Endovascular Embolization of Large Hepatic Arteriovenous Fistulas

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ABSTRACT

Treatment of hepatic artery to portal vein fistulas (HAPFs) has shifted in the past two decades from surgical resection of the involved liver to embolization. A uniform technique for percutaneous intervention has not been established because the approach is influenced by the size, location, and number of feeding arteries. We report two cases of HAPFs treated with embolization at our institution. Different outcomes in these two patients illustrate several fundamental principles in the treatment of HAPFs.

KEYWORDS: Endovascular, embolization, fistula, arteriportal, arteriovenous fistula

Objectives: Upon completion of this article, the reader should understand the nature of hepatic arteriportal fistulas and the current approaches to their successful treatment.

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Arteriovenous fistulas (AVFs) are direct connections between the arterial and venous systems. The lack of an intervening capillary bed results in a low-resistance pathway that increases in size over time until high flow causes clinical deterioration. These lesions can be congenital or acquired, and they may vary in clinical significance from those that are asymptomatic to ones in need of urgent intervention due to complications of the high flow through the fistula.

Hepatic arterial to portal vein fistulas (HAPFs) may present a therapeutic challenge. Their central

location within the liver may makes surgical resection impossible because of insufficient postoperative liver volume in both noncirrhotic and cirrhotic patients. In the past two decades, endovascular treatment has generally replaced surgery as the first-line treatment of these lesions.^{1–3} The optimal endovascular approach to HAPFs has remained unclear given the relatively small number of reported cases and a wide variation in techniques. We present two cases of endovascular embolization of HAPF with differing outcomes that demonstrate the behavior of these lesions when

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Figure 1 Pretreatment Doppler ultrasound of arteriovenous fistula. Note large size of fistula and high flow rate.

inadequately embolized and that emphasize important principles of fistula management in any location.

CASE 1

A 51-year-old man with Wilson's disease presented to his primary care physician with relatively sudden onset of weakness, confusion, weight loss, shortness of breath, muscle atrophy, and ascites. He had undergone multiple liver biopsies since childhood, the last 10 years prior. Previous biopsies had not shown cirrhosis, but the patient did report that an ultrasound 10 years before had shown what was thought to be portal vein thrombosis. The patient presented to our institution with the diagnosis of portal hypertension. However, treatment with diuretics by his primary care provider had been without benefit.

An ultrasound of the abdomen revealed a large right hepatic lobe HAPF (Fig. 1). A subsequent arteriogram confirmed the fistula and showed direct shunting from an enlarged and tortuous right hepatic artery to the right portal vein. Hepatofugal portal flow was demonstrated. Treatment was not immediately undertaken because the size of the fistula required coils not in inventory at the time. An embolization procedure was planned.

Before the planned embolization procedure, the patient began experiencing severe abdominal and back pain, nausea, vomiting, occasional confusion, and increasing ascites. Laboratory evaluation was notable for total bilirubin of 1.1 mg/dL, international normalized ratio of 1.6 U, partial thromboplastin time of

45.2 seconds, albumin of 2.9 g/dL, and creatinine of 1.6 mg/dL. After thorough discussions of the risks and benefits of surgical resection of the right lobe of the liver in a patient with underlying liver disease, a decision was made to attempt embolization given the high morbidity and mortality related to right hepatectomy in the setting of such a large fistula and underlying liver disease. The night before the scheduled elective procedure, the patient had an episode of massive gastrointestinal bleeding from esophageal varices requiring copious blood products, variceal banding, and sclerotherapy.

After stabilization, the patient was brought to the interventional suite. Hepatic arteriography confirmed the presence of a HAPF fed by a single enlarged hepatic artery (Fig. 2A). Selective left hepatic arteriography did not communicate with the fistula (Fig. 2B). Hepatofugal portal and coronary vein flow filled esophageal varices (Fig. 2C). Through a 6F guide sheath placed into the right hepatic artery, a 5F Davis catheter (Cook, Bloomington, IN) was advanced to the distal right hepatic artery just proximal to the fistula. Further advancement of the catheter or a subsequently placed microcatheter could not be achieved because of the tortuosity and length of the hepatic artery. It appeared that the HAPF fistula was fed by this single large hepatic artery branch. Embolization was performed from this position.

Three 15-mm Gianturco coils (Cook, Bloomington, IN) were placed as a backstop for further embolization with a total of 33 4-, 8-, 10-, and 12-mm Nester coils (Cook, Bloomington, IN) (Fig. 3). An immediate

Figure 2 Precociling angiograms. (A) Right hepatic arteriogram demonstrates site of expected arteriportal fistula. Note large tortuous right hepatic artery leading to site of fistula. (B) Left hepatic arteriogram does not show any collateral vessel to fistula. (C) Venography shows patent portal vein with retrograde flow.

follow-up hepatic arteriogram revealed stasis in the distal right hepatic artery and no filling of the portal vein via the fistula. Thrombosis of the portal vein was a concern after occlusion of such a large artery. However, given the patient's massive bleeding the night before, anticoagulation was avoided.

Over the next few days, the patient's symptoms improved, and he was discharged. He returned 1 month later with ascites that had returned to preprocedure levels, requiring frequent paracentesis. Repeat ultrasound and computed tomography (CT) evaluation revealed continued blood flow through the HAPF and

evidence of partial portal vein thrombosis. Repeat embolization was then performed.

A second main feeding vessel from the right hepatic artery to the HAPF was visualized (Fig. 4A). This artery had not been seen during the previous intervention. Subselective embolization of branches of this artery feeding the AVF was performed using a Rapid Transit microcatheter (Cordis, Miami Lakes, FL). The fistula itself could still not be crossed. A combination of 700- to 1000-micrometer Contour polyvinyl alcohol (PVA) particles (Boston Scientific, Natick, MA) (Fig. 4B) followed by multiple 4-mm

Figure 3 Coiling of main feeding vessel just proximal to fistulous communication. Note that microcatheter could not be advanced all the way to communication.

Nester coils were used for embolization of the feeding artery. The microcatheter was withdrawn into the main right hepatic artery, and this artery was embolized with additional PVA and 6-, 8-, and 10-mm Nester coils until complete stasis of the main right hepatic artery was achieved. Proper hepatic arteriography postembolization revealed no residual filling of the portal vein or HAPF (Fig. 4C). Superior mesenteric artery angiography revealed a patent extrahepatic portal vein with antegrade flow. The right portal vein branch was patent. Retrograde flow in the gastroduodenal artery was demonstrated. The patient was anticoagulated to prevent portal vein thrombosis and discharged home after 3 days.

The patient's ascites failed to resolve at 4 weeks, and subsequent CT evaluation revealed continued blood flow through the fistula (Fig. 5A). A third embolization procedure was undertaken. Arteriography at this time revealed multiple small feeding arteries arising from both the gastroduodenal (Fig. 5B) and left hepatic artery (Fig. 5C) to the HAPF. The previously embolized right hepatic artery remained thrombosed. Given the innumerable arterial feeding vessels, embolization of the venous drainage of the fistula was attempted. A large-volume paracentesis was performed. The left portal vein was accessed utilizing ultrasound guidance and an AccuStick set (Cook, Bloomington, IN), and a 5F Kumpe catheter (Cook, Bloomington, IN) was placed. Venography revealed patent left and main portal veins. The segment of the right portal vein

draining the dome of the liver was also patent. The large draining vein from the AVF could not be visualized, likely secondary to high-volume retrograde flow from the AVF (Fig. 6A). Multiple attempts using various catheter and guidewire combinations were unsuccessful at catheterizing the main vein draining the AVF from either this left portal approach or a subsequent right portal approach (Fig. 6B). At this point, the ascitic fluid being drained became blood tinged. Although the patient's vital signs remained stable, his hematocrit had dropped to 26.5% from 31.0%. The procedure was terminated with removal of catheters and embolization of puncture tracts with Gelfoam and coils.

The patient remained stable overnight after a 2 U blood transfusion. Transplant surgery was consulted. The morbidity and mortality of hepatectomy was thought to be prohibitive. The patient was evaluated for orthotopic liver transplantation, which he underwent 4 months later. The initial transplant did not function, and two surgical re-explorations, >300 U of blood products, and retransplantation were required. His course was complicated by the development of acute renal failure, sepsis, multiorgan failure, and eventual death.

CASE 2

A 45-year-old woman with autoimmune hepatitis who had had multiple liver biopsies to assess the status of this disease was found to have an abdominal bruit on routine examination in the hepatology clinic. The patient was asymptomatic except for her usual generalized fatigue. An ultrasound revealed reversed blood flow in the right portal vein and low resistance in the proper hepatic and right anterior hepatic artery. Although an HAPF was not identified, these findings were thought to suggest such a lesion. A subsequent multiphase CT did reveal a large HAPF in the right lobe of the liver. The patient was scheduled for elective embolization of this lesion in interventional radiology. While awaiting the procedure, the patient returned to the clinic complaining of right upper quadrant discomfort, "blackish" diarrhea, and light-headedness. There was concern for gastrointestinal bleeding secondary to portal hypertension, and it was believed that immediate closure of the AVF was necessary.

Using a right common femoral artery access, hepatic arteriography was performed and confirmed a large fistula from a right hepatic artery branch to a right portal vein tributary. There appeared to be two areas of communication between the segmental artery and the vein (Fig. 7A). The feeding artery was selectively catheterized with a Rapid Transit microcatheter, and a FasDasher wire (Boston Scientific,

Figure 4 (A) Angiography 1 month after first intervention shows second large feeding artery to the arteriovenous fistula as well as many small collateral vessels. (B) Microcatheterization as close to communication as possible with injection of polyvinyl alcohol particles. (C) Coil placement with apparent nonfilling of fistula.

Natick, MA) was used to cross the fistula (Fig. 7B). A 10-mm Guglielmi Detachable Coil (GDC; Boston Scientific, Natick, MA) was deployed into the right portal vein branch, followed by a 12-mm GDC. This slowed the blood flow through the fistula. A 6-mm GDC was then deployed in the vein just across the fistula and pulled back into the artery. Nester coils and a fibred GDC were then used to pack the remaining portion of the feeding artery. Follow-up arteriograms showed complete stasis of blood flow through the fistula (Fig. 7C). Portography through superior mes-

enteric artery showed single-segment portal vein branch occlusion. The patient tolerated the procedure and improved symptomatically. She was anticoagulated to prevent of portal vein thrombosis and discharged 2 days later.

At 2 weeks postprocedure, the patient reported feeling greatly improved. Ultrasound with Doppler evaluation revealed no evidence of remaining fistula. Follow-up visceral arteriography 3 months postprocedure showed no evidence of residual AVF (Fig. 8), and the patient continues to do well clinically.

Figure 5 (A) Abdominal computed tomography (CT) after second intervention reveals some persistent filling of hepatic artery to portal vein fistula (HAPF). (B) Collateral vessels from superior mesenteric artery are seen supplying HAPF. (C) Additional collateral vessels from left hepatic artery are also seen.

DISCUSSION

HAPF are generally acquired through trauma, iatrogenic procedures, rupture of aneurysm, or neoplasm.^{1,2} Liver biopsy is recognized as an increasing cause of HAPF.⁴⁻⁷ The reported incidence following liver biopsy ranges from 0 to 54%,^{1,6} and the rate appears to depend on needle biopsy technique and follow-up time because many fistulas close spontaneously. Furthermore, the vast majority of HAPF are asymptomatic, so occurrence rates depend on whether routine surveillance or patient reporting is used. It is worth reiterating that both of our patients presented after multiple liver

biopsies in their past, and these were thought to be causative.

Clinical presentation of patients with fistulas is often delayed until high output failure, or in the case of HAPF, portal hypertension develops. Unexplained liver enzyme elevation, ascites, and variceal bleeding, often with rapid worsening of symptoms, may be the first clue to the diagnosis. A bruit can sometimes be heard on abdominal auscultation. The presence of HAPF can be confirmed using several imaging modalities.¹ Doppler ultrasound is the least invasive technique that can detect a fistula. Multiphase CT

Figure 6 (A,B) Attempted venous access to hepatic artery to portal vein fistulas. These attempts were unsuccessful because of high flow through fistula and inability to locate exact site of arteriovenous communication.

is more sensitive, especially for more centrally located lesions. When ultrasound is negative but clinical factors support the diagnosis, CT should be obtained. Finally, arteriography gives detailed architectural information but is often only performed immediately prior to the intervention because of its more invasive nature.

The benefits of an endovascular approach to the treatment of HAPF are common to all endovascular procedures. Compared with open surgery, there is shorter hospital stay, decreased pain, decreased morbidity and mortality, and increased preservation of liver parenchyma.^{1,2} Proximal surgical ligation frequently is ineffective with rapid development of intrahepatic collateral vessels and persistent AVF filling, analogous to our first case where proximal embolization was performed. Furthermore, the endovascular procedure can be repeated more easily when required. The risks include portal thrombosis, partial embolization with formation of collateral vessels, liver infarction, migration of embolic material to unintended locations, as well as the standard risks of angiography.

The successful embolization of large HAPF has been reported by others.^{2,3,8,9} Undoubtedly the age and architecture of the fistula itself plays a role. The first patient had a main feeding artery that was extremely tortuous, preventing embolization directly at the fistula site. Closure of a fistula at the site of the fistula itself to preclude recruitment of collateral vessels is the most important aspect of endovascular fistula closure. Either the hole must be crossed to exclude the venous drainage

in addition to the artery, or the downstream artery, when the feeding artery is not an end artery, must be embolized. Case 1 demonstrates the result when this is not accomplished with a large mature fistula. The resulting fistula may become even more difficult to treat should the initial procedure fail because of the development of innumerable feeding arteries.

The second factor in determining the success of embolization is the technique used. Use of various embolic materials has been reported. These include vascular sclerosants, glue, particles, steel coils, and detachable balloons.^{1,2,9,10} The selection of material depends on the size of the feeding artery, the operator's ability to cross the fistula or access the downstream artery, and the number of arterial feeding vessels. Coils are the most commonly used agents to close small or simple single-artery fistulas. Normally the fistula hole is crossed to the downstream artery and the artery is embolized across the fistula neck. Detachable coils such as GDCs increase the safety margin in high-flow lesions because they can be placed without the fear of venous migration. Detachable balloons, if available, would have the same advantage and can be sized appropriately for the feeding artery and fistulous connection.^{2,9}

Liquid sclerosants, glues, and small particles are appropriate only when inflow can be controlled to prevent misadministration.^{9,10} With hepatofugal portal flow, these agents might reach the lungs if flow cannot be nearly arrested during administration. These techniques may be most appropriate when the fistula is complex with multiple feeding arteries or when the fistula cannot be reached.

Figure 7 (A) Angiography reveals large fistulous communication between branches of right hepatic artery and portal vein. (B) Microcatheterization at site of arteriovenous communication. (C) Postembolization images shows lack of filling of fistula or portal vein.

Technique can also differ in whether the embolization occurs from the venous or arterial side.¹¹ In both presented cases the predominant approach was arterial. In the first case, a venous approach was attempted as a last effort, but this was unsuccessful because of high flow through the fistula and inability to locate the exact site of the fistula. This was not chosen as a primary approach because the patient had massive ascites and underlying liver disease. A noteworthy difference in the second case was coiling of the venous drainage of the fistula from an arterial access to slow the blood flow through the fistula.

Again, this step allowed more precise positioning of the subsequent arterial coils and exclusion of the low resistance pathway from circulation.

The patient in Case 1 may have benefited from the utilization of an alternative approach such as temporary balloon occlusion of the feeding artery with administration of glue to cross the fistula or venous embolization of the entire hepatic segment. These techniques or tools may not be available when a case is undertaken in an urgent timeframe such as the development of variceal bleeding. In this case one is forced to

Figure 8 Follow-up hepatic angiogram 3 months after intervention demonstrates continued lack of filling at site of fistula and no shunting to portal circulation.

balance the current clinical situation with a possible failed procedure.

CONCLUSION

In summary, we have described two cases of transarterial embolization of hepatic arteriovenous fistulae. The two cases had differing outcomes and illustrated some of the principles and difficulties of an endovascular approach. Due to the variation in hepatic arterial fistulas, a standard endovascular approach will probably not ever be achieved, but understanding the primary goals, to exclude the connection and preclude the downstream artery from recruiting collateral vessels, will help improve success.

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