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# The use of splenic artery embolization to maintain adequate hepatic arterial inflow after hepatic artery thrombosis in a split liver transplant recipient

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## ABSTRACT

**INTRODUCTION:** Split liver transplant is gaining increasing use in the current environment of growing organ shortage. It is associated with a higher risk of complications, owing to its complexity and technical challenges. Splenic artery steal syndrome, is a complication that can occur following liver transplant and cause inadequate hepatic arterial inflow, hepatic artery thrombosis and graft loss. We report a successful management of hepatic artery thrombosis and splenic artery steal syndrome after a split liver transplant by surgical thrombectomy followed by angiography and splenic artery embolization.

**CASE:** 60-year old female, with liver cirrhosis, who underwent a deceased donor right lobe orthotopic liver transplant. The procedure was complicated by hepatic artery thrombosis, requiring re-exploration. However, despite anastomotic revision the patient had poor hepatic arterial inflow. Both angiography and ultrasonography demonstrated splenic artery steal syndrome. This was successfully managed by splenic artery embolization with improved hepatic arterial flow on ultrasonography and angiography.

**CONCLUSION:** Splenic artery steal syndrome is a rare complication that can occur after a liver transplant. Experience with this phenomenon is limited in split liver transplantation. We demonstrated successful early management of splenic artery steal syndrome with coil embolization in a split liver transplant preventing further morbidity and graft loss.

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## 1. Introduction

Split Liver transplantation was first introduced in the 1980s, but lost traction due to the ease of deceased donor whole liver transplantation. However, this procedure has seen some resurgence and has re-taken a more prominent role in the setting of on-going organ shortage [1].

Despite advances in surgical techniques, this procedure remains technically challenging, with a higher rate of post-operative surgical complications than traditional orthotopic liver transplantation (OLT). Significant reconstruction of both the vascular and biliary system must be performed after the organ is split in order to allow for adequate length and caliber of these conduits for implantation. These technical complexities and potential complications often translate to more difficult post-operative management [2]. We present a patient who underwent a right lobe split liver trans-

plantation complicated by early hepatic artery thrombosis. The patient subsequently developed splenic steal syndrome, which was successfully managed with empiric splenic artery embolization.

## 2. Case detail

The patient is a 60 year old female who developed end stage liver disease and liver cirrhosis due to non-alcoholic steatohepatitis (NASH). The patient underwent a comprehensive pre-transplant evaluation and deemed to be an acceptable candidate for a split liver transplant. The donor was a 32 year-old male brain dead donor with no major medical co-morbidities and a BMI 26. The left lateral segment was separated for a pediatric recipient leaving segments 4, 5, 6, 7, 8 for the adult recipient.

## 3. Transplant procedure

The donor underwent an uncomplicated right “split liver” hepatectomy including segment 4 with an intact right hepatic artery, right portal vein, inferior vena cava (IVC) and common bile duct. On the back table, the left hepatic vein stump was over sewn, the supra and infra hepatic IVC were stapled, the right hepatic artery was extended using donor external iliac artery segment and the por-

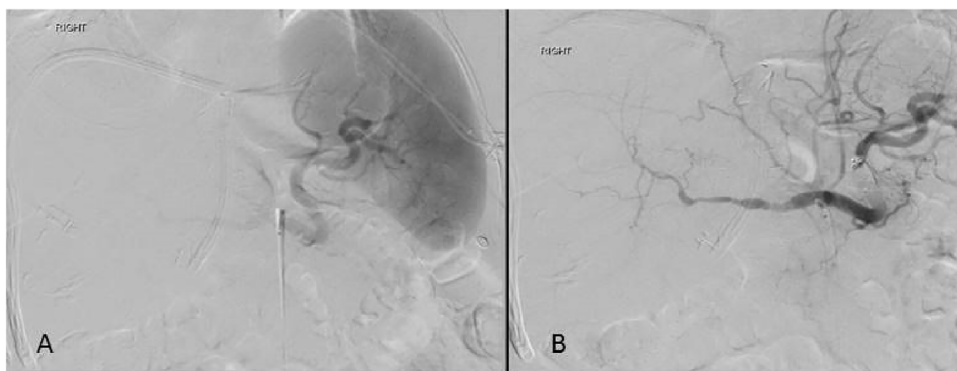
*Abbreviations:* OLT, orthotopic liver transplantation; NASH, non-alcoholic steatohepatitis; IVC, inferior vena cava.

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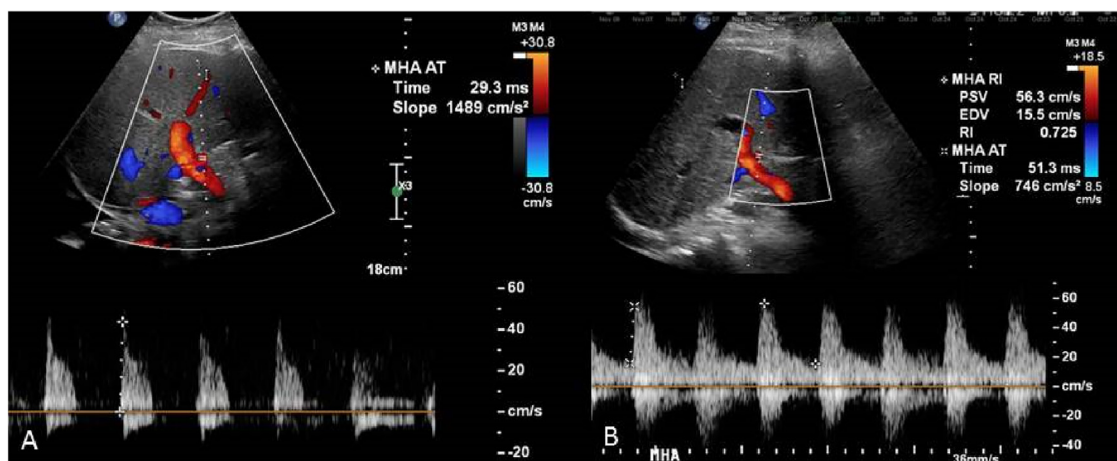
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**Fig. 1.** A. Angiography showing minimal flow within hepatic artery with significant flow within spleen. B. Post embolization with increased flow within the hepatic artery with opacification of distal hepatic artery.



**Fig. 2.** A. Doppler ultrasound showing lack of diastolic flow in the hepatic artery consistent with splenic steal syndrome. B. Post splenic artery embolization showing improved systolic and diastolic flow in the hepatic artery.

tal vein was extended using donor external iliac vein segment. The recipient surgery was done in standard fashion with using a transverse subcostal “chevron” incision. The donor hepatectomy was in standard fashion, leaving an adequate hepatic artery, portal vein and bile duct length. Transplantation was done by cavo-caval side-to-side anastomosis, the donor extended right hepatic artery was anastomosed to the recipient’s common hepatic artery, the portal vein of the recipient was anastomosed to the extended donor right portal vein and the donor common bile duct was anastomosed to the recipient common bile duct.

Adequate hepatic artery flow was verified by palpation and intraoperative Doppler signals. Flow measurements were not done intraoperatively. The patient’s initial post-operative course was unremarkable with normal liver function tests and down trending liver enzymes. We performed doppler ultrasounds within 6 h of completion of surgery and then daily. Doppler ultrasounds were normal on until post op day #3 when we were unable to detect flow within the hepatic artery. Given concern for hepatic artery thrombosis the patient taken back to the operating room emergently for exploration. No palpable pulse was noted in the artery, and after re-opening the anastomosis between the jump graft and the donor right hepatic artery, a thrombus was discovered. A successful thrombectomy was performed and the anastomosis was revised. Adequate flow was again restored as confirmed by intra-operative Doppler signals.

However, serial postoperative Doppler studies demonstrated worsening velocities and, increasing resistivity indices with absent diastolic flow. Therefore angiography was done, and demonstrated

poor flow within the right hepatic artery but otherwise strong flow within splenic artery. (Fig. 1A) The splenic artery was embolized, with immediate improvement of the flow within the transplant hepatic artery. (Fig. 1B) This was confirmed on post embolization Doppler studies, with significant improvement within the waveform and velocities within the donor hepatic artery (Fig. 2A-B). The rest of her post-operative course was uneventful and the patient was discharged home with normal liver function and normal arterial signals in the hepatic artery.

This work has been reported in line with the SCARE criteria [7]

#### 4. Discussion

Split liver transplantation has emerged a potential solution to organ shortage [1]. This remains a technically challenging procedure, requiring careful patient selection and close monitoring in the postoperative period. Given that some form of technical reconstruction is often required, it therefore necessary to maintain a high index of suspicion for postoperative complications, as a timely intervention prevents further morbidity and graft loss. In this patient, although the basic laboratory analyses, including lactate and LFTs remained unchanged and continued to improve, serial doppler ultrasounds was necessary to early detect hepatic artery thrombosis, not intervened on would have resulted major comorbidities [3]. Despite surgical thrombectomy and revision of arterial anastomosis, hepatic arterial inflow remained inadequate. Angiography was necessary to identify splenic artery steal syndrome with

the advantage of radiologic intervention to embolize the splenic artery and improve the hepatic arterial inflow.

Splenic artery syndrome is a poorly understood phenomenon with no current consensus on clinical diagnosis criteria. However, it is typically diagnosed on an angiogram and characterized by diminished flow to the transplanted hepatic artery without thrombosis and with significant flow diverting to the splenic parenchyma. There are no known definite causes of this syndrome however there have been many postulated theories including portal hyperperfusion causing hepatic artery vasospasm. Currently, there are no study proven risk factors to the syndrome however typical presentation is elevated liver enzymes with doppler ultrasound demonstrating poor hepatic artery flow, high resistivity index and reversal of diastolic flow. A follow up angiography is required to confirm the diagnosis. Treatment is largely based upon transcatheter techniques as it minimally invasive and effective [4].

Although coil embolization for splenic steal syndrome has been previously described [5], this case represents the first report of its use to salvage a split liver transplant allograft with favorable outcomes. There is no resulting functional asplenia as the splenic artery is not completely occluded and there is collateral flow through the short gastric arteries. In fact it has been previously described that the celiac axis can be utilized directly for arterial flow in liver transplantation without evidence of splenic ischemia [6]. Therefore post splenectomy vaccination is not required, which is beneficial in the immunosuppressed patient population.

This case is unique in the fact that the steal syndrome was detected after the patient already experienced a thrombosis event. Additionally, this was detected on routine imaging prior to any clinical symptoms or evidence graft dysfunction. In this case, the syndrome was successfully managed with angiography and embolization of the splenic artery, avoiding further operations and associated morbidity, while at the same time rescuing the allograft from potential early graft loss.

## 5. Conclusion

Splenic artery steal syndrome is an uncommon complication that can occur following a complicated split liver transplant procedure. Diagnosis of this condition requires a high index of suspicion, but can be managed non-operatively with angiography and coil embolization. Successful management can avoid further morbidity and early graft loss.

## Conflicts of interest

None.

## Sources of funding

None.

## Ethical approval

Case reports are exempt from ethical approval, as long as the patient is consented.

## Consent

Written and signed consent obtained from the patient.

## Author contribution

Kevin Ricci: Writing – Original Draft, Writing – Review & Editing, Visualization.

Ashraf El-Hinnawi: Conceptualization, Visualization, Writing – Review & Editing.

## Registration of research studies

N/A.

## Guarantor

Ashraf El-Hinnawi, MBBS, FACS.

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