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Median Arcuate Ligament Syndrome (MALS), also known as Dunbar syndrome – pathophysiology. diagnosis and treatment: a narrative review

Authors:

Adrian Baran [AB] (Corresponding author)

Faculty of Medicine, Jagiellonian University Medical College, ul. św. Anny 12,31-008 Kraków, Poland

ORCID: https://orcid.org/0009-0000-5658-076X

Email: aabaran01@gmail.com

Michał Maciejowski [MM]
Central Teaching Hospital of Medical University of Lodz FYI, Poland
ORCID: https://orcid.org/0009-0004-5847-9592
Email: michal.maciejowski00@interia.pl

Mateusz Zdaniewicz [MZ]
The Brothers Hospitallers of Saint John Grande Hospital, Kraków, Poland
ORCID: https://orcid.org/0009-0003-2157-7941
Email: mateuszzdaniewicz@gmail.com

Jakub Adamiak [JA]
Medical University of Lodz, al. Tadeusza Kosciuszki 4, 90-419 Lodz, Poland
ORCID: https://orcid.org/0009-0009-2344-6164
Email: jakub.adamiakk@gmail.com

Barłomiej Czyżak [BC]
Independent Public Healthcare Institution MSWiA in Lodz, Poland
ORCID: https://orcid.org/0009-0006-3375-9955
Email: bartek-czyzak@wp.pl

Agnieszka Olejnik [AO]
Independent Public Healthcare Institution MSWiA in Lodz, Poland
ORCID: https://orcid.org/0009-0002-4180-5270
Email: agnieszkv.olejnik@gmail.com

Kacper Kiereta [KK]
Wroclaw Medical University, wyb. Ludwika Pasteura 1, 50-367 Wrocław, Poland
ORCID: https://orcid.org/0009-0007-6612-8495
Email: kacper.kiereta@student.umw.edu.pl

Zuzanna Cichowska [ZC]
Wroclaw Medical University, wyb. Ludwika Pasteura 1, 50-367 Wrocław, Poland
ORCID: https://orcid.org/0009-0001-9597-2587
Email: zuzanna.cichowska@student.umw.edu.pl

Małgorzata Bacik [MB]
Wroclaw Medical University, wyb. Ludwika Pasteura 1, 50-367 Wrocław, Poland
ORCID: https://orcid.org/0009-0006-8350-5064
Email: malgorzata.bacik@student.umw.edu.pl

Klaudia Głodowska [KG]
Wroclaw Medical University, wyb. Ludwika Pasteura 1, 50-367 Wrocław, Poland
ORCID: https://orcid.org/0009-0007-4389-0591
Email: klaudia.glodowska@student.umw.edu.pl

Abstract:

Introduction and purpose: Median arcuate ligament syndrome (MALS), also known as Dunbar syndrome, is a rare disorder caused primarily by compression of the celiac axis by the median arcuate ligament and diaphragmatic crura. This disorder usually causes weight loss, nausea, vomiting, and postprandial epigastric pain. Because the diagnosis of MALS requires ruling out other conditions, as it lacks specific criteria, it still presents as a diagnostic and therapeutic challenge. This narrative review was conducted to consolidate current knowledge of this syndrome, focusing on its etiology, diagnosis, and therapeutic strategies.

A brief description of the state of knowledge: MALS remains a controversial diagnosis, which can only be established after excluding all other potential causes of abdominal pain. Nowadays, the primary first-line diagnostic tool is Doppler ultrasound, which typically reveals elevated peak systolic velocity during expiration; however, in most cases, the diagnosis must be confirmed by computed tomography angiography (CTA) or, in some cases, magnetic resonance angiography (MRA). Surgery may be performed using an open approach or a minimally invasive technique, including laparoscopic or robot-assisted methods.

Summary: While MALS has been acknowledged for decades, standardized diagnostic and treatment protocols are still incomplete. Multiple treatment options exist, with selection often based on the patient's specific clinical presentation and preferences. Many concerns, including

the long-term quality of life following robotic decompression and whether vascular reconstruction is needed in cases of persistent stenosis, still need thorough prospective studies.

Key words: Median arcuate ligament syndrome; MALS; Dunbar syndrome.

Introduction and purpose

Median arcuate ligament syndrome (MALS) is defined by symptoms arising from external compression of the celiac artery by the median arcuate ligament of the diaphragm, which frequently results in reduced mesenteric blood flow and irritation of the celiac ganglion. Asymptomatic compression of the celiac trunk is a relatively common incidental radiological finding in the general population. However, if the constriction causes significant hemodynamic disruption or neurogenic pain, it presents with non-specific chronic or recurrent symptoms—most notably postprandial abdominal pain, nausea, vomiting, and weight loss—and still proves to be a diagnostic and therapeutic challenge. Different medical centers choose different treatments, ranging from laparoscopic release to open vascular reconstruction, based on their experience and preferences. Our article aims to bring together the latest knowledge and present a clear overview of the disease. We start with normal anatomy, pathophysiology, epidemiology, and symptoms, then cover diagnosis, and finish with treatment options.

In order to create this article on 22.03.2026, we conducted a review of the literature using PubMed. Two independent authors (A.B. and M.M.) performed a search using terms such as „Median arcuate ligament syndrome", „MALS", and „Dunbar syndrome". Disagreements regarding inclusion were resolved through discussion and consultation with a third reviewer (K.K.). Additional references were identified by examining the bibliographies of selected articles.

State of Knowledge: Pathophysiology of MALS

Anatomical Background and Vascular Architecture

The aorta is the main artery of the human body, traversing from the thorax into the abdominal cavity via the diaphragmatic aortic hiatus at the level of the twelfth thoracic vertebra

(T12). In the abdominal region, it descends slightly to the left of the midline, anterior to the lumbar spine [1]. The celiac trunk (celiac axis) typically arises from the abdominal aorta between the T11 and L1 vertebral levels, although considerable anatomical variations in its origin are well documented [2].

As an unpaired vessel, the celiac artery emerges just inferior to the median arcuate ligament (MAL). It subsequently trifurcates into the left gastric, splenic, and common hepatic artery, providing the essential blood supply to the spleen and organs derived from the embryonic foregut [3].

Mechanics of Compression and Respiratory Dynamics

The median arcuate ligament is a fibrous structure connecting the diaphragmatic crura that border the aortic hiatus. Clinical compression of the celiac artery, defining MALS, frequently results from a high-riding arterial origin or an abnormally low diaphragmatic attachment, leading to pathological mechanical contact [4].

A defining characteristic of MALS is that this mechanical conflict is dynamic and fluctuates with the respiratory cycle. During inspiration, the celiac artery typically moves inferiorly, away from the MAL fibers, frequently resulting in a transient alleviation of the narrowing. Conversely, during expiration, the inferior displacement of the diaphragm brings the MAL into closer proximity to the celiac trunk, thereby worsening the stenosis. This respiratory-dependent change is a hallmark diagnostic sign in computed tomography (CT) or magnetic resonance (MR) angiography, where the obstruction is most pronounced at the end of exhalation [5].

Clinical Consequences: Ischemia and Aneurysm Formation

Compression of the celiac artery may induce hyperplasia of the intimal wall, leading to luminal stenosis and subsequent ischemia of the abdominal organs[6]. A severe complication of MALS is the development of visceral artery aneurysms. Significant celiac artery stenosis alters regional hemodynamics and forces retrograde flow through the pancreaticoduodenal arcades. The resulting hemodynamic stress causes intimal injury and medial layer dysfunction, ultimately leading to the formation of true pancreaticoduodenal artery aneurysms [7].

The Pathophysiological Debate: Ischemia vs. Neuropathy

While vascular compromise was historically considered the primary cause of symptoms, modern research suggests a dual pathophysiology. The celiac plexus, located near the celiac artery, contains sympathetic and parasympathetic nerve fibers that relay signals between the embryological foregut and midgut structures [8]. In 2021, Barbon et al published a single-institution, retrospective cohort study of patients with a clinical diagnosis of MALS. Most patients had less postprandial pain and fewer gastrointestinal symptoms after a celiac plexus block. Crucially, this symptomatic improvement did not always correlate with the severity of vascular abnormalities. These findings strongly suggest that neuropathy, rather than isolated arterial compression, may be the predominant cause of the clinical manifestations in MALS [9].

Epidemiology and appearance

Median arcuate syndrome was first described by Lipschutz in 1917 using anatomical preparations [10]. Later, in 1963, Harjola reported that a 57-year-old man experienced relief from postprandial epigastric pain after surgery to decompress the celiac artery, which was affected by fibrosis of the celiac ganglion [11]. Shortly thereafter, in 1965, Dunbar et al. consolidated these findings by publishing a definitive case series. This led to the eponym Dunbar Syndrome [12].

Epidemiologically, MALS is classified as a rare disorder, with an estimated clinical incidence of approximately 2 per 100,000 individuals [13]. Despite its rarity, the European Society for Vascular Surgery recognizes it as the second most prevalent cause of single-vessel mesenteric artery occlusive disease (MAOD) [14]. Nevertheless, a significant epidemiological paradox exists: while symptomatic MALS is rare, asymptomatic compression of the celiac axis is observed in 13% to 50% of the general population during routine imaging. This underscores the necessity of clinical correlation for a definitive diagnosis [15].

The typical patient profile is a female (representing 73% of cases) in her fourth decade of life (median age of 40 years) [16]. A slender or asthenic body habitus is a well-documented risk factor, likely due to the absence of retroperitoneal fat, which otherwise functions as a protective buffer between the MAL and the celiac trunk [6].In addition to body type, common related conditions include smoking, high blood pressure, high cholesterol, and a history of abdominal surgeries [17]. While this is usually diagnosed in adults, more cases are now being seen in children, suggesting that some people may be born with an anatomical predisposition [5].

The 2026 Consensus Statement [18] highlights the clinical significance of this condition, particularly given its strong association with secondary vascular pathologies. Studies report that 50% to 60% of true pancreaticoduodenal artery aneurysms (PDAA) and gastroduodenal artery aneurysms (GDAA) are associated with celiac artery stenosis or occlusion, often due to compression by the median arcuate ligament syndrome (MALS). Epidemiological data from large-scale studies, including an analysis of 990 patients, indicate that celiac artery obstruction occurs in 2.3% of the population, with more than 60% of these cases directly attributable to MALS.

Symptoms and clinical features

Patients with median arcuate ligament syndrome often have symptoms like nausea, vomiting, pain in the upper abdomen after eating (postprandial pain), and sitophobia, which is a strong aversion to food or eating and is sometimes mistaken for anorexia. If these symptoms go undiagnosed for a long time, they can lead to weight loss [19][20]. These clinical manifestations are inherently dynamic and are typically exacerbated during expiration. This respiratory dependence is caused by the caudal movement of the diaphragm, which increases the mechanical compression of the celiac trunk by the median arcuate ligament [21].

Because these symptoms resemble those of more common conditions such as biliary colic, gastroparesis, Helicobacter pylori disease, gastroesophageal reflux disease (GERD), peptic ulcer disease, and inflammatory bowel disease (IBD), physicians must first exclude these diagnoses. As a result, diagnosing MALS is often delayed, with the average time from initial symptoms to diagnosis ranging from 10.5 months to 2.6 years [22]. This prolonged state of chronic pain and diagnostic uncertainty is frequently associated with comorbid mental health conditions, including anxiety, depression, panic disorder, and post-traumatic stress disorder [23]. Such psychological impacts are particularly prevalent in the pediatric population; studies by Stiles-Shields et al. indicate that more than half of pediatric patients evaluated for MALS present with at least one comorbid psychiatric condition [24].

Beyond the classic presentation, MALS can occasionally manifest through highly unconventional clinical signs. A notable example of this is the reported occurrence of obstructive jaundice, which can result from the direct compressive effect of multiple pancreaticoduodenal artery aneurysms (PDAAs) on the common bile duct. While such a presentation is extremely rare, it demonstrates the complex relationship between MALS-

induced hemodynamic shifts and secondary mechanical complications in the retroperitoneal space [25].

Diagnosis

MALS is usually a diagnosis of exclusion. Prior to MALS evaluation, a comprehensive gastroenterology assessment is recommended to exclude more common causes of the patient's symptoms. Esophagogastroduodenoscopy, colonoscopy, motility studies, cross-sectional imaging, and relevant hematologic tests should be performed [6]. A diagnosis of MALS is typically considered only when persistent abdominal symptoms, which cannot be attributed to other causes, occur in conjunction with radiological evidence of celiac artery (CA) stenosis or obstruction resulting specifically from external compression [14].

However, identifying CA stenosis is merely the clinical starting point. In the differential diagnosis of MALS, it is necessary to distinguish extrinsic compression from internal vascular pathologies or systemic disorders that may manifest with similar arterial narrowing or the formation of visceral artery aneurysms. Physicians have to carefully exclude atherosclerosis—the most common cause of arterial stenosis—as well as rare hereditary and non-inflammatory vascular conditions. These include Marfan syndrome, vascular Ehlers-Danlos syndrome (vEDS), segmental arterial mediolysis (SAM), fibromuscular dysplasia (FMD), and various chronic infections. Furthermore, it is critical to differentiate MALS-induced changes from pancreatitis-related pseudoaneurysms, which may present with similar vascular complications but necessitate fundamentally different management strategies [26].

Diagnostic methods

Imaging is important for diagnosing MALS. Several methods can help with this, but some are more effective than others. These include computed tomography angiography (CTA), Doppler ultrasound, and magnetic resonance angiography (MRA). Each method can help assess how much the celiac artery is narrowed. Still, imaging should be combined with clinical symptoms to judge how severe the disease is [21].

Ultrasound examination

Duplex ultrasound (DUS) is the recommended first-line investigation. Compared to angiography, DUS is more cost-effective, noninvasive, and does not expose patients to significant radiation [6]. The diagnostic process utilizes a combination of grayscale, color, and spectral Doppler to visualize the characteristic "hook" sign—a focal, downward angulation of the celiac artery. This morphological feature is important as it distinguishes extrinsic compression by the median arcuate ligament from intrinsic pathological narrowing, such as atherosclerosis [19].

Hemodynamic assessment is performed by measuring the peak systolic velocity (PSV) during different respiratory phases. A PSV markedly exceeding normal limits during expiration—with thresholds ranging from >226 cm/s [27] to >249 cm/s [28]—is considered highly suggestive of significant compression. A primary diagnostic criterion is the dynamic nature of these findings: during inspiration, the ligament typically relaxes, leading to a normalization of flow or a decrease in PSV by more than 68 cm/s. Such respiratory-dependent fluctuations are considered pathognomonic of celiac artery compression in MALS [27, 28].

Computed tomography (CT)

CT angiography is often needed to evaluate how severe the stenosis is. A typical sign is focal narrowing or extrinsic compression at the start of the coeliac trunk, which makes it look hooked or J-shaped. Another radiological sign is the "hair bun and shawl" sign. This appears when the distorted coeliac trunk is seen on a single axial plane, positioned between the abdominal aorta at the back and the median arcuate ligament at the front, which almost surrounds both. These features look like a head (the aorta) with hair in a bun (the coeliac trunk origin), covered by a shawl (the median arcuate ligament). Recognizing these signs helps diagnose the condition during routine scans and when screening patients [29].

In addition to these primary morphological changes, CT effectively visualizes the secondary hemodynamic consequences of the obstruction. These include post-stenotic dilatation of the celiac trunk and the development of prominent peripancreatic collateral vessels, which function as critical imaging indicators of significant proximal compression [30].

Magnetic resonance (MR)

Magnetic resonance angiography (MRA) demonstrates superiority in specific scenarios, particularly for diagnosing and planning preoperative management of median arcuate ligament syndrome (MALS) in pediatric populations [21].

Treatment methods

The primary goal in treating patients with MALS is to relieve symptoms caused by compression of the median arcuate ligament on the celiac trunk and plexus. Treatment options include celiac plexus block, celiac angioplasty, celiac bypass, and either open or minimally invasive (robotic or laparoscopic) median arcuate ligament release, or a combination of these [22]. According to the literature reports, 97% of procedures performed for median arcuate ligament syndrome (MALS) involve median arcuate ligament release [31]. While both open and minimally invasive techniques are utilized, the laparoscopic approach is often preferred due to its clinical benefits, such as lower postoperative pain, shorter hospital stays, and faster overall recovery [32].

The efficacy of these surgical procedures was recently evaluated in a 20-year international study published in 2023 by the Vascular Low Frequency Disease Consortium, which looked at 516 median arcuate ligament (MAL) release procedures. Of these, 227 were open surgeries, 235 were laparoscopic, and 54 were robotic. The study found no significant difference in long-term failure rates between open and laparoscopic MAL decompression, but open surgery had higher rates of complications during the perioperative period. Furthermore, the study showed that 51.9% of patients were free from treatment failure at three years (95% CI, 46.1%-57.3%). Factors linked to higher rates of treatment failure included robotic MAL release, previous gastroparesis, a history of abdominal cancer, swallowing difficulties, no relief from a preoperative celiac plexus block, and having pain in more locations [33].

Beyond its primary management, MALS retains significant clinical relevance as an incidental yet important factor in major hepatopancreatobiliary (HPB) surgery. This consideration is particularly important during the Whipple procedure (pancreatoduodenectomy), where surgical success relies on maintaining adequate arterial perfusion to the liver and stomach. In cases of undiagnosed MALS, intraoperative division of collateral vessels may precipitate acute postoperative ischemia. The resulting hypoperfusion is a substantial concern, as it

markedly increases the risk of anastomotic leakage, a complication that can markedly impair patient recovery [34].

Open approach

Traditionally, surgeons decompressed the celiac artery using an open approach, either with a chevron or upper midline laparotomy to locate the MAL and celiac artery. They would then cut the compressive band, remove the celiac ganglion (ganglionectomy), and fully expose the proximal celiac artery. Ganglionectomy is preferred over simple neurolysis to better address neuropathic pain in MALS. Recently, laparoscopic methods have become more common for decompressing the celiac artery [31].

Laparoscopic

Advances in minimally invasive surgery have made laparoscopic decompression the preferred method for treating MALS. This approach is valued because it uses smaller incisions, which reduces surgical trauma, lowers complication rates, and gives surgeons a better view of the periaortic anatomy [35]. Approximately 85% of patients experience immediate symptom relief following laparoscopic decompression of the celiac artery [36]. However, this technique also has some challenges. Limited space can make it hard to fully divide the median arcuate ligament fibers, which may cause symptoms to continue. Also, because the dissection is close to major blood vessels, there is a small risk of accidentally injuring the abdominal aorta [35].

For this laparoscopic procedure, the patient is placed in the reverse Trendelenburg position, and five ports are used. The main goal is to clearly expose the diaphragmatic crura for improved visualization during surgery. The dissection moves upward to find the celiac trunk and its main branches: the common hepatic, left gastric, and splenic arteries. For better safety and visibility, the left gastric artery is usually pulled aside with a vessel loop. After reaching the abdominal aorta, the surgeon identifies the median arcuate ligament fibers and the celiac plexus. The surgeon uses hook diathermy to remove the median arcuate ligament, which relieves pressure on the blood vessels. At the same time, the celiac plexus fibers are cauterized to block pain signals. Throughout the procedure, it is important to watch for unusual or extra blood vessels and preserve them to keep blood flowing to the liver and other nearby organs [37].

Robotic

The clinical application of robotic technology for MALS was first reported by Jaik et al. in 2007, documenting a successful median arcuate ligament (MAL) release in a 23-year-old woman who achieved full symptom remission at a six-week follow-up [38]. Since this landmark case, the robotic platform has become a sophisticated alternative to conventional methods, particularly for the meticulous periaortic dissection required in MALS management.

The incorporation of robotic platforms into the treatment of median arcuate ligament syndrome (MALS) constitutes a considerable technological development. The seven degrees of freedom in the instrument joints, tremor filtration, and high-definition three-dimensional visualization of abdominal structures enable robotic assistance to markedly enhance surgical precision. Additionally, the robotic platform offers surgeons greater ergonomic comfort compared to both open and conventional laparoscopic surgery. These advantages, combined with the use of a third robotic arm, can lower dependence on manual assistant retraction. Although robot-assisted procedures currently remain more expensive than classic approaches, the chance for better patient safety and surgical comfort is often considered paramount [39].

The clinical value of this approach is confirmed by a 2024 systematic review encompassing 290 patients. The analysis showed favorable perioperative outcomes, including an average operative time of 117 minutes and minimal estimated blood loss of 5-30 mL. Furthermore, the study reported a low conversion rate of 1.37% and an average hospital stay of less than two days, supporting the viability of the robotic platform as a precise and safe alternative for MALS management [40].

Revascularization

Current clinical evidence does not support using primary celiac artery (CA) revascularization as the first treatment for MALS. Instead, most experts recommend starting with a release procedure to lower the risk of complications that come with stenting a vessel still under pressure. Placing a stent in a CA that is still compressed by the median arcuate ligament can lead to structural problems, such as stent fracture or displacement[14].

Secondary revascularization procedures, such as CA stenting, bypass surgery, or celiac ablation, should be reserved for carefully selected patients. These treatments are usually considered only if significant narrowing and symptoms continue after the initial surgical

decompression of the MAL [14,35]. This step-by-step approach ensures that the anatomical compression is fully addressed before any permanent vascular reconstruction is performed.

Conclusions

Median arcuate ligament syndrome often causes non-specific symptoms that can last for a long time. It should be considered when diagnosing patients with nausea, vomiting, postprandial pain, and sitophobia. Doppler ultrasound is usually enough for an initial diagnosis, but other imaging tests are often needed. Surgery remains the only proven way to relieve symptoms. Options include laparoscopic or robotic-assisted ligament release (celiac artery decompression), open surgical decompression, and, if arterial narrowing continues, celiac artery revascularization or stenting. Despite many studies, there are still questions about the role of celiac ganglionectomy, the long-term results of ligament release alone, and which patient factors predict good surgical outcomes. More research is needed to answer these questions.

Disclosure:

Authors' contribution

Conceptualization AB and MM;

Methodology: MB and JA;

Software: BC and AO;

Check: ZC, KK and MB;

Formal analysis: AB;

Investigation: MZ and BC;

Resources: KG and MM;

Data curation: AO;

Writing - rough preparation: JA and ZC;

Writing - review and editing: AB, ZC and MZ;

Visualization: MB and KG;

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