Clinical Case Report

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# Median arcuate ligament syndrome and arterial anastomotic bleeding inducing hepatic artery thrombosis after liver transplantation

## A case report

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**Abstract**

**Rationale:** Median arcuate ligament (MAL) may compress the coeliac trunk inducing median arcuate ligament syndrome (MALS). MALS is a risk factor for hepatic artery thrombosis (HAT) in liver transplant recipients.

**Patient concerns:** A thin female complained about upper abdominal pain for two months.

**Diagnoses:** The patient was diagnosed as primary biliary cirrhosis.

**Interventions:** The patient received two liver transplantations. During the first liver transplantation, the hepatic artery (HA) pulsations were normal. Doppler B ultrasonography showed normal blood flow in the HA in the first week. A 4 cm hematoma was detected in the first porta hepatis. On the ninth day, the hematoma had increased to 9 cm along with development of HAT. Exploratory laparotomy was performed. Bleeding at the site of arterial anastomosis was considered to be the reason for the hematoma. Doppler imaging revealed no blood flow in the liver. Computed tomography angiography demonstrated MALS. Salvage liver transplantation combined with dissection of MAL was performed. The maximum velocity of HA increased to 87 cm/s.

**Outcomes:** The patient was discharged from the hospital 17 days after the second transplantation. At discharge, the liver function was normal and Doppler showed good blood flow in the HA.

**Lessons:** MALS can cause HAT after liver transplantation. Before the liver transplantation, we should use Doppler B ultrasonography and sagittal CT imaging to judge whether the patient is with MALS. Also, before arterial anastomosis in liver transplantation is conducted, we should observe the impacts on the HA caused by pre-blocking gastroduodenal artery, which determines if we are supposed to do MAL dissection or bridge HA with aorta.

**Abbreviations:** ALT = alanine aminotransferase, AST = aspartate aminotransferase, CT = computed tomography, CTA = computed tomography angiography, DBIL = direct bilirubin, GDA = gastroduodenal artery, HA = hepatic artery, HAT = hepatic artery thrombosis, MAL = median arcuate ligament, MALS = median arcuate ligament syndrome, TBIL = total bilirubin, $V_{max}$ = maximum velocity.

**Keywords:** arterial anastomosis, hepatic artery thrombosis, liver transplantation, median arcuate ligament syndrome

### 1. Introduction

The fibrous ligament which connects the pairs of diaphragmatic crura mostly at the front top of the celiac trunk is called median arcuate ligament (MAL). The celiac trunk is liable to be constricted by MAL together with ganglions and nerve plexus, especially when the distance between the root of the celiac trunk and the diaphragmatic crura is limited. The clinical symptoms caused by the constriction of median arcuate ligament are referred to as the median arcuate ligament syndrome (MALS). Most patients who have few symptoms and are incidentally diagnosed on computed tomography (CT) require no treatment. Dissection of the MAL or arterial reconstruction is essential to increase collateral blood flow in patients who experience intermittent abdominal pain, postprandial abdominal pain, or abdominal pain after exercise.[1] MALS has an adverse effect on the liver graft. Some reviewers suggest that MALS may contribute to a decrease in the mean hepatic artery (HA) velocity from 425 to 200 cm/s.[2] This indicates that MALS may disturb the graft blood supply from HA, delay the recovery of graft function, and eventually lead to biliary complications. MALS is considered a high-risk factor for hepatic artery thrombosis (HAT) in liver transplant recipients[3,4]; however, few associated cases have been reported till date.

Here, we report a patient who underwent 2 orthotopic liver transplantations within a period of 10 days. The first transplantation was performed to treat primary biliary cirrhosis, whereas the salvage transplantation was performed because of HAT triggered by arterial anastomotic bleeding and MALS. Based on a literature review, we found that although the incidence rate of MALS in liver transplant recipients can reach 3.7% to 10%, seldom is HAT induced by this syndrome.[5] Here,

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we discuss the settings in which MALS can trigger HAT and propose steps to reduce the complications attributable to MALS in liver transplant recipients.

## 2. Case report

The study was approved by the institutional review board of Jilin University. The informed consent for the research and publication has been signed by the patient. A 52-year-old woman was diagnosed as primary biliary cirrhosis, portal hypertension, and upper gastrointestinal tract hemorrhage, with no family or psychological history. Then she received orthotopic liver transplantation in our hospital. Two months before the first liver transplantation, the patient began to complain of upper abdominal pain. Epigastric tenderness and jaundice were the main clinical findings. The liver donor was a 52-year-old female victim of severe craniocerebral trauma and the liver was donated after brain death. Warm ischemia time was 3 minutes, and cold ischemia time was 10 hours. The bleeding volume during surgery was 1800 mL. Arterial anastomotic reconstruction was achieved by anatomosing the celiac trunk of the recipient and the bifurcation between the common hepatic artery and the gastroduodenal artery (GDA) of the donor. The hepatic artery pulsations were normal after achievement of vascular patency and at the completion of the surgery.

In the first week after operation, we used Doppler B ultrasonography for daily monitoring, and the maximum velocity ($V_{max}$) of hepatic artery was 25 to 40 cm/s with a normal wave form. At the same time, a hematoma (diameter 4 cm) was observed in the first porta hepatis. As the size of the hematoma remained stable and laboratory investigations showed progressive improvement in liver function indices (Fig. 1), no active intervention was planned for the hematoma.

Obvious jaundice was observed on the ninth day after the operation. Laboratory examination showed alanine aminotransferase (ALT) 337.5 U/L, aspartate aminotransferase (AST) 88.9 U/L, total bilirubin (TBIL) 210 mmol/L, and direct bilirubin (DBIL) 130 mmol/L (Fig. 1). Of note, the diameter of the hematoma had increased to 9 cm and an abnormal wave form of the outer HA was detected, whereas $V_{max}$ of inner HA had decreased to 10 cm/s and resistive index dropped to 0.4; these findings were consistent with the formation of arterial thrombosis (Fig. 2A and B). Dilatation of the bile duct was also observed. Exploratory laparotomy was performed immediately. During the operation, bleeding from the site of arterial anastomosis was considered to be the reason for the hematoma. In addition to the thrombus, lack of pulse was observed in the outer hepatic artery, which was remote from the site of anastomosis No. 4 Forget duct was utilized to eliminate the thrombus. The pulse of the outer HA was recovered to normal; however, no blood flow in the liver was detected on Doppler B ultrasonography. Furthermore, radiography through splenic artery revealed a tenuous inner HA. It was inferred that the thrombosis had occurred in the inner HA as well. Thrombolytic therapy with alteplase was administered.

Six hours after intravenous injection of alteplase, no blood flow was detected by Doppler; moreover, one 2 cm × 3 cm ischemic lesion was observed in the right liver lobe. Serum AST level was increased to 1461 U/L and serum ALT level was increased to 2611 U/L. Digital subtraction angiography was performed immediately, which showed recurrence of thrombosis and eccentric stenosis of the root of the celiac trunk (Fig. 2D and E). Enhanced CT and sagittal reconstruction revealed that MAL had compressed the celiac trunk which led to MALS (Fig. 2C).

Salvage liver transplantation combined with dissection of MAL was performed on the same day (Fig. 2F). After the operation, the $V_{max}$ increased to 70–87 cm/s. Three days later, laboratory examination showed ALT 79 U/L, ALT 299 U/L, TBIL 54 μmol/L, and DBIL 24 μmol/L. The patient was discharged from the hospital 17 days after the salvage liver transplantation with absolutely normal liver function (Fig. 1).

## 3. Discussion

Hepatic artery thrombosis is 1 of the most serious early complications of liver transplantation and an important cause of graft loss of function, graft host death, and re-transplantation. Even with successful thrombectomy or thrombolysis, some cases develop biliary duct complications.[6] Usually, anastomotic stenosis, inversion of anastomosis, arterial tortuosity or arterial angulation, and other technical factors are the main reasons for HAT. However, other factors that may contribute to decreased blood flow, such as splenic artery steal syndrome, small diameter of HA, and also MALS should also be taken into consideration.[3]

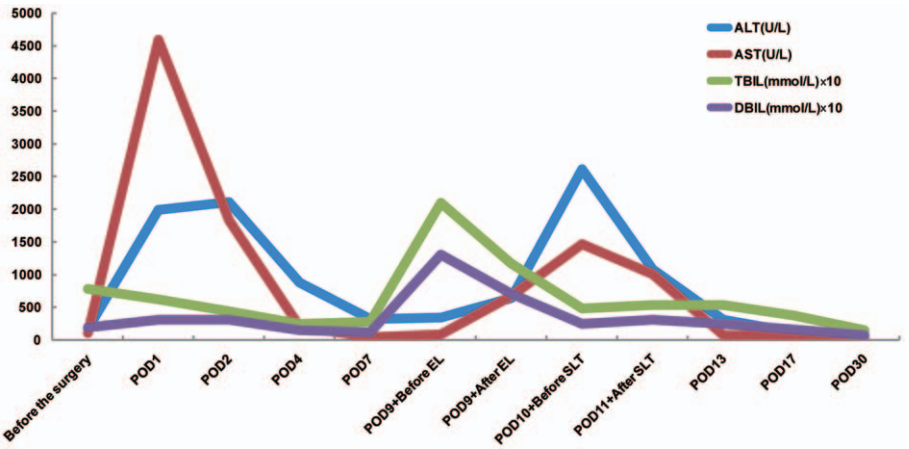


**Figure 1.** Course of alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin (TBIL), and direct bilirubin (DBIL) during the perioperative period. EL = exploratory laparotomy, POD = postoperation day, SLT = salvage liver transplantation.

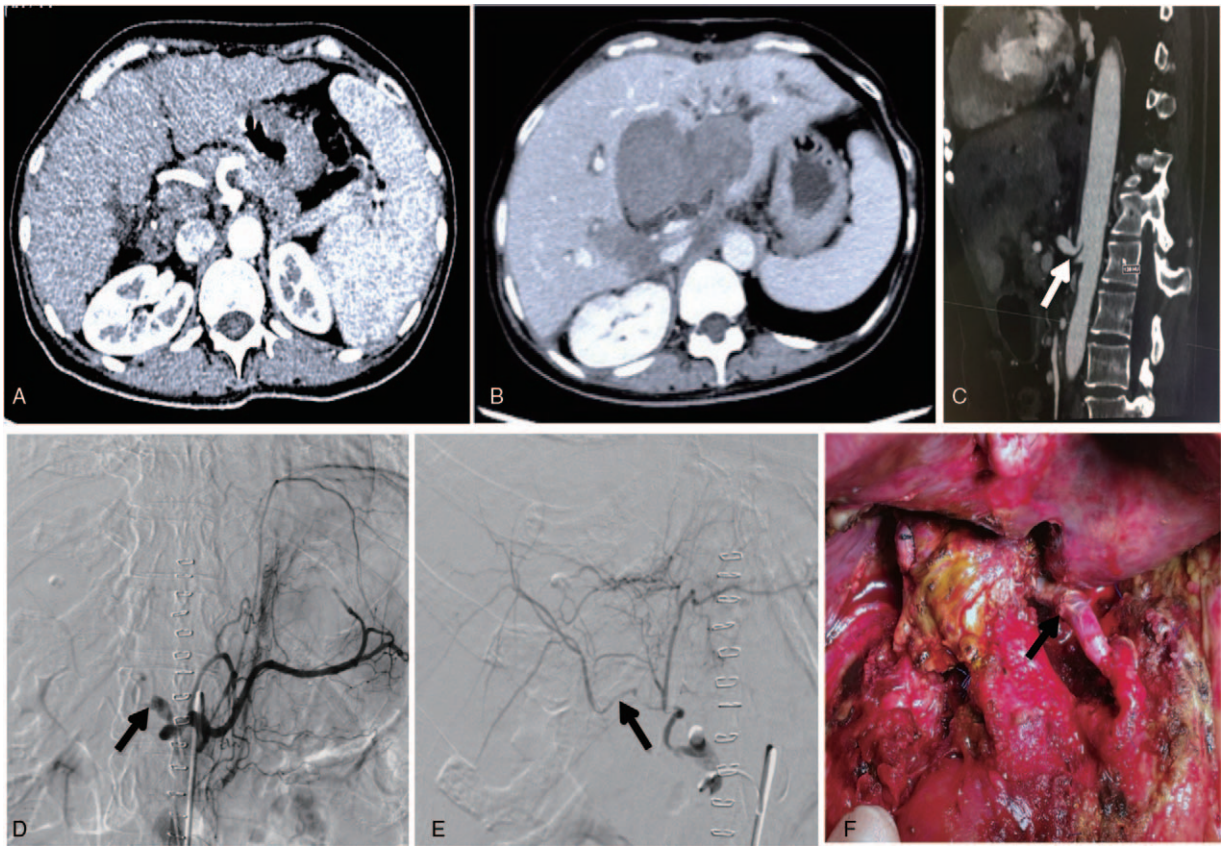


**Figure 2.** Diagnostic data for MALS and hepatic arterial thrombosis. (A) Enhanced CT before the first transplantation. (B) Enhanced CT on POD9 showing the formation of hematoma, dilatation of the intrahepatic bile duct, and the ischemic lesion. (C) Computed tomographic angiography showing stenosis of the celiac trunk (arrow) compressed by the MAL. (D) DSA in anteroposterior projection of the celiac trunk performed on POD 10 (after the exploratory laparotomy) showing thrombosis of hepatic arterial anastomosis (arrow). (E) DSA in anteroposterior projection of hepatic artery performed on POD 10 (after the exploratory laparotomy) showing decreased blood supply and thrombosis of the hepatic artery (arrow). (F) Intraoperative photograph showing hepatic arterial thrombosis (arrow) during salvage liver transplantation. DSA = digital subtraction angiography, MAL = median arcuate ligament, MALS = median arcuate ligament syndrome, POD = postoperation day

In 1917, Lipshutz[7] first described the phenomena of compression of abdominal aorta. Harjola[8] and Dunbar et al[9] reported cases of MALS in 1963 and 1965, respectively. Until 1972, Colapinto et al[10] utilized CT to provide the first imaging diagnosis of MALS. Clinicians typically employ a combination of imaging findings, clinical symptoms, and exclusion of other diseases to establish a diagnosis of MALS; however, there is a lack of standardized diagnostic criteria for MALS. This partly explains the wide variability in the reported incidence of MALS. According to the data provided by Harjola,[8] the estimated prevalence of MALS in the general population varies from 10% to 24%; however, only 1% of the population develops severe stenosis of the celiac trunk. Fukuzawa et al reported 1.6% to 10% incidence rate of MALS amongst liver transplantation recipients, based on the number of patients in whom hepatic artery pulse could only be restored by dissection of MAL or aortic arch bridging.[2,5,11] Gruber et al[12] adopted Doppler B ultrasonography to examine 362 patients, and found that 1.7% patients had MALS. Higher incidence rate was observed in earlier reports; in our opinion, this reflects the development of the understanding of MALS over the decades. In this case, we paid no attention to MALS because of the lack of awareness of this syndrome in the process of the first transplantation, and also the exploratory laparotomy, and obviously, we did not deal with the MAL at first. Therefore, even after the exploratory, the liver function decreased gradually. Then, based on previous researches, we hypothesized MALS might be blamed for the failure of the operations. Also, it is demonstrated by the fact that after the dissection of MAL and the salvage liver transplantation, the patients recovered finally.

What can we do during the first transplantation to decrease the side effects caused by MALS? We searched the other reports. Portal hypertension, hypersplenism, and interventional therapy in patients with liver cancer were reported to attenuate the hepatic artery and decrease the blood flow. Bifurcation between the common hepatic artery and GDA of recipients are usually chosen for anastomosis, which implies that the blood supply from the superior mesenteric artery through GDA to HA may be blocked; this tends to amplify the effect of MAL on the blood flow in the HA. According to some reports, MALS decreased the mean blood flow of HA from 425.7 to 200 mL/min,[2,13] and caused ischemic biliary duct complications. Jurim et al[2] demonstrated that MALS is an independent risk factor for HAT; however, only few recipients were reported to have undergone surgical treatment. This implies that not all transplant recipients require active intervention for MALS, unless MAL leads to moderate or severe stenosis. Interestingly, in some patients with MALS, amputation of GDA did not decrease the blood flow in the hepatic artery. This is likely attributable to the ectopic collateral

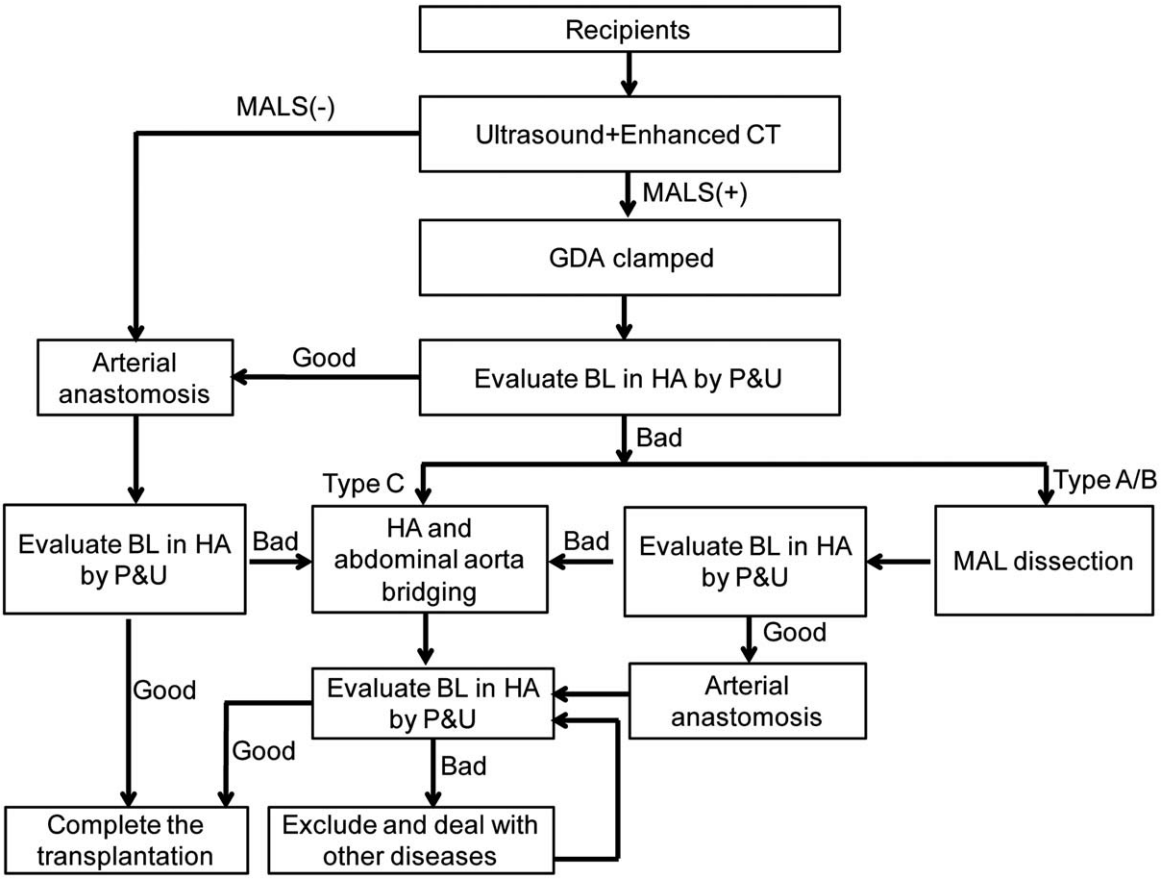


**Figure 3.** Algorithm for management of median arcuate ligament syndrome in liver transplantation if the celiac trunk of the recipient and the bifurcation between the common hepatic artery and the gastroduodenal artery (GDA) of the donor are chosen to be anatomosed. BL = blood flow, HA = hepatic artery, MAL = median arcuate ligament, MALS = median arcuate ligament syndrome, P&U = palpation and ultrasound.

circulation originating from the superior mesenteric artery and flowing into the common hepatic artery or the celiac trunk.

Obviously, an accurate diagnosis of MALS before liver transplantation is critical for formulating an appropriate surgical plan. Owing to the nonspecific symptoms, MALS is hard to distinguish from chronic liver disease; therefore, imaging plays an important role in preoperative diagnosis. Firstly, ultrasonography of celiac trunk is important for MALS diagnosis. Gruber et al compared the ultrasonography findings between 6 patients with MALS and 20 normal persons. They reported 2 indices that may facilitate a diagnosis of MALS: end-expiratory $V_{max}$ of celiac trunk >350 cm/s and end-expiratory upturn-angle (deflection angle) >50°. Combined use of these 2 indices for diagnosis of MALS was associated with 83% sensitivity and 100% specificity.[12] Lateral celiac trunk angiography used to be the gold standard for the diagnosis of MALS; however, with advances in imaging technology, it has been gradually replaced by computed tomography angiography (CTA).[14] When CTA is used, end-inspiratory arterial phase, end-expiratory portal venous phase, and sagittal artery reconstruction are necessary. In addition, it is critical to distinguish MALS from atherosclerosis and aorto-arteritis, both of which can cause thickening of the arterial intima; however, these kinds of stenosis are not alleviated by dissection of MAL.

According to the diameter of the stenotic part and the normal part, the length of the stenotic part, and the distance from the aorta, Sugae et al[15] classified MALS into 3 types. They suggested that it is not essential to pay attention to type A MALS in pancreatoduodenectomy; however, type B requires dissection of MAL, and artery reconstruction is recommended for type C lesions. Maintaining the blood supply of the hepatic artery is very important in liver transplantation and pancreatoduodenectomy. In particular, the liver graft (including liver and biliary duct) is more sensitive to hemodynamic changes in the hepatic artery; therefore, whether type A should be manipulated needs to be determined based on the pulse of HA during operation. To the best of our best knowledge, most MALS liver recipients till date were diagnosed after the arterial anastomosis was done, and the most valuable signs which indicated the need for intervention included the weak pulse of HA or the obvious change in pulse with respiratory movements.[2,5] Earlier, owing to the lack of awareness of MALS, clinicians usually bridged the HA and abdominal aorta. Nowadays, most surgeons opt for dissection of the MAL. Both interventions can restore the blood flow in the hepatic artery.[3,4,16–18] Some reports suggest that retaining GDA completely without dissection of MAL does not increase the incidence of arterial thrombosis, compared with that with arterial reconstruction.[16]

Based on our experience with this case, once the diagnosis of MALS is established in liver transplant recipients, and MALS is found to impede HA blood flow, the dissection of MAL, and also arterial reconstruction are valid interventions. Intravascular stenting might not be suitable for MALS owing to the stiffness of the MAL.[19] If the constriction of the celiac trunk is released in

time, the graft may regain normal function, which may preclude the need for a second transplantation. Thrombolysis alone shows limited effect on the thrombus promoted by MALS.

In conclusion, MALS has a relative low incidence in the general population. However, a better awareness of this condition during preoperative evaluation for liver transplantation may help formulate an appropriate surgical strategy, especially in thin patients or in patients with upper abdominal pain. Doppler B ultrasonography and sagittal CT imaging are important tools for diagnosis of MALS. Moreover, classification of this syndrome before transplantation confers considerable leverage during formulation of the surgical strategy. Misdiagnosis and delayed intervention may lead to severe arterial or biliary complications. The treatment principle during transplantation is evaluation of the hepatic artery after preblocking GDA through palpation, ultrasound, and also with the measurement of vascular velocity. If the pulse or $V_{max}$ is unsatisfactory, dissection of MAL should be conducted immediately. After completion of arterial anastomosis, it is indispensable to re-examine the artery by ultrasonography. If the dissection of MAL does not improve the blood flow of HA, bridging of HA with aorta should be performed (Fig. 3).

## Author contributions

**Conceptualization:** Guoyue Lv.
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**Visualization:** Guoyue Lv.
**Writing – original draft:** Xiaodong Sun, Zhongqi Fan.
**Writing – review & editing:** Zhongqi Fan, Guoyue Lv.

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