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Robotic Approach for Median Arcuate Ligament Relief: A Case Report and Literature Review

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Rezumat

Abordul robotic în sindromul de ligament arcuat median: prezentare de caz

Indroducere: În prezent, sunt descrise puține cazuri de sindrom de ligament arcuat median cu tratament chirurgical prin abord robotic. Această entitate patologică apare în momentul în care baza trunchiului celiac este comprimată de ligamentul arcuat median al diafragmului. Următoarele simptome tipice sunt descrise acestui sindrom: discomfort şi dureri în etajul abdominal superior, în mod particular post prandial şi scădere în greutate. În timpul investigațiilor este important să se excludă alte cauze ce pot determina simtomatologie similară şi de a demonstra, prin mijloace imagistice, comprimarea trunchiului celiac. Secționarea ligamentului este elemental principal al tratamentului chirurgical.

Caz clinic: O pacientă în vârstă de 25 de ani s-a prezentat în urgență cu dureri severe în etajul abdominal superior după efort fizic şi, de asemenea, post-prandial. Diagnosticul de sindrom de ligament arcuat median a fost ulterior stabilit prin tomografie computerizată, ecografie Doppler şi angio-CT. După instituirea tratamentului conservator şi pregatirea preoperatorie specifică, am practicat secționarea ligamentului prin abord robotic. Pacienta a fost externată fără incidente în ziua a doua postoperator. Studiile imagistice postoperatorii nu au descris stenoză reziduală la nivelul trunchiului celiac.

Concluzii: Am raportat cazul unei paciente cu diagnosticul de sindrom de ligament arcuat median, tratat prin abord robotic. Utilizarea platformei robotice este fezabilă şi oferă siguranță atât pentru pentru pacient cât şi pentru actul chirurgical.

Cuvine cheie: sindrom Dunbar, stenoză de trunchi celiac, chirurgie robotică, ligament arcuat median

Abstract

Introduction: There are very few reported cases of robotic surgery for median arcuate ligament syndrome. This clinical condition develops when the root of the celiac trunk is compressed by the median arcuate ligament of the diaphragm. The symptoms that typically accompany this syndrome are: discomfort and pain in the upper abdominal region, particularly after eating, and weight loss. During the diagnostic process, it is important to rule out other potential causes and demonstrate compression using any imaging technique available. Transecting the median arcuate ligament is the primary focus of the surgical treatment. We report a case of robotic MAL release, focusing on the particular aspects of the surgical technique. A literature review was also performed on the topic of robotic approach for MALS.

Clinical case: A 25-year-old woman presented with sudden onset severe upper abdominal pain after physical activity and eating. She was then diagnosed with median arcuate ligament syndrome by imagistic means with computer tomography, doppler ultrasound, and angiographic computed tomography. After conservative management and careful planning, we performed robotic division of median arcuate ligament. The patient was discharged from the hospital without any complaint on the second day after surgery. Subsequent imaging studies revealed no residual celiac axis stenosis.

Conclusion: The robotic approach is a safe and feasible treatment modality for median arcuate ligament syndrome.

Key words: Dunbar syndrome, celiac trunk stenosis, robotic surgery, median arcuate ligament

Introduction

The celiac artery compression syndrome (CACS) is a rare condition characterized by prolonged postprandial abdominal discomfort, epigastric pain, and weight loss. The syndrome develops when the median arcuate ligament (MAL) of the diaphragm induces extrinsic compression and constriction of the celiac artery (CA){Bibliography} (1). Although it was first described back in 1963 by Harjola et al (2), there has been no progress made in defining the pathophysiological mechanism. The presence of celiac compression in asymptomatic individuals is indicative that the mechanical injury generated by extrinsic compression is not the only source of the harm to the celiac artery (3). Moreover, given the rarity of the disease, there is no consensus in terms of the optimal surgical technique (4).

Open surgical division of the MAL was first described by Dunbar in 1965 (5), in 13 patients, with good results, and it has been the most widely accepted treatment for symptomatic patients since. Concomitant celiac bypass or patch angioplasty may be performed to prevent reinterventions for residual stenosis (6).

The laparoscopic approach was then described by Roaye et al. in the early 2000s with a concurrent drop in open procedures (7,8).

The first reported use of robotic surgery for MAL release was described by Jaik et al. in 2007 in a case of a 23-year-old woman with symptom remission at 6-week follow-up (9). The downsides of the laparoscopic approach are the limited maneuverability of the instruments and the presence of a confined space. Vascular damage is the most common intraoperative consequence during laparoscopic MAL release (7.3%) compared to robotic approach (5.3%) (3).

The robotic method may bring better

accuracy during finer dissection procedures in delicate spaces and could result in a more effective MAL release (10,11).

This article presents a case of MALS that was successfully treated by robotic decompression. This case report was developed based on SCARE criteria (12).

Case Report

We present the case of a 25-year-old female who presented to the Emergency Department of Ponderas Academic Hospital, Bucharest, with upper abdominal pain for the last 24 hours. The pain had started after intense physical activity during the previous day and then worsened after a copious meal. When she presented to the emergency department the pain was hard to tolerate and she was laying in antalgic position. Nausea was an accompanying symptom, but there was no vomiting. She had a history of recurrent post-prandial colicky abdominal pain for the past few years. The patient had no history of chronic disease or drug use.

On admission, the patient had a mildly distended abdomen, with diffuse pain at rest and on palpation, with the maximum intensity around the umbilical area and in the upper abdomen. There were no signs of peritoneal irritation. The laboratory tests were essentially unchanged (no anemia, no elevated white blood cells, normal amylase levels and normal liver tests, normal D-Dimer levels) apart from an elevated creatine kinase level of 238 U/L.

The abdominal X-ray showed no air-fluid levels or pneumoperitoneum. Emergency CT scan with intravenous contrast showed severe compression of the proximal celiac axis by the median arcuate ligament, L5 lumbar scoliosis and unicornuate uterus.

The patient was admitted to the surgical ward to resume the investigations and receive appropriate arrangements. Intravenous fluid therapy, analgesia, and low molecular weight heparin were employed as conservative measures. With progressive symptom relief, the patient remained hemo-dynamically stable and apyretic. Repeated blood tests revealed no increase in cellular ischemia/necrosis markers.

Dynamic re-evaluation with abdominal Doppler Ultrasound (DUS) showed a decrease in velocity in the celiac trunk during antalgic position, with normalization of velocity during dorsal decubitus.

CT Angiography (CTA) confirms a

Figure 1. 3D reconstruction of CTA showing proximal celiac trunk stenosis and post-stenotic dilatation.

remarkable narrowing of the celiac trunk at 2 cms from its origin from the aorta, with concomitant limitation of blood flow of more than 90 per cent. *Figure 1* shows a 3D reconstruction of abdominal aortic angiotomography showing severe stenosis of the proximal segment of the celiac axis and post-stenotic dilatation.

The case was extensively discussed in multidisciplinary meetings and there was a consensus to proceed to surgery. Informed consent was obtained.

The procedure was performed under general anesthesia. The patient was placed in a reverse Trendelenburg position with his legs spread apart. The operation was performed using the Da Vinci Xi (Intuitive Surgical, Sunnyvale, CA). Trocar positioning is shown in *Fig. 2*. We used grasper, 30º angle scope, bipolar forceps and monopolar scissors). After establishing the pneumoperitoneum and trocar insertion, a complete abdominal cavity inspection was performed. No other significant findings were noted.

After division of the pars flaccida of the gastrohepatic ligament, the superior margin of the common hepatic artery and the left gastric artery were identified. The placement of vascular tape around the left gastric artery allowed an excellent exposure of the celiac trunk and facilitated traction (*Fig. 3*).

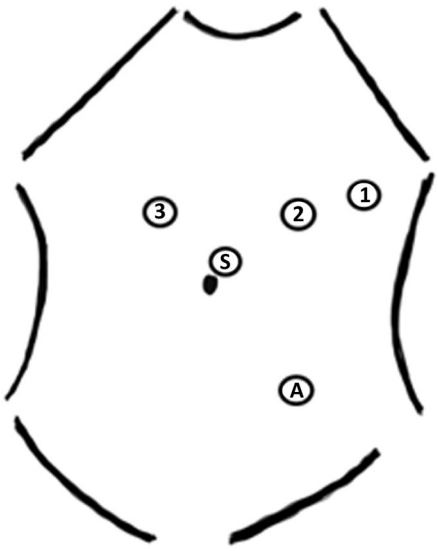

Figure 2. Port placement
1- Robotic trocar; 2 - Robotic trocar; 3 - Robotic trocar; S - Scope; A - AirSeal® and assistant port.

The right crus of the diaphragm was then identified, and the peritoneal lining of the right crus was opened, moving cranially from the celiac trunk. The MAL, which was very well represented, was then transected in a retrograde fashion up until 1.5 cms cranially from the origin of the celiac trunk. After complete sectioning of the MAL along with the neurolymphatic plexus, a significant bulge

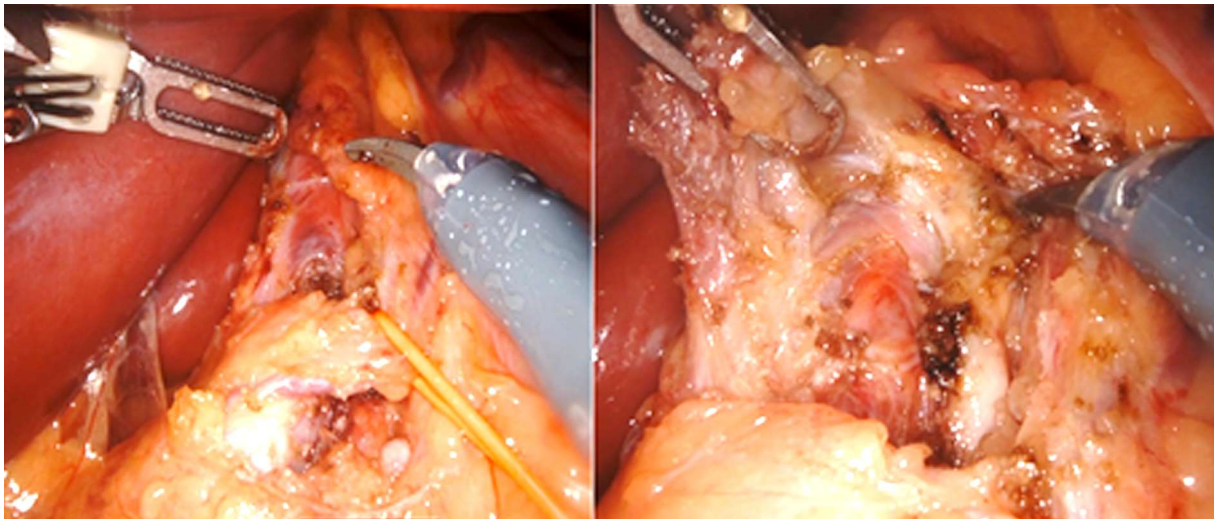

Figure 3. Median arcuate ligament and celiac trunk exposure by manipulating the left gastric artery.

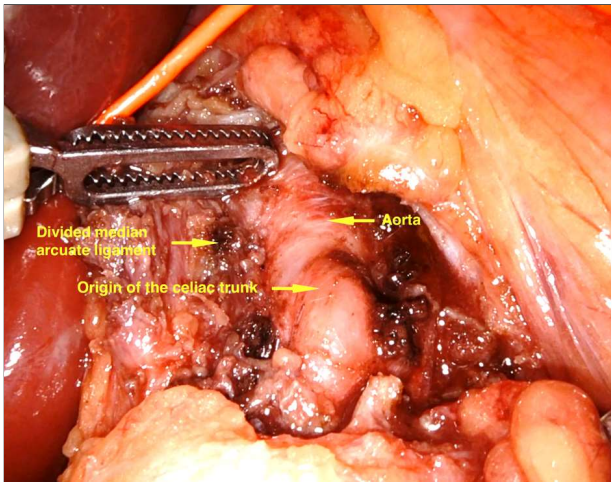

Figure 4. Pressure release and bulging of the celiac trunk after the last fibers of the MAL have been sectioned

and pressure release was seen from the celiac axis (*Fig. 4*).

Intraoperative Doppler Ultrasound confirmed complete MAL release. The operative time was 60 minutes, and there was no blood loss. After surgery, immediate symptomatic improvement was acquired. An enhanced CT scan with 3D reconstruction (*Fig. 5*) was repeated on postoperative day 1 which described a celiac trunk with a normal calibre, with homogenous opacification. The patient was discharged on postoperative day 2.

Subsequent Doppler Ultrasounds (follow-up at two weeks and 1 month) revealed no residual celiac axis stenosis or post-stenotic dilatation.

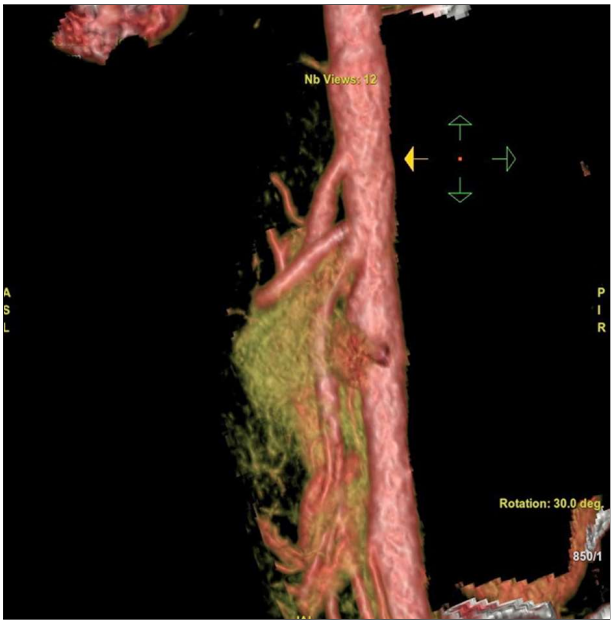

Figure 5. Follow-up 3D aortic reconstruction showing a normal caliber of the celiac artery, without evidence of stenosis (arrow head) or post-stenotic dilatation (arrow)

Literature Review and Summary

There are 9 studies (9,13-15) in the available literature that report a total of 71 specific cases with robotic MALR. Three of the publications are case studies, with the remaining six being cohort studies. A total of 41 patients (57.7%) had complete symptom relief, 14 (19.71%) had partial symptom resolution, 5 (7.04%) experienced symptom return, and 11 (15.49%) had no resolution. *Table 1* provides a summary of these findings. The higher

Table 1. Patient outcomes for all current published literature on robotic MALR

Author	N	Complete Symptom Resolution	Partial Symptom Resolution	No Symptom Resolution	Symptom Recurrence
Jaik et al, 2007	1	1 (100%)	0	0	0
Meyer et al, 2012	1	1 (100%)	0	0	0
Relles et al, 2012	3	2 (66.7%)	1 (33.3%)	0	0
You, et al, 2013	1	1 (100%)	0	0	0
Do et al, 2013	4	2 (50%)	1 (25%)	1 (25%)	0
Thoolen et al, 2015	9	4 (44.4%)	5 (55.6%)	0	0
Khrucharoen et al, 2019	18	8 (44.4%)	2 (11.1%)	3 (16.7%)	5 (27.8%)
Fernstrum et al, 2020	25	17 (68.0%)	1 (4.0%)	1 (4.0%)	6 (24.0%)
Magnus et al, 2022	9	5 (55.5%)	4 (44.4%)	0	0
TOTAL	71	41 (57.7%)	14 (19.71%)	5 (7.04%)	11 (15.49%)

number of studies evaluating laparoscopic and open release revealed a higher proportion of rapid symptom alleviation than for the present robotic literature. To accomplish this, both pre- and postoperative nonsurgical therapies, such as stenting, were employed more frequently. As a result, reliable outcomes amongst different treatment approaches are challenging in the present research.

Discussion

Although the incidence of MALS is unknown, it is more prevalent in young women (4:1) and in slender patients (4,16,17). An autopsy research study found that 34% of individuals of the overall population had celiac artery compression by the median arcuate ligament (18). In addition, undetected MALS may become clinically significant during pancreatoduodenectomy in up to 4% of patients following division of the gastroduodenal artery, necessitating intraoperative care for hemodynamic impairment in celiac distribution (19).

Anatomically, the MAL is a musculofibrous structure that connects the two anterior diaphragmatic crura to form the aortic hiatus (13). Low ligament insertion or high celiac axis takeoff, or both, might result in extrinsic compression of the celiac artery (3). When adequate blood flow cannot be accomplished after meals due to compression of the CA, patients have symptoms that are exacerbated especially during expiration (1,3,4).

Chronic postprandial epigastric pain, nausea, vomiting, diarrhea, and unintended weight loss are the most frequent symptoms of this condition. Because the symptoms of MALS closely resemble those of other abdominal illnesses, it is typically regarded as a diagnosis of exclusion (3,4,20).

The gold standard imaging approach is angiography with breathing maneuvers (1). However, when compared to angiography, DUS has advantages as an initial investigation because it is less expensive, noninvasive, and does not expose patients to high doses of radiation (4,21). In 2012, Gruber et al. carried out the largest study on the use of ultrasound in the diagnosis of MALS (22). According to Gruber's findings, functional ultrasound should be used as a screening tool.

When MALS is suspected, non-invasive CTA or magnetic resonance angiography (MRA) can be employed to confirm the location of the celiac trunk (21). The CTA and MRA provide precise 3D visualization and reconstruction of anatomical structures and are important parts of the routine preoperative examination because they both allow identification of concurrent abdominal pathology in addition to MALS findings (6,23,24).

Only symptomatic patients with confirmed celiac artery compression on vascular imaging studies should undergo celiac artery decompression. Postprandial abdominal symptoms should be monitored in asymptomatic patients (4).

The aim of treatment in MALS patients is to normalize celiac artery blood flow by cutting the median arcuate ligament (6,8,9,25). Endovascular intervention by itself does not address the extrinsic compression of the celiac artery, thus making it ineffective as an isolated treatment for MALS (6). Three surgical methods are described in the literature (16). The first method is the antegrade approach, and consists of cutting the MAL from the upper aorta down to the celiac axis (26). The second method is the retrograde approach. In this method, the transection of the MAL is done starting from the hepatic artery/left gastric artery going upwards on the aorta (27). The third method is a mixture of both approaches (28).

The decompression methods may be used either by open or minimally invasive techniques. Approximately 85% of patients will experience immediate symptom relief after laparoscopic decompression of the celiac artery (11,29). Nonetheless, instrument maneuverability is limited, which may result in a high conversion rate (9-11%) due to vascular injury (17).

Due to the seven degrees of freedom joints of the instrument, tremor filtration, and three-dimensional vision of abdominal cavity

structures, robotic assistance improves surgical precision (11). Furthermore, the robotic platform provides the surgeon with greater comfort during the operation than open or traditional laparoscopic surgery. These features, in conjunction with the utilization of the third arm, can also reduce the need for assistant retraction (30). Tight bands are frequently adherent to and also indistinguishable from the celiac arterial wall, which may be vulnerable to trauma during dissection (31). By using the robotic platform, the surgeon can perform accurate motions with no shaking while creating a secure surgical plane (14,27,30).

However, robot-assisted procedures are still costlier than equivalent open or conventional laparoscopic procedures, but the patient's surgical comfort and safety are paramount. Furthermore, in the event of arterial injury, the time to hemorrhage control may be extended as equipment is moved out of the field (30). This can be mitigated by technical ability to repair minor injuries robotically and by tactical use of instrumentation to control bleeding while preparing to perform a laparotomy.

Given the high response rate to surgical decompression, the prognosis for MALS is generally favorable. With a mean follow-up of 9 years, the largest contemporary series reports a symptom-free index of 75% (32).

Conclusion

Because there is a lack of published data on robotic MALR approached and outcomes, this study definitely adds to the current evidence. MALS diagnosis and treatment must be patient-centered. Robotic decompression is an effective treatment for MALS that can provide immediate symptom relief while being less invasive and much safer for the patient.

Conflicts of Interests

The authors have no conflict of interest.

Ethical Statement

All procedures performed were in accordance with the ethical standards of the 1964 Helsinki Declaration and its later amendments. Informed consent was obtained.

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