Diagn Interv Radiol 2026; DOI: 10.4274/dir.2026.263679

INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

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Tract embolization using absorbable gelatin sponge torpedoes following transsplenic or transhepatic access in pediatric patients

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PURPOSE

To evaluate the feasibility and early postprocedural hemorrhage outcomes of absorbable gelatin sponge (AGS) torpedo tract closure and to briefly describe the tract-closure method used following portal vein recanalization in pediatric native-liver extrahepatic portal vein obstruction.

METHODS

We retrospectively reviewed the cases of 18 consecutive children [11 boys, 7 girls; median age, 7 years (range, 5–12)] treated between 2020 and 2025 who underwent transsplenic and/or trans-hepatic portal vein recanalization with planned tract embolization using AGS torpedoes. The access sheath sizes were 5F and 6F, and unfractionated heparin was administered intraprocedurally in all cases. Procedures with inadvertent sheath dislodgment before embolization or intraprocedural wire perforation were excluded. The primary outcome was clinically significant access-tract hemorrhage within 24 hours, defined as a hemoglobin decrease > 2 g/dL together with an interval increase in intraperitoneal free fluid on ultrasound. Descriptive statistics were used; technical outcomes were summarized per tract and safety outcomes per patient.

RESULTS

Eighteen patients underwent embolization of 28 access tracts (13 transsplenic and 15 trans-hepatic). The median number of torpedoes used per tract was three (range, 2–4). All access tracts were successfully embolized with AGS torpedoes (28/28, 100%). No clinically significant access-tract hemorrhage occurred at either the patient (0/18) or tract level (0/28) within 24 hours after AGS embolization. Small perisplenic or perihepatic fluid collections were observed in 16 (88.9%) patients immediately after the procedure without an interval increase on follow-up ultrasound within 24 hours following the intervention.

CONCLUSION

AGS torpedo tract closure appears feasible and effective in preventing clinically significant access-tract hemorrhage after pediatric portal vein recanalization, including cases requiring dual access with introducer sheaths of up to 6F and intraprocedural anticoagulation. Prospective, large, multicenter studies using standardized hemostasis endpoints are needed to validate these preliminary findings.

CLINICAL SIGNIFICANCE

A readily available, absorbable material deployed as torpedoes can achieve controlled, layered parenchymal sealing in pediatric portal venous interventions.

KEYWORDS

Child, embolization, therapeutic, gelatin sponge, portal hypertension, portal vein

Handling editor: Bahri Üstünsöz

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Received 16 October 2025; revision requested 01 November 2025; last revision requested 14 December 2025; accepted 18 January 2026.

Epub: 04.02.2026

Publication date: 02.11.2026

DOI: 10.4274/dir.2026.263679

You may cite this article as: Bayramoğlu M, Şentürk YE, Cantürk EM, Samadli V, Oğuzkurt L. Tract embolization using absorbable gelatin sponge torpedoes following transsplenic or transhepatic access in pediatric patients. *Diagn Interv Radiol*. 2026;32(6):810-817.

Meso-Rex bypass surgery is a commonly used technique in pediatric patients with chronic extrahepatic portal vein obstruction (EHPVO) and its related complications. Recently, percutaneous portal vein recanalization has emerged as an alternative approach and has been included as a new recommendation in the Baveno VII consensus, providing a guideline-based rationale for clinical use in appropriate candidates.[1] Both strategies aim to redirect splanchnic blood flow to the liver, thereby restoring physiological hepatopetal portal flow, which, in turn, alleviates portal hypertension.[2]

Historically, safety concerns have surrounded percutaneous transsplenic and transhepatic portal venous interventions.[3-5] In contrast to diagnostic splenoportography, percutaneous portal vein recanalization procedures are technically more complex yet have become indispensable for managing portal venous complications in pediatric recipients of liver transplant.[6] However, studies specifically addressing native liver with chronic EHPVO in pediatric patients remain limited. In this cohort, hypersplenism-associated thrombocytopenia, intraprocedural anticoagulation, and the need for dual splenic/hepatic access with sheaths of up to 6F may increase the risk of access-tract hemorrhage, defined as bleeding from the percutaneous access tract through the hepatic or splenic parenchyma.[7-9] In children, even small-volume blood loss may be hemodynamically significant, underscoring the need for tract embolization.[10,11]

A variety of embolic agents have been described to minimize access-tract hemorrhage, albeit with limitations such as cost and the risk of non-target embolization or imaging artifacts. Nevertheless, there is no universally accepted optimal technique for tract embolization.[12-14] Absorbable gelatin sponge (AGS) has traditionally been used in slurry form, but its torpedo configuration may offer more controlled delivery and effective parenchymal sealing.

Given the limited evidence regarding AGS torpedoes for access-tract embolization in pediatric native-liver EHPVO, we describe our method for AGS torpedo tract closure and retrospectively evaluate its feasibility and early postprocedural hemorrhage outcomes following transsplenic and/or transhepatic recanalization.

Main points

- Following pediatric portal vein recanalization, absorbable gelatin sponge (AGS) torpedo tract embolization closed all 28 access tracts, with no cases meeting the 24-hour primary hemorrhage endpoint.
- The technique remained effective in cases requiring dual access, the use of sheaths of up to 6F, and intraprocedural anticoagulation. The technique described in this study enabled controlled, layered AGS torpedo delivery and helped avoid bleeding during sheath exchange.
- AGS torpedo embolization is a safe, cost-effective technique that minimizes imaging artifacts and preserves options for future percutaneous reinterventions.

Methods

Ethical approval

The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the institutional ethics committee of the Koç University Committee on Human Research (approval number: 2025.440.IRB2.197, date: 08.10.2025). Due to the retrospective design, the requirement for informed consent for study participation was waived.

Study design and patient population

This retrospective, single-center cohort study included pediatric patients who underwent endovascular recanalization for chronic EHPVO between 2020 and 2025. A total of 24 patients were screened. Demographic data, clinical presentation, and the underlying etiologies of portal vein thrombosis were retrospectively extracted from medical records. The inclusion criteria were pediatric native-liver chronic EHPVO with relevant clinical manifestations. The exclusion criteria were procedures in which tract closure could not be attempted because the access sheath was inadvertently dislodged prior to embolization and procedures complicated by intraprocedural hemorrhage due to guidewire perforation during the recanalization attempt. These exclusion criteria were selected to focus the safety analysis on cases in which tract embolization was technically feasible, thereby avoiding the misclassification of hemorrhage events that were not preventable by tract closure. The study group selection process is summarized in Figure 1. Five patients were excluded because tract embolization could not be completed after sheath dislocation, and one patient was excluded due to vascular perforation during recanalization. The final cohort comprised 18 patients [11 boys, 7 girls; median age, 7 years (range, 5–12)].

Interventional procedure

Transsplenic or transhepatic access was obtained under ultrasound guidance using a 21-gauge introducer needle (AccuStick II, Cook Medical, Bloomington, IN, USA). A V-18 control wire (Boston Scientific, Natick, MA, USA) was advanced into the punctured parenchymal portal or splenic vein branch, followed by introducer placement and diagnostic portography. Following placement of a stiff guidewire (Amplatz Super Stiff, Boston Scientific, Marlborough, MA, USA), the introducer was withdrawn and a 5F or 6F 11-cm sheath (Avanti+ Sheath Introducer, Cordis,

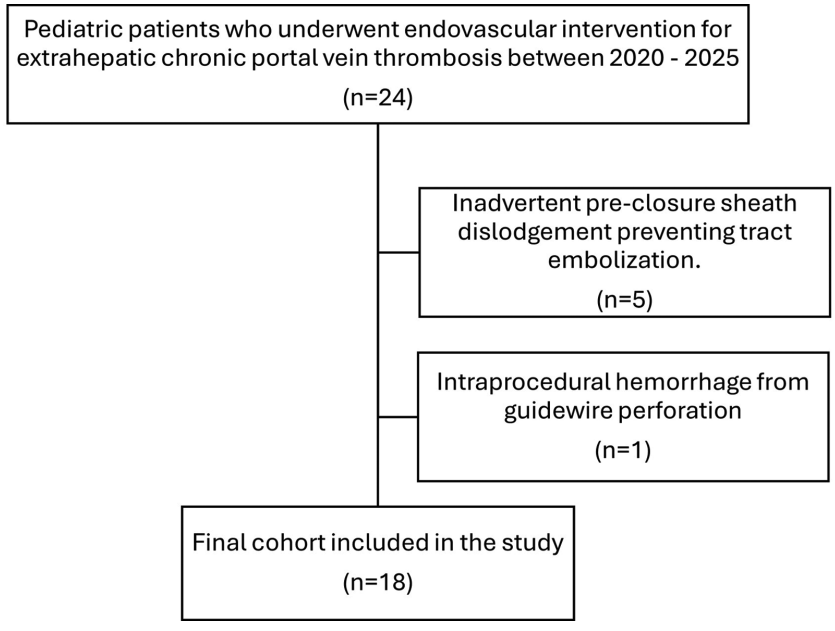


Figure 1. Flow diagram summarizing the study group selection process.

Santa Clara, CA, USA) inserted; for transsplenic access with tortuous splenic veins, a 6F 23-cm-long sheath (Brite Tip Sheath Introducer) was preferred to provide additional support.

In five procedures, sheath placement could not be maintained after the initial tract assessment; the procedure was therefore completed via alternative access, and these cases were excluded from the primary analysis. One additional procedure was excluded because guidewire perforation might have confounded access-tract hemorrhage assessment. All access tracts, including those from alternative access and the original tract in the perforation case, were successfully embolized.

Systemic anticoagulation was administered with an initial unfractionated heparin bolus (75 U/kg), followed by a continuous infusion of 20 U/kg per hour. Periprocedural activated clotting time monitoring was not performed. Recanalization, defined as the restoration of hepatopetal flow in the previously occluded main portal vein through balloon angioplasty (PTA), was achieved using standard wire and catheter techniques. No stents were used in this cohort, reflecting our institutional preference of avoiding permanent fixed-diameter implants in children that may not accommodate somatic growth and may complicate future reinterventions. At the end of the procedure, the sheath was withdrawn under ultrasound and fluoroscopic guidance until the tip was positioned just outside the vessel wall and clamped at the skin. The sheath was then cut approximately 3 cm proximal to the clamp. This approach was particularly useful with long sheaths, enabling non-deformed AGS delivery and more uniform tract packing, potentially achieving sealing with less material and a lower foreign-material burden. Sterile AGS blocks (Cutanplast, 50 × 70 × 10 mm; Mascia Brunelli S.p.A., Milan, Italy) were cut into rectangular strips along the short and horizontal axes with a scalpel. Each piece was manually rolled to form a tight cylindrical torpedo, sized to match the sheath lumen, and then shortened, yielding final torpedo lengths of approximately 15–25 mm. After instillation of a small volume of undiluted contrast medium into the sheath lumen, the torpedoes were introduced manually or using forceps. Under fluoroscopic guidance, the torpedoes were advanced through a manually stabilized sheath using a shortened manipulation catheter. The catheter and contrast-impregnated torpedoes were both visible under fluoroscopy, allowing precise placement. After deployment of the first torpedo, additional torpedoes were delivered as required, with intermittent contrast instillation and gradual unsheathing to ensure layered embolization until the whole tract was embolized (Figure 2). Embolization was completed using 2–4 torpedoes per tract. The procedure was concluded if either contrast was observed beyond the splenic or hepatic capsule during torpedo advancement or the sheath was freely mobile outside the parenchyma on fluoroscopy after unsheathing (Figure 3).

Follow-up

Ultrasound assessments were performed immediately after the procedure, on the evening of the procedure, and again prior to discharge at approximately 24 hours. During hospitalization, patients were clinically monitored for their general condition, abdominal pain, and signs of leakage or infection at the puncture site. Laboratory follow-up for hemorrhage included serial complete blood count measurements at approximately 4, 8, and 24 hours after the procedure, and analyses were based on the 24-hour values to align with the prespecified endpoint and to reduce variability from early post-procedural hemodilution and fluid shifts. Unfractionated heparin was discontinued at the end of the procedure and not resumed that day. In the absence of hemorrhage, all patients were started on low-molecular-weight heparin the following morning, which was continued for 1 month. After discharge, all patients returned at approximately 1 month for clinical evaluation and targeted Doppler ultrasound.

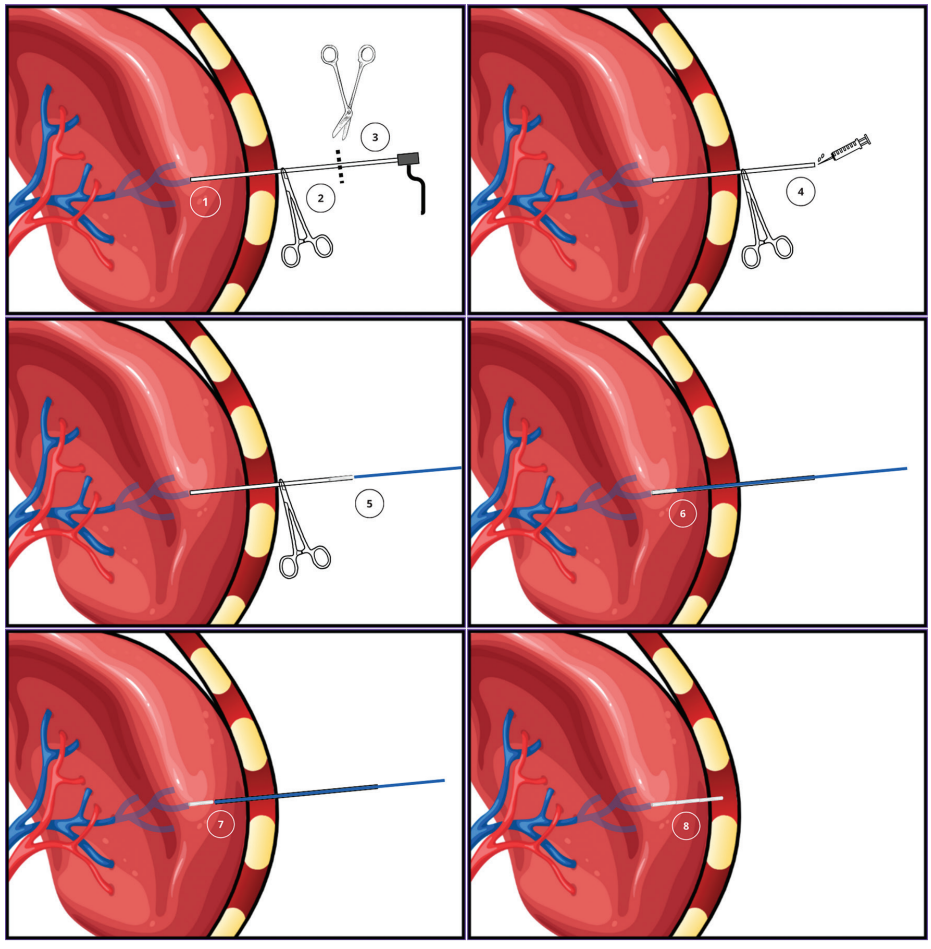


Figure 2. Schematic of the stepwise technique for absorbable gelatin sponge (AGS) torpedo tract embolization following transsplenic portal vein recanalization. Although the illustration relates to transsplenic access, the same technique is applicable to transhepatic embolization. (1) The sheath was withdrawn under ultrasound guidance until the tip lay just outside the vessel wall. (2) The sheath was clamped at the skin. (3) The sheath was cut approximately 3 cm proximal to the clamp. (4) A few drops of contrast were instilled into the sheath lumen. (5) An AGS torpedo was introduced into the lumen. (6) The torpedo was advanced to the sheath tip under fluoroscopic guidance using a manipulation catheter. (7) The sheath was gradually retracted using the unsheathing technique. (8) Additional torpedoes were delivered as required, with intermittent contrast instillation and gradual unsheathing to achieve complete tract embolization.

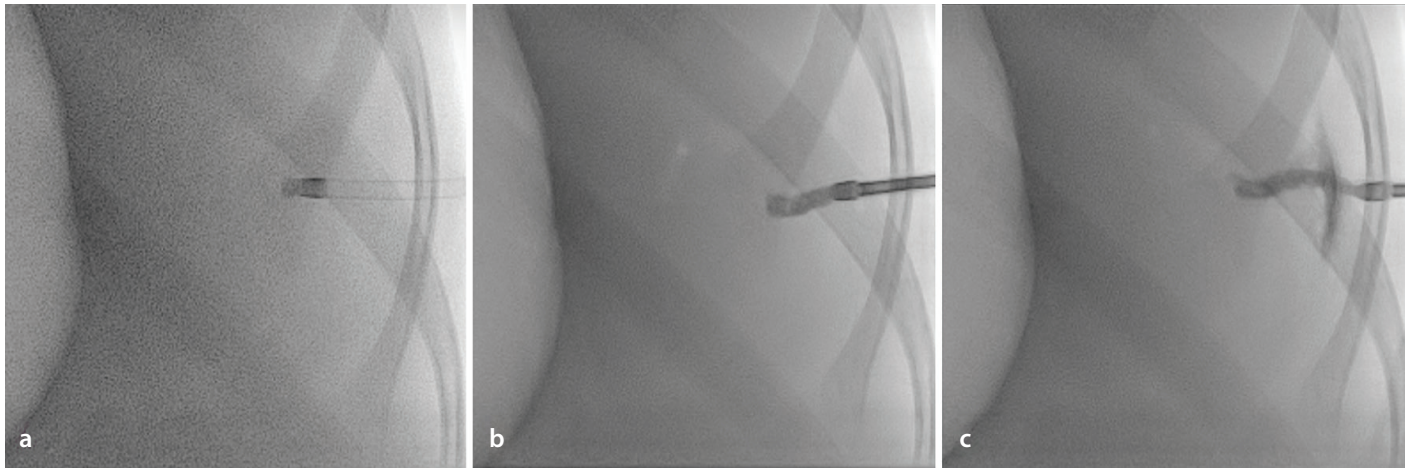


Figure 3. Fluoroscopic images demonstrate the stepwise process of absorbable gelatin sponge (AGS) torpedo tract embolization. **(a)** Contrast instilled into the sheath allows clear visualization of the first AGS torpedo after positioning. **(b)** Additional AGS torpedoes are sequentially deployed while the sheath is gradually retracted using the unsheathing technique. **(c)** A small amount of contrast leaking beyond the parenchymal surface can be used as an indicator of complete tract embolization.

Study endpoints

The primary outcome was the presence of postprocedural hemorrhage within 24 hours, ascertained by a retrospective review of laboratory and procedural records and defined as a hemoglobin decrease > 2 g/dL together with an interval increase in intraperitoneal free fluid on follow-up ultrasonography.[15]

Statistical analysis

Continuous variables were summarized as the median (range) and categorical variables as counts (%). Technical outcomes were summarized per tract and safety outcomes per patient. No hypothesis testing or imputation was performed. Given the exploratory design and zero primary-outcome events, no further inferential analyses were undertaken. Proportions are reported with 95% confidence intervals (CIs) using the Clopper–Pearson exact method; zero-event outcomes are presented with exact upper bounds.

Results

Study population

A total of 24 patients were screened between 2020 and 2025. Of these, 6 were excluded according to the predefined criteria, leaving 18 patients [11 boys, 7 girls; median age, 7 years (range, 5–12)] for analysis. The underlying etiologies of portal vein thrombosis were umbilical vein catheterization in 14 (77.8%) patients, umbilical infection in 1 (5.6%) patient, elevated von Willebrand factor in 1 (5.6%) patient, and *PAI-1* 4G/5G mutation in 1 (5.6%) patient; the etiology remained unknown in 1 (5.6%) patient (Table 1). The most common presenting features were hypersplenism, growth impairment, and hematochezia, which frequently co-occurred in the same patients.

Procedural details

All vascular entries were performed under ultrasound guidance, with successful cannulation in every patient. Of the 18 patients, percutaneous access was achieved using a transsplenic approach in 3 (16.7%) patients, a transhepatic approach in 5 (27.8%) patients, and a combined transsplenic–transhepatic approach in 10 (55.6%) patients. EHPVO recanalization was technically successful in 14 (77.8%) patients, with the portal vein restored with PTA (Figures 4 and 5). In four (22.2%) patients, recanalization could not be achieved. Across 18 patients, 28 access tracts were embolized with AGS torpedoes (13 transsplenic and 15 transhepatic), and embolization succeeded in all tracts (28/28, 100%). No patient met the prespecified primary outcome of clinically significant access-tract hemorrhage within 24 hours (0/18, 0.0%; 95% CI: 0.0%–15.3%). On a per tract basis, no clinically significant hemorrhage occurred after AGS embolization (0/28, 0.0%; 95% CI: 0.0%–10.1%). Among the transsplenic interventions, five (38.5%) were performed with a 6F sheath and eight (61.5%) with a 5F sheath. Among the transhepatic interventions, six (40.0%) were performed with a 6F sheath and nine (60.0%) with a 5F sheath. The median number of torpedoes used per tract was three (range, 2–4).

The median preprocedural hemoglobin level was 10.4 g/dL (range, 7.1–12.5), and the median postprocedural hemoglobin level was 10.3 g/dL (range, 6.1–12.6). The median

Table 1. Demographic and etiological characteristics of the study population

Characteristic	Value
Total patients	18
Gender	
Boys	11 (61.1%)
Girls	7 (38.9%)
Age	
Median (range)	7 (5–12) years
Etiology	
Umbilical vein catheterization	14 (77.8%)
Umbilical infection	1 (5.6%)
Elevated vWF	1 (5.6%)
PAI-1 gene mutations	1 (5.6%)
No known etiology	1 (5.6%)

vWF, von Willebrand factor.

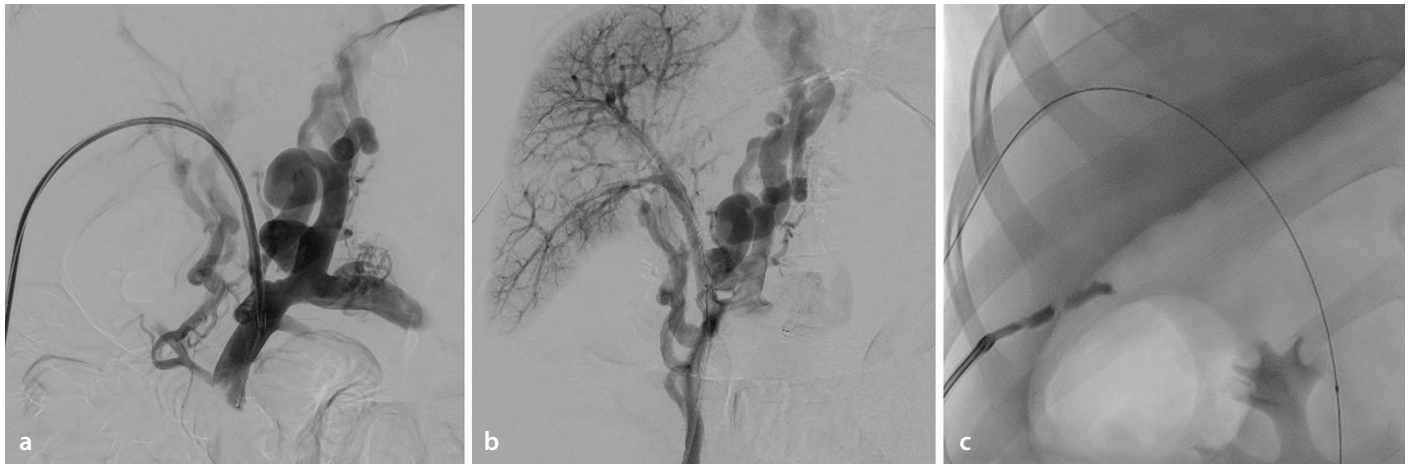


Figure 4. Combined transsplenic and transhepatic approach in a pediatric patient with chronic extrahepatic portal vein obstruction likely related to an umbilical vein catheter placed immediately after birth. **(a)** Transhepatic access was used to traverse the portal vein obstruction, and the portogram obtained before balloon dilatation demonstrates complete obstruction of the main portal vein with opacification of periportal collaterals. At this stage, no filling of the intrahepatic portal veins is observed. **(b)** Following angioplasty, simultaneous opacification of the segmental intrahepatic portal vein branches confirms restoration of hepatopetal flow through the recanalized main portal vein and its right portal branches. Although catheterization of the left portal branches was technically feasible through the transsplenic approach, further manipulation was avoided to prevent potential injury to the recanalized main portal vein. **(c)** Fluoroscopic image shows transhepatic tract embolization with absorbable gelatin sponge torpedoes. Small gaps left between torpedoes were acceptable, as the material expands after deployment to achieve complete sealing.

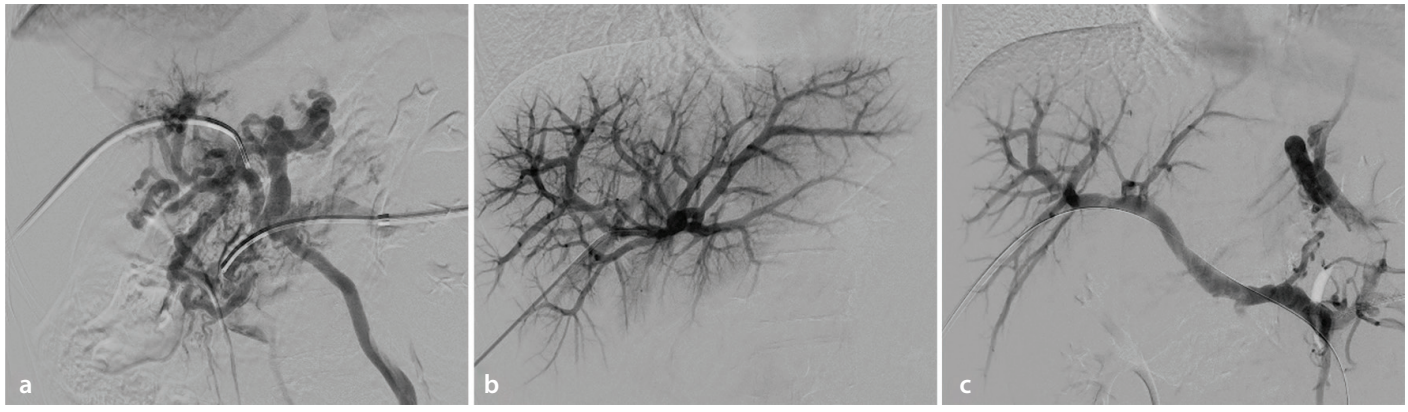


Figure 5. Combined transsplenic and transhepatic approach in a pediatric patient with chronic extrahepatic portal vein obstruction successfully recanalized using dual access. **(a)** Portogram obtained via the transsplenic approach demonstrates markedly dilated and tortuous collateral veins without opacification of the intrahepatic portal branches at this stage. **(b)** Portogram from the transhepatic access shows patent and unaffected intrahepatic portal veins. **(c)** Following successful recanalization, collateral filling has been resolved, and normal opacification of the main and intrahepatic portal veins is restored. Both access tracts were successfully embolized (images not shown).

hematocrit was 31.5% (range, 25.0%–39.0%) before the procedure and 32.0% (range, 22.0%–40.0%) after the procedure. The median platelet count was 77.5 $\times 10^9$/L (range, 46.0–558.0) pre-procedure and 80 $\times 10^9$/L (range, 55.0–560.0) post-procedure. The pre-procedural median international normalized ratio was 1.1 (range, 1.1–1.5), and the median activated partial thromboplastin time was 26.5 seconds (range, 15.4–31.9). A 0–1 g/dL decrease occurred in 4/18 (22.2%) patients, a 1-2 g/dL decrease in 5/18 (27.8%) patients, and a >2-g/dL decrease in 1/18 (5.6%) patients; hemoglobin increased in 6/18 (33.3%) patients and remained unchanged in 2/18 (11.1%) patients. No patient met the 24-hour hemorrhage endpoint. The pre- to postprocedural hemoglobin changes are summarized in Table 2.

Among the patients with postprocedural hemoglobin increases (n = 6), five received one peri-procedural unit of packed red blood cells (PRBCs), and the observed increase (0.2–2.1 g/dL; median, 0.7 g/dL) was therefore largely transfusion related; in the remaining patient, the 0.2-g/dL increase likely reflected hemoconcentration rather than true erythrocyte gain. The single patient with a > 2-g/dL hemoglobin decline required two units of PRBCs a few hours after the intervention for hematochezia. Consequently, this decline was attributable to gastrointestinal bleeding rather than procedure-related hemorrhage. No other patients received peri- or postprocedural PRBC transfusion. A small amount of perisplenic or perihepatic fluid was observed in 16 (88.9%) patients immediately after the procedure, with no subsequent increase on serial ultrasonography. At the approximately 1-month outpatient evaluation, no delayed access-tract complications were identified through clinical assessment or Doppler ultrasound, including no hemorrhage, pseudoaneurysm, abscess, or new intraperitoneal free fluid.

Six patients (age 1–8 years; median 3 years; five boys, 83.3%) were excluded, comprising five sheath dislodgments (83.3%) and one wire perforation (16.7%). In the six

excluded patients, portal vein recanalization was technically successful in four (66.7%), who subsequently underwent percutaneous transluminal angioplasty, whereas two (33.3%) had failed recanalization attempts. Hemoglobin decreased by a median of 1.6 g/dL (range, 0.8–2.4). Transfusion was required in three patients (50.0%), and no additional hemostatic interventions were necessary.

Discussion

In this retrospective cohort of children with native-liver EHPVO undergoing portal vein recanalization via transsplenic and/or transhepatic access, portal vein recanalization was technically successful in 14 of the 18 patients (77.8%), and tract embolization with AGS torpedoes, as described, was technically successful in all 28 access tracts; no patient experienced clinically significant access-tract hemorrhage within 24 hours. Cases in which the sheath was dislodged before embolization developed access-tract hemorrhage, underscoring the importance of performing tract closure whenever technically feasible.

AGS is a temporary, inexpensive, and widely available embolic agent that liquefies within around 7 days and is fully resorbed in 4–6 weeks. By absorbing several times its weight in water and concentrating platelets and clotting factors, the swelling gelatin matrix enhances hemostasis through mechanical compression while preserving the possibility of repeat percutaneous access through or near the prior tract.[16] This is particularly relevant in pediatric EHPVO, where distorted portal venous anatomy may leave a limited number of targetable vessels for percutaneous access. However, the use of AGS as a slurry may have two important drawbacks. First, uncontrolled injections, particularly in pediatric patients, carry the risk of non-target (including paradoxical) embolization.[17,18] Second, in cases with wide sheath tracts, the high-pressure flow in the portal vein after successful recanalization may displace the AGS slurry into the peritoneal cavity, leading to inadequate tract occlusion.[19] Our torpedo-based technique was designed to allow controlled, layered deployment of AGS torpedoes tailored to the sheath lumen, which may improve the stability of the access tract.

In an adult cohort, Tc et al.[18] reported AGS torpedo plugging of the transsplenic access tract after portal vein interventions in adults to be feasible and safe, with no cases requiring interventional or surgical treatment. Previous pediatric studies using various tract embolization materials have reported access-tract hemorrhage rates ranging from 0% to 27%, and most of these studies, particularly in recipients of liver transplant, have described AGS as a tract-embolization material used either as a slurry or as pledgets deployed directly within the tract (Table 3). Uller et al.[8] reported 11 tract closures in 10 pediatric patients, predominantly recipients of liver transplant, using eight transhepatic and three transsplenic accesses with 4F to 6F sheaths. Tracts were closed with AGS slurry, and one procedure was complicated by bleeding requiring a single transfusion, with no re-bleeding during follow-up. Monroe et al.[9] reported 26 children undergoing transsplenic portal venous access. Tract embolization with AGS was performed in 13/26 procedures, whereas ≤ 4F access tracts were not embolized and were not associated with hemorrhage. Intraperitoneal bleeding occurred in 2/26 procedures.[9] Similarly, Patel et al.[20] reported 42 percutaneous portal vein interventions in 21 pediatric recipients of liver transplant, performed via transhepatic portal venous access with a 5F sheath. Transhepatic tracts were plugged with AGS pledgets, and no major procedure-related hemorrhagic complications were reported. Consistent with these experiences, AGS torpedoes achieved successful tract closure in our cohort. By contrast, Pimpalwar et al.[7] reported a higher access-tract hemorrhage rate in 44 transsplenic portal interventions in 30 children, including 13 procedures for native-liver chronic portal vein thrombosis. Tracts were embolized with AGS pledgets, and intraperitoneal bleeding occurred in 12 of the 44 procedures, with all cases managed conservatively; anticoagulation was iden-

Table 2. Distribution of pre-to-postprocedural hemoglobin change in the study cohort

Periprocedural laboratory values		
Measure	Preprocedure, median (range)	Postprocedure, median (range)
Hemoglobin, g/dL	10.4 (7.1–12.5)	10.3 (6.1–12.6)
Hematocrit, %	31.5 (25.0–39.0)	32.0 (22.0–40.0)
Platelet count, $\times 10^9$/L	77.5 (46.0–558.0)	80.0 (55.0–560.0)
INR	1.1 (1.1–1.5)	—
[a]PTT, s	26.5 (15.4–31.9)	—
Distribution of pre-to-postprocedural hemoglobin change (ΔHb)		
ΔHb category	n	Percent of cohort
0–1 g/dL decrease	4	22.2%
1–2 g/dL decrease	5	27.8%
> 2 g/dL decrease	1	5.6%
Increase (ΔHb > 0)	6	33.3%
No change (ΔHb = 0)	2	11.1%
Total	18	100%

ΔHb, hemoglobin change; INR, international normalized ratio; [a]PTT, activated partial thromboplastin time.

Table 3. Summary of studies reporting tract embolization and access-tract hemorrhage in pediatric patients

Study	Closure technique	n patients/tracts	Access-tract hemorrhage
Uller et al.[8]	AGS slurry	9/11	1/11 (9%)
Monroe et al.[9]	AGS slurry, pledgets	26/13	2/26 (7.7%)
Patel et al.[20]	AGS pledgets	21/42	0/42 (0%)
Pimpalwar et al.[7]	AGS pledgets, microfibrillar collagen	30/44	12/44 (27%)
Marra et al.[13]	NBCA	11/15	1/15 (7%)
Our study	AGS torpedoes	18 /28	0/18 (0%)

AGS, absorbable gelatin sponge; NBCA, N-butyl cyanoacrylate.

tified as a significant risk factor for hemorrhage. Intraprocedural anticoagulation was routinely used in all cases in our cohort. A procedural factor that might contribute to hemorrhage is the brief interval during long-to-short sheath exchange; this potential window was avoided in the present study by clamping and cutting the sheath in the desired position, thereby eliminating the need for sheath exchange and minimizing the risk of hemorrhage even when long sheaths were used.

One of the most employed tract-embolization methods in adults is embolization with an ethiodized oil–N-butyl cyanoacrylate (NBCA) mixture, but published pediatric experience remains limited. Marra et al.[13] reported 15 percutaneous portal vein interventions, in which the tract was embolized with this technique in 11 children with non-cirrhotic EHPVO, performed via transhepatic, transsplenic, or combined access. Hemoperitoneum occurred in one procedure, which was managed conservatively.[13] Adoption of an ethiodized oil–NBCA mixture is a potential option for tract embolization; however, its use is technically demanding, requires meticulous flow control, and the risk of inadvertent embolization is of particular concern in pediatric patients. However, to prevent non-target embolization, a combination of coils and an ethiodized oil–NBCA mixture may be employed. Pediatric data on coil-based tract embolization remains limited to isolated cases;[21] Ohm et al.[22] reported no access-tract hemorrhage using this technique in adults. Permanent metallic embolic materials such as coils and vascular plugs may be less desirable in children, as they can produce artifacts on follow-up magnetic resonance imaging, carry a risk of foreign-body reaction in immunosuppressed patients, and impede repeat access when reintervention is required.[8,12,18] Although studies describing tract embolization in adults using vascular closure devices as an alternative are available, their routine use for portal or splenic parenchymal tract closure may not be feasible due to the relatively high cost.[23] Therefore, AGS torpedoes may offer a cost-effective and widely available alternative to ethiodized oil–NBCA embolization, coils, and device-based options such as vascular plugs or closure devices.[19]

Our study has several limitations. First, it is a single-center, retrospective study with a small sample size and no comparator arm using other widely used tract-embolization techniques. Our results should be interpreted as feasibility and safety data for AGS torpedoes rather than definitive evidence of superiority; adequately powered multicenter studies with standardized endpoints and matched or randomized comparators are needed. Accordingly, our results are intended to inform tract-closure techniques in this pediatric setting and were not designed to assess recanalization efficacy or comparative effectiveness. Second, we excluded procedures in which tract embolization could not be attempted because the access sheath was dislodged before closure; although consistent with our efficacy-focused objective, this may bias hemorrhage estimates downward and restrict generalizability to cases in which tract closure is technically feasible. In addition, access profiles in our cohort were limited to 5F and 6F sheaths; therefore, extrapolation to larger sheath sizes (e.g., 8F and 9F, used for stent delivery in other settings) should be performed cautiously. When tract embolization cannot be performed, close hemodynamic and laboratory monitoring, prompt correction of coagulopathy, and a low threshold for transfusion are essential to mitigate hemorrhagic risk. In exceptional cases, surgical management may be considered in a multidisciplinary setting. Finally, selection bias was unavoidable given the heterogeneous etiologies of portal vein obstruction, although most chronic cases were related to prior umbilical venous catheterization.

In conclusion, this preliminary study suggests that torpedo-based tract closure with AGS using a transsplenic and/or transhepatic approach appears feasible and was not associated with clinically significant hemorrhagic complications after recanalization of EHPVO, particularly in procedures requiring dual access and sheaths of up to 6F performed under routine intraprocedural anticoagulation. These findings should be interpreted as technique-focused feasibility and early safety data, rather than evidence of superiority, and warrant verification in larger comparative studies.

Footnotes

Conflict of interest disclosure

The authors declared no conflicts of interest.

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