Surg Oncol.* 2021;28:639–47.
14. Tsunoda S, Shinohara H, Kanaya S, Okabe H, Tanaka E, Obama K, et al. Mesenteric excision of upper esophagus: a concept for rational anatomical lymphadenectomy of the recurrent laryngeal nodes in thoracoscopic esophagectomy. *Surg Endosc.* 2020;34:133–41.
15. Gosling RG, King DH. Arterial assessment by Doppler-shift ultrasound. *Proc R Soc Med.* 1974;67:447–9.
16. Robba C, Cardim D, Sekhon M, Budohoski K, Czosnyka M. Transcranial Doppler: a stethoscope for the brain-neurocritical care use. *J Neurosci Res.* 2018;96:720–30.
17. Noshiro H, Urata M, Ikeda O, Iwasaki H, Nabae T, Uchiyama A, et al. Triangulating stapling technique for esophagogastrostomy after minimally invasive esophagectomy. *Surgery.* 2013;154:604–10.
18. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg.* 2004;240:205–13.
19. Kim EN, Lamb K, Relles D, Moudgill N, DiMuzio PJ, Eisenberg JA. Median arcuate ligament syndrome-review of this rare disease. *JAMA Surg.* 2016;151:471–7.

20. Horton KM, Talamini MA, Fishman EK. Median arcuate ligament syndrome: evaluation with CT angiography. *Radiographics*. 2005;25:1177–82.
21. Trinidad-Hernandez M, Keith P, Habib I, White JV. Reversible gastroparesis: functional documentation of celiac axis compression syndrome and postoperative improvement. *Am Surg*. 2006;72:339–44.
22. Liebermann-Meffert DM, Meier R, Siewert JR. Vascular anatomy of the gastric tube used for esophageal reconstruction. *Ann Thorac Surg*. 1992;54:1110–5.
23. Libicher M, Reichert V, Aleksic M, Brunkwall J, Lackner KJ, Gawenda M. Balloon occlusion of the celiac artery: a test for evaluation of collateral circulation prior endovascular coverage. *Eur J Vasc Endovasc Surg*. 2008;36:303–5.
24. Yuhn C, Hoshina K, Miyahara K, Oshima M. Computational simulation of flow-induced arterial remodeling of the pancreaticoduodenal arcade associated with celiac artery stenosis. *J Biomech*. 2019;92:146–54.
25. Lammerts RGM, van Det MJ, Geelkerken RH, Kouwenhoven EA. Risk-assessment of esophageal surgery: diagnosis and treatment of celiac trunk stenosis. *Thorac Cardiovasc Surg Rep*. 2018;7:e21–3.
26. Gaujoux S, Sauvanet A, Vullierme MP, Cortes A, Dokmak S, Sibert A, et al. Ischemic complications after pancreaticoduodenectomy: incidence, prevention, and management. *Ann Surg*. 2009;249:111–7.
27. Sugae T, Fujii T, Kodera Y, Kanzaki A, Yamamura K, Yamada S, et al. Classification of the celiac artery stenosis owing to median arcuate ligament compression, based on severity of the stenosis with subsequent proposals for management during pancreatoduodenectomy. *Surgery*. 2012;151:543–9.
28. Tachimori Y, Ozawa S, Numasaki H, Ishihara R, Matsubara H, Muro K, et al. Comprehensive registry of esophageal cancer in Japan, 2010. *Esophagus*. 2017;14:189–214.
29. Aisu Y, Okada T, Sumii A, Ganeko R, Okamura R, Nishigori T, et al. Laparoscopic surgery for median arcuate ligament syndrome using real-time stereotactic navigation. *Asian J Endosc Surg*. 2021. <https://doi.org/10.1111/ases.12990>.
30. Tsunoda S, Okabe H, Obama K, Tanaka E, Akagami M, Kinjo Y, et al. Laparoscopic gastrectomy for patients with a history of upper abdominal surgery: results of a matched-pair analysis. *Surg Today*. 2014;44:271–6.
31. Ito K, Takemura N, Oikawa R, Inagaki F, Mihara F, Kokudo N. Detailed anatomy and procedure of celiac artery decompression in median arcuate ligament syndrome. *Langenbecks Arch Surg*. 2021;13:1717.

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