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Embolization of Portosystemic Shunts for Treatment of Medically Refractory Hepatic Encephalopathy

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Abstract

Treatment options for refractory hepatic encephalopathy (HE) are limited. Patients who fail medical management may harbor large portosystemic shunts (PSSs) which are possible therapeutic targets. This study aims to describe patient selection, effectiveness, and safety of percutaneous PSS embolization in those with medically refractory HE. A retrospective evaluation of consecutive adult patients with medically refractory HE referred for PSS embolization at a tertiary center was performed (2003–2015). Patient data collected included the type of HE, medications, Model for End-Stage Liver Disease (MELD) score, shunt type, embolization approach, and materials used. Outcomes of interest were immediate (7 days), intermediate (1–4 months), and longer-term (6–12 months) effectiveness and periprocedural safety. Effectiveness was determined based on changes in hospitalization frequency, HE medications, and symptoms. Twenty-five patients with large PSS were evaluated for shunt embolization. Five were excluded due to high MELD scores ($n = 1$), comorbid conditions ($n = 1$), or technical considerations ($n = 3$). Of 20 patients who underwent embolization, 13 had persistent and 7 had recurrent HE; 100% (20/20) achieved immediate improvement. Durable benefit was achieved in 100% (18/18) and 92% (11/12) at 1–4 and 6–12 months, respectively. The majority (67%; 8/12) were free from HE-related hospitalizations over 1 year; 10% developed procedural complications, and all resolved.

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Six developed new or worsening ascites. In conclusion, PSS embolization is a safe and effective treatment strategy that should be considered for select patients with medically refractory HE.

Hepatic encephalopathy (HE) is a neuropsychiatric syndrome most often seen in the setting of cirrhosis with portal hypertension (type C), though it can be seen in noncirrhotic conditions such as acute liver failure (type A) and alcoholic hepatitis, as well as nonliver conditions such as congenital shunts (type B).⁽¹⁾ The presentation can range from subtle cognitive slowing to a completely comatose state. The treatment and secondary prevention of HE aims to attenuate gut-derived ammonia production and includes lactulose with or without nonabsorbable antibiotics, namely, rifaximin and neomycin. The majority of patients who recover from an episode of overt hepatic encephalopathy (OHE) require maintenance medications. A small, yet undefined, fraction of patients develop medically refractory, recurrent, or persistent HE. Liver transplantation (LT) has generally been the only treatment option for patients with medically refractory HE. However, in the current organ allocation paradigm, patients with HE do not receive additional priority for transplantation, as was the case prior to 2002. Therefore, it is important to consider alternative lines of treatment in this difficult-to-manage population.

Percutaneous embolization of large portosystemic shunts (PSSs) is a rescue treatment for patients who have persistent encephalopathy or recurrent OHE despite optimal medical management. There are emerging data on the techniques, safety, and efficacy of this modality, but more data are needed before solidifying the role of this treatment in the management paradigm. Some series have reported an increased risk of portal hypertensive bleeding after embolization of large shunts, whereas others have suggested poor outcomes with mortality within 3 months.⁽²⁾ In the series with high mortality, it was postulated that these outcomes were related to candidate selection as patients undergoing embolization had Child-Pugh Class C cirrhosis. The ideal candidates for shunt embolization are currently not well defined. Herein, we report on the selection of patients for PSS embolization, the technique used, and clinical outcomes.

Patients and Methods

This retrospective study was approved by the institutional review board at Mayo Clinic. In total, 25 patients with medically refractory HE were evaluated for percutaneous embolization of large PSSs between January 1, 2003 and September 30, 2015. In accordance with the 2011 International Society for Hepatic Encephalopathy and Nitrogen Metabolism consensus statement,⁽³⁾ as well as the updated joint American Association for the Study of Liver Diseases–European Association for the Study of the Liver guidelines,⁽¹⁾ patients were classified based on the etiology, time course, and severity of their HE. Patients who developed or had persistence of spontaneous PSS after LT were also included. Patients were labeled as having persistent HE when they displayed patterns of behavioral alterations that were always present and punctuated by episodes of overt HE. Those who experienced recurring episodes of overt HE within a 6-month time interval were defined as having recurrent HE.

Baseline clinical and demographic data including age, sex, etiology of cirrhosis, shunt type, presence of any (pre-embolization) sequelae of portal hypertension, comorbid conditions, HE medications, Model for End-Stage Liver Disease (MELD) score, and ammonia level were collected. Procedural data were obtained regarding the specific approach for vascular access as well as method of embolization (coil, Amplatzer occluder, or both). Data were then obtained during 3 different time periods to assess effectiveness of the intervention. Immediate effectiveness was assessed within 1 week, intermediate within 1–4 months, and longer term between 6 and 12 months. Within the first week, patients were either reported as improved or not improved based on patient and/or physician observation. Procedural or periprocedural complications within the first week were also documented and described, such as bleeding, infection, fever, or access site complications. For the intermediate and longer-term follow-up periods, additional data were collected including HE medications, frequency of episodic overt HE, HE-related hospitalizations, worsening of portal hypertension, and overall effectiveness. From a safety perspective, particular emphasis was placed on identifying changes in manifestations of portal hypertension, including new, enlarging, or bleeding varices, and new or worsening ascites (Supplemental Table 3). Effectiveness was then graded systematically as follows: *marked improvement*, no hospitalizations for recurrent HE and the patient was off all HE medications; *moderate improvement*, no hospitalizations for recurrent HE but remained on HE medications to maintain remission; *mild improvement*, patient experienced recurrent HE, but the frequency and/or severity of symptoms are less than what was present prior to shunt embolization; *nonresponder*, no change in frequency or severity of HE or HE medication use; and *lost response*, individuals with initial improvement who subsequently returned to baseline HE symptomatology. The Fisher's exact test was used to analyze categorical data.

Results

PATIENT SELECTION

Between 2003 and 2015, 25 patients were referred to interventional radiology for consideration of PSS embolization, 20 of whom ultimately received intervention (Fig. 1). All patients had HE symptoms despite optimal medical treatment. Five patients were excluded due to technical factors ($n = 3$), comorbid conditions ($n = 1$), or severity of liver disease ($n = 1$); 4 of these patients had underlying cirrhosis. One patient was declined given the small size of the portal vein; it was deemed unlikely for such a diminutive venous system to manage the anticipated large amounts of venous return once portosystemic shunting was corrected. A second patient was declined due to low shunt flow, and the third patient was declined due to the presence of a small left gonadal–inferior vena caval shunt that was deemed unlikely to contribute significantly to the patient's ongoing HE. The final 2 patients were declined due to comorbid conditions that would have precluded safe completion of the procedure. One of those patients had acute-on-chronic renal failure (MELD = 18), and the second patient displayed advanced liver disease with a MELD score of 34.

PATIENT CHARACTERISTICS

Of the 20 patients who underwent PSS embolization, the most common etiologies of cirrhosis were nonalcoholic steatohepatitis (NASH; $n = 8$, 40%), alcohol ($n = 5$, 25%), and

hepatitis C virus (HCV; $n = 2$, 10%; Table 1). The mean preprocedural MELD score was 13.1 ± 3.4 . Prior to embolization, 14 (70%) patients had overt, preexisting portal hypertension; 10 (50%) with evidence of portal hypertensive gastropathy (PHG); 8 (40%) with esophageal varices and 2 (10%) with ascites. Of the 8 patients with esophageal varices, 4 had a history of prior bleeding. The most common type of shunt present was a splenorenal shunt ($n = 12$; 60%). In regards to the classification of HE, 13 (65%) had persistent and 7 (35%) had recurrent HE.

PROCEDURAL APPROACH

In regards to the technical aspects of percutaneous embolization, 15 (75%) underwent coil embolization, 4 (20%) received Amplatzer occluders, and 1 (5%) received both. Vascular access was transhepatic in 25% ($n = 5$), whereas the remainder were via the right femoral vein ($n = 6$, 30%), internal jugular vein ($n = 5$, 25%), umbilical vein ($n = 1$, 5%), or the right axillary vein ($n = 3$, 15%).

EFFECTIVENESS

Overall, 20 of 20 patients experienced significant improvement in HE symptoms within 1 week of the procedure (100% immediate effectiveness; Fig. 2).

Intermediate-term follow-up data were available at 1–4 months after embolization for 18 patients at a median of 88 days. Of these patients, 100% experienced sustained improvement in their HE at 1–4 months (Table 2). Of these, 3 (17%) had mild improvement, 10 (55%) had moderate improvement, and 5 (28%) saw marked improvement. Overall, 28% (5/18) of these patients were able to stop taking medications for HE; 28% (5/18) were able to decrease the number of HE medications; and 44% (8/18) were maintained on the same regimen.

Longer-term follow-up at 6–12 months after embolization was available for 12 of the initial 20 patients at a median of 365 days. Reasons patients were lost to follow-up included inability to contact them ($n = 5$) or death ($n = 1$) within the follow-up period. Two patients did not have longer-term follow-up available due to having very recently undergone their embolization procedure. Among the 12 with available longer-term follow-up data, 12 had achieved immediate improvement after embolization, and 92% (11/12) reported a durable treatment response. Among the 11 patients who achieved sustained improvement, 1 (9%) was graded as marked, 6 (55%) as moderate, and 4 mild (36%).

Two patients who had initially experienced improvement after embolization developed repeated episodic HE and required hospitalizations. One of these patients, a 74-year-old female, died 8 months after the embolization procedure in an outside hospital; the cause of death was unknown. The second patient, who had a remote history of a simultaneous liver-kidney transplant, reported marked improvement for 5 months until she began having recurrent HE requiring several short hospitalizations. Repeat transhepatic venogram was performed at 8 months after embolization and demonstrated a persistently occluded shunt. Thereafter, she was found to have liver allograft cirrhosis at 6 months and renal allograft dysfunction 12 months following embolization, and neither were thought to be related to shunt occlusion. Overall, 8/12 (67%) patients were able to avoid HE-related hospitalizations throughout the 12-month follow-up period. Of the 4 who were hospitalized, 2 patients had 1

hospitalization and the other 2 had 3 hospitalizations, with average time to hospital admission of 4 months after embolization.

SAFETY

Adverse events from the PSS embolization were minimal. One patient (post-LT, noncirrhotic) developed fevers 1 day following the procedure and was eventually diagnosed with biliary obstruction and bacterial cholangitis secondary to transient hemobilia from the recent procedure. This spontaneously resolved with a course of antibiotic therapy. A second patient required readmission to the hospital for pain at the right midaxillary puncture site. A computed tomography (CT) scan performed at the emergency department prior to transfer was negative, and the pain resolved within 24 hours with conservative measures. Thus, the overall procedural complication rate was 10%. It should also be noted that 35% (7/20) of patients developed evidence of worsening portal hypertension at some point within the 12-month follow-up period. On average, evidence of increased portal hypertension was discovered at 4 months after embolization. Six (86%) were noted to have new ($n = 3$) or worsening ascites ($n = 3$), and 1 (14%) developed new small nonbleeding varices seen at surveillance endoscopy. The mean preprocedure MELD was 13, and postprocedure MELD at 1–4 months was 15 in the 7 patients with worsening portal hypertension. Of the 6 patients with ascites, symptoms were minimal and well controlled with diuretics for 2 patients, whereas 4 patients required intermittent paracentesis.

Discussion

HE develops in approximately 50% of patients with cirrhosis. Most patients with a history of OHE require treatment with lactulose, with or without nonabsorbable antibiotics to maintain remission and prevent hospitalization. A small proportion of patients develop recurrent or persistent HE symptoms despite optimal medical therapy. Approximately 45%–70% of patients with refractory HE have large PSSs discovered on further evaluation.^(4–6) Data on the technique, safety, and outcomes of percutaneous embolization of large PSSs are still relatively sparse.

Recently, a European consortium reported their experience with 37 patients with cirrhosis with refractory HE and large PSSs that were treated with percutaneous embolization.⁽⁷⁾ Approximately 59% were HE-free within 100 days of the procedure ($P < 0.001$ versus before embolization), of which 18 (48.6% of patients overall) remained HE-free over a follow-up period of approximately 700 days. It was noted that the strongest positive predictive value for patients to have recurrence was a MELD score greater than 11. There were 8 procedural complications in this series, which included 1 cutaneous infection at the access site, 3 puncture site hematomas, 1 contrast nephropathy, 2 periprocedural fevers, and 1 subcapsular bleed with resultant hemorrhagic shock requiring surgery.

There was no significant increase in complications related to worsening portal hypertension, although in the 15 patients who had evidence of ascites after embolization, 40% had new onset ascites. Among the other series in the literature on shunt embolization, the largest is 14 patients.⁽⁸⁾ In this series, during a median follow-up period of 27 months, 93% (13/14) of patients achieved resolution of their HE. Aggravation of esophageal varices was reported in

29% (4/14) of these patients. In a study by Zidi et al.⁽²⁾ (n = 7), 3 patients (43%) died within 3 months of the procedure and the remainder did not derive sustained benefit. In another small series by Sakurabayashi et al.,⁽⁹⁾ 57% derived benefit from embolization. In total, the data on safety and effectiveness from existing literature is heterogeneous.

This series is the largest US and largest single-center study including 20 patients who underwent embolization of PSSs. Overall, the immediate response rate within 1 week was 100% (20/20), which was maintained in 100% at months 1–4, and in 92% at months 6–12. Overall, the embolization of large PSSs for treatment of refractory HE appears to be a very promising approach for appropriately selected patients with refractory HE.

There are limitations to this study including the retrospective nature of the study, missing data, and the lack of follow-up beyond 1 year. Currently, there are no prospective trials to evaluate PSS embolization in the United States, and therefore, these data will be helpful for clinicians and provide ideas for future trials. There are a limited number of US Food and Drug Administration–approved medications for the secondary prevention of OHE. When these medications fail and patients are frequently hospitalized for recurrent overt HE with potential for development of deadly nosocomial infections, percutaneous embolization of large PSSs should be considered as an option. It is important to carefully select patients in whom this procedure has a high probability of benefit and low chance of harm. For patients with cirrhosis, shunt embolization should be conceptualized as a bridging treatment as most individuals will eventually require LT.

The procedural and periprocedural safety in this series was excellent. Two (10%) patients had complications that could have been related to the embolization (self-limited hemobilia and access-site pain) compared to the 22% in the European consortium, which may suggest that a high-volume center may have fewer complications. Six patients (median MELD = 15) went on to develop clinically relevant, worsening portal hypertension resulting in new or worsening ascites over an average of 4 months, where intermittent large-volume paracentesis was necessary to control ascites in 67%. A single patient was found to have new small nonbleeding varices. Of the 8 participants who were known to have varices prior to embolization, none of them had any clinically relevant portal hypertensive bleeding complications. Although it is very difficult to know if changes in portal hypertension manifestations were a result of the procedure itself or the natural history of decompensated cirrhosis, the patient and provider must be prepared for these potential developments.

Most patients in this series were carefully selected, which may indeed be a primary reason for the high rates of safety and effectiveness. The operating hypothesis was that patients with higher MELD scores were less likely to derive benefit from the procedure and were at higher risk of decompensation. Additionally, clinical suspicion for clinically relevant PSS is highest in patients who have HE out of proportion to their MELD score. Therefore, patients with higher MELD scores were generally not considered candidates at our institution. This hypothesis is supported by the recent analysis by Laleman et al.⁽⁷⁾ which demonstrated through logistic regression that patients with MELD scores > 11 were more likely to have recurrent HE after embolization. The mean pre-embolization MELD score for the patients in our series was 13.1 ± 3.4 (range, 8–23). There were not enough treatment failures in this

series to formally assess factors associated with nonresponse. The patient with the highest MELD score (23) went on to experience only mild improvement, had the highest number of hospitalizations, and experienced de novo development of ascites that was medically refractory.

A unique feature of this study is the inclusion of patients with prior LT. Overall, there were 2 LT patients who underwent embolization: 1 who derived sustained benefit, and another who developed worsening allograft function and developed recurrent HE. The patient deriving benefit had a residual shunt identified within the first year after LT, whereas the second patient was found to have a shunt nearly 20 years after LT and later found to have allograft cirrhosis. We postulate that patients with residual shunts who undergo embolization early after LT for HE symptoms are more likely to do well. However, due to the small sample size, caution should be exercised in pursuing shunt embolization in post-LT patients.

In terms of the technical aspects of shunt embolization, the choice of venous access site and embolic agent depend on the anatomy of the shunt, the anticipated complexity of the embolization, and the expected stability of the embolic agent in the vein. A uniform and systematic approach was taken for patients in this study. For simple shunts, such as most spontaneous splenorenal shunts, access from a systemic vein, which is technically easier and carries less procedural risk, is usually sufficient (Fig. 3A–C). For more complex shunts, or in cases where the exact anatomy of the shunt is unclear from CT or magnetic resonance imaging, the transhepatic approach may be superior. By directly injecting the tributaries of the portal system, the exact anatomy of the shunt is clearly demonstrated, allowing safe and effective embolization. The goal of the embolization is to provide a permanent focal occlusion of the vein. The 2 widely available options are coils and the Amplatzer plugs. Coils are easily deployed and pass easily through catheters traversing tortuous anatomy. However, many coils may be necessary to achieve the desired occlusion (Fig. 4A–D). A similar occlusion can be achieved with 1 or 2 Amplatzer plugs, but they require a larger delivery system that will not track through tortuous anatomy. An additional advantage of the Amplatzer plug is it can be deployed, a venogram can be obtained to document satisfactory position and stability, and only then is it released. If the position is unsatisfactory, they can be reconstrained by the delivery sheath and repositioned.

In conclusion, in appropriately selected patients with refractory HE, shunt embolization is a viable therapeutic option to improve symptoms of HE, decrease hospitalizations, and potentially temporize the need for LT in a time where the organ allocation system does not favor these individuals. Further prospective trials and multicenter reports on percutaneous embolization of large PSSs in this population are warranted to solidify the role of this modality in treatment of refractory HE.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Abbreviations

A1ATD alpha-1-antitrypsin deficiency

AIH	autoimmune hepatitis
CT	computed tomography
EGD	esophagogastroduodenoscopy
EtOH	ethanol
HCV	hepatitis C virus
HE	hepatic encephalopathy
IMV	inferior mesenteric vein
LT	liver transplantation
MELD	Model for End-Stage Liver Disease
NASH	nonalcoholic steatohepatitis
OHE	overt hepatic encephalopathy
PHG	portal hypertensive gastropathy
PSC	primary sclerosing cholangitis
PSS	portosystemic shunt
SD	standard deviation
SMV	superior mesenteric vein

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FIG. 1.
Overview of patients excluded and/or lost to follow-up.

FIG. 2.

Overall and durable response rates. Response is mild, moderate, or marked as outlined in text. Nonresponse is failure to improve symptoms between days 0 and 7. Lost response is when symptom severity or frequency return to baseline.

FIG. 3.

(A) Coronal contrast-enhanced CT image demonstrating large left upper quadrant varices draining into the left renal vein. (B) Selective injection of the dilated left inferior phrenic vein prior to embolization. Same projection as Fig. 1A. (C) Injection into the left inferior phrenic vein after deployment of 2 Amplatzer plugs.

FIG. 4.

(A) Coronal contrast-enhanced CT image demonstrated large left lower quadrant varices draining into the left gonadal vein. (B) Transhepatic splenic venogram demonstrating retrograde flow in the IMV with filling of large left lower quadrant varices. (C) Later image from the same splenic venogram shows the varices draining into the left gonadal and left renal veins. (D) Transhepatic splenic venogram after shunt embolization shows there is no longer filling of the IMV and that there is improved portal perfusion into the liver.

TABLE 1

Pre-embolization Baseline Characteristics for Patients With Medically Refractory HE

	Patients With Cirrhosis (n = 20)
Age, years, mean $\pm$ SD	60.9 $\pm$ 8.1
Sex, male, n (%)	10 (50)
Etiology of shunt, n (%)	
NASH	8 (40)
EtOH	5 (25)
HCV	2 (10)
AIH	1 (5)
PSC	1 (5)
EtOH + NASH	1 (5)
A1ATD + NASH	1 (5)
Cryptogenic	1 (5)
Portal hypertension, n (%)	
Yes	14 (70)
PHG	10 (50)
Esophageal varices	8 (40)
Ascites	2 (10)
No	5 (25)
Unknown (no EGD)	1 (5)
Comorbidities, n (%)	
Diabetes mellitus	14 (70)
Obesity	11 (55)
Hypertension	10 (50)
Coronary artery disease	3 (15)
Chronic kidney disease	2 (10)
HE classification, n (%)	
Persistent	13 (65)
Recurrent	7 (35)
HE medications, n (%)	
Lactulose	5 (25)
Lactulose + rifaximin	7 (35)
Lactulose + rifaximin + zinc	6 (30)
Lactulose + neomycin + zinc	1 (5)
None	1 (5)
Preprocedural MELD, mean $\pm$ SD	13.1 $\pm$ 3.4
Preprocedural ammonia, mean $\pm$ SD	101.5 $\pm$ 56.0
Type of shunt	
Splenorenal	12 (60)
IMV-ovarian	2 (10)
SMV-ovarian	1 (5)

Patients With Cirrhosis (n = 20)	
Portal-right gonadal	1 (5)
IMV-left renal	1 (5)
Periumbilical-portosystemic	1 (5)
Multiple	2 (10)
Method of shunt occlusion, n (%)	
Coil embolization	15 (75)
Amplatzer occluder	4 (20)
Coil embolization + Amplatzer	1 (5)

TABLE 2

Outcomes for Patients in Both Intermediate and Longer-term Follow-up Periods

	Intermediate Follow-up, 1–4 Months (n = 18)	Longterm Follow-up, 6–12 Months (n = 12)
Improvement, n (%)	18 (100)	11 (92)
Mild	3 (17)	4 (36)
Moderate	10 (56)	6 (55)
Marked	5 (28)	1 (9)
HE medications, n (%)		
No change	8 (44)	8 (67)
Reduced dosing	5 (28)	3 (25)
None	5 (28)	1 (8)
Patients hospitalized for HE, n (%)	3 (17)	3 (25)
Development of worsening portal hypertension, n (%)	5 (28)	2 (17)
New ascites	2 (11)	1 (8)
Worsened ascites	2 (11)	1 (8)
New varices, nonbleeding	1 (6)	0 (0)

*
Sum of percentages is >100% due to rounding.