Splenic Embolization for Reduction and Portal Hypertension: Coils, Plugs or Particles?

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First Partial splenic embolization (PSE) was reported by Maddison in 1973 influential paper by Spigos et al in 1979.

- **Hypersplenism**: splenomegaly, a variable combination of anemia, leucopenia thrombocytopenia and compensatory bone marrow hyperplasia.

- Partial Splenic Embolization (PSE) has been used to safely palliate the effects of **hypersplenism**.

## INDICATIONS FOR SAE

- Hypersplenism due to cirrhosis.
- Variceal bleeding (PHT)
- Bleeding gastric varices due to splenic venous thrombosis.
- Thrombocytopenia related to systemic chemotherapy administration.
- Pre-op before splenectomy
- Blunt splenic trauma
- Splenic artery aneurysm
- Splenic artery steal syndrome
- Refractory ascites
Three-dimensional drawing of normal anatomy in the upper abdomen shows the main splenic artery and its branches.


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Three-dimensional drawing of selective partial splenic arterial embolization shows change in color (brown area) that represents absence of perfusion in the inferior portion of the spleen.

TOTAL (PROXIMAL) SAE

- Embolization of main splenic artery with metallic coils.
- Intact collateral supply.
SPLENIC EMBOLIZATION

• VOLUME REDUCTION / INfarction

• EFFICACY

• COMPLICATIONS
## COMPLICATIONS

<table>
<thead>
<tr>
<th>MINOR</th>
<th>MAJOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAIN</td>
<td>ABSCESS</td>
</tr>
<tr>
<td>POST EMBOLIZATION SYNDROME</td>
<td>SEPTICEMIA</td>
</tr>
<tr>
<td></td>
<td>SPLENIC RUPTURE</td>
</tr>
<tr>
<td></td>
<td>PLEURAL EFFUSION</td>
</tr>
<tr>
<td></td>
<td>PANCREATITIS</td>
</tr>
<tr>
<td></td>
<td>PARALYTIC ILEUS</td>
</tr>
<tr>
<td></td>
<td>PNEUMONIA</td>
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</table>
Partial Splenic Embolization in the Treatment of Patients with Portal Hypertension: A Review of the English Language Literature

Kristen Gledhill Koconis, MD, Harjit Singh, MD, and Gregory Soares, MD

This article reviews the existing literature on the use of partial splenic embolization in patients with portal hypertension. All articles published in the English language on splenic embolization or partial splenic embolization as a treatment for portal hypertension were identified with a PubMed search from 1973 through 2005. Partial splenic embolization appears to be efficacious in reducing episodes of variceal bleeding, improving hematologic parameters, enhancing hepatic protein synthesis, and reducing the severity of hepatic encephalopathy. Associated morbidity and mortality appear to be acceptable. The literature, however, is limited in quality. Given the potential benefits of partial splenic embolization, further investigation is warranted to allow evidence-based evaluation of its use.

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401 pts (series over 10 pts): 1 percent mortality
No RCT
Partial splenic embolization for hypersplenism in cirrhosis: A long-term outcome in 62 patients

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Abstract

Background. Although partial splenic embolization (PSE) has been widely used for treatment of leucocytopenia and thrombocytopenia in cirrhosis, only few studies on the correlation between splenic infarction rate and long-term outcome of partial splenic embolization have been reported.

<table>
<thead>
<tr>
<th></th>
<th>GROUP A</th>
<th>GROUP B</th>
<th>GROUP C</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>N=12</td>
<td>N=34</td>
<td>N=16</td>
</tr>
<tr>
<td>% INFARCT</td>
<td>&gt;70%</td>
<td>50-70%</td>
<td>&lt;50%</td>
</tr>
<tr>
<td>PLATELET/LEUKOCYTE</td>
<td>P&lt;0.05</td>
<td>P&lt;0.05</td>
<td>6 M</td>
</tr>
<tr>
<td>(2WKS TO 5 YEARS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAJOR COMPLICATIONS</td>
<td>50%</td>
<td>8.8%</td>
<td>NONE</td>
</tr>
</tbody>
</table>

Conclusions. In partial splenic embolization, the splenic infarction rate should be limited to 50%–70% in order to ensure the long-term efficacy in alleviating hypersplenism and reduce complications.

Keywords: Cirrhosis; Hypersplenism; Long-term outcome; Partial splenic embolization
Sixteen patients received 22 embolizations, with 11 patients undergoing a single session and 5 patients undergoing multiple sessions.

Indications included hypersplenism, gastrointestinal hemorrhage, ascites, and autoimmune hemolytic anemia.
Table 2. Infectious Complications, Splenectomy, and Mortality after PSE

<table>
<thead>
<tr>
<th></th>
<th>Abscess</th>
<th>Sepsis</th>
<th>Splenectomy</th>
<th>Delayed Death*</th>
<th>P Value†</th>
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<tbody>
<tr>
<td>PSE type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-session</td>
<td>3</td>
<td>3‡</td>
<td>4</td>
<td>3</td>
<td>P = .5</td>
</tr>
<tr>
<td>(n = 11)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple-session</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>(n = 5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pattern of infarction per PSE session</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large confluent</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>P = .2</td>
</tr>
<tr>
<td>(n = 12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral/wedge-shaped (n = 10)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pattern of infarction per patient</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large confluent</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>P = .2</td>
</tr>
<tr>
<td>(n = 8)</td>
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<tr>
<td>Peripheral/wedge-shaped (n = 7)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: PSE, partial splenic artery embolization.
*Attributed to PSE, >30 days.
†Delayed death attributed to PSE, P = .1 by log-rank test.
‡Two cases of sepsis were associated with splenic abscess.
• Partial splenic embolization is an effective to manage low blood cell counts, ascites, and hemorrhage in the liver transplant recipient.

• When a large confluent splenic infarction is created, abscess and death appear to be more likely. Inherently immunosuppressed groups subjected to large infarctions are particularly vulnerable.

• Small-volume (<50%) sequential partial splenic embolization is more likely to produce peripheral/wedge-shaped infarction and appears to be a safer technique.
88 pts underwent SAE for NOM of trauma

Major complications 14 percent: 75 percent pts with complications underwent distal embolization
COIL/PLUG EMBOLIZATION

- PROXIMAL VS DISTAL LOCATION
Coil Embolization of the Splenic Artery: Impact on Splenic Volume

Stephen R. Preece, MD, Stacey M. Schriber, MD, Kingshuk R. Choudhury, PhD, Paul V. Suhocki, MD, Tony P. Smith, MD, and Charles Y. Kim, MD

ABSTRACT

Purpose: To determine the impact of coil embolization of the splenic artery on splenic volume based on computed tomography (CT) imaging.

Materials and Methods: Splenic artery embolization (SAE) was performed in 148 consecutive patients over an 8-year period in an institutional review board–approved retrospective study. Of these, 60 patients (36 men; mean age, 49 y) had undergone contrast-enhanced CT before and after SAE with a mean time interval of 355 days. Pre- and postembolization splenic volumes were calculated with volume-rendering software. Presence of Howell–Jolly bodies was ascertained on laboratory tests. A trauma control group consisted of 39 patients with splenic laceration and follow-up CT but no splenic intervention.

Results: SAE in trauma patients resulted in an insignificant decrease in mean spleen size from 224 cm³ to 190 cm³ (P = .222). However, postembolization splenic volume was significantly smaller than follow-up volume in the trauma control group (353 cm³; P < .001). In nontrauma patients, the mean splenic volume decreased from 474 cm³ to 399 cm³ after SAE (P = .068). Multivariable analysis revealed that coil pack location was the only factor significantly affecting resultant splenic volume (P = .016). For trauma and nontrauma patients, distal embolization resulted in significant splenic volume loss (P = .034 and P = .013), whereas proximal embolization did not. No patients had persistent circulating Howell–Jolly bodies after SAE. No patients required repeat embolization or splenectomy.

Conclusions: Coil embolization of the splenic artery resulted in a modest but significant decrease in splenic volume when performed distally; proximal embolization resulted in an insignificant volume change.
**Figure 1.** Patient flowchart.

- **Embolization cohorts**
  - Splenic artery embolization with coils (n=148)
  - +pre & post embolization contrast-enhanced CT (n=80)
  - Exclude: adjunct distal embolic agents (n=20)
  - Embolization cohort (n=60)
    - Nontrauma embolization cohort (n=31)
    - Trauma embolization cohort (n=29)

- **Trauma control cohort**
  - Acute blunt trauma with splenic laceration on CT (n=328)
  - +follow-up contrast-enhanced CT (n=83)
  - Exclude: surgical or endovascular intervention on spleen (n=44)
  - Trauma control cohort (n=39)
TAKE HOME POINTS

- The only variable tested that correlated with resultant splenic volume on multivariate analysis was **coil pack location** \((P = .016)\).

- Distal embolization resulted in a **30% decrease in splenic volume** \((P = .003)\).

- Sub-analysis: patients with volume reduction >50%: **coil pack extended into one or more hilar branches in 7/8 cases** compared with 17 of 52 cases without volume loss of >50% \((P = .005)\).
ADVERSE EVENT PROFILE

- No splenic abscess after embolization.

- No patients developed clinically apparent pancreatitis attributable to SAE or occlusion of pancreatic branches.
2007-2011
681 patients
54 pts went SAE for PHP (n=42) – refractory ascites (n=12)
Gianturco coils and/or Amplatzer vascular plugs in the proximal splenic artery to prevent spleen infarction.

Results:
Improved hepatic arterial resistive indices
No major complications
Safety and efficacy of splenic artery coil embolization for hypersplenism in liver cirrhosis

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Correspondence to: Wei-Jun Peng. Email: weijun.peng.sh@gmail.com

Abstract
Background: Partial splenic artery embolization is an effective treatment for hypersplenism but often lacks long-term benefits.

Purpose: To evaluate the long-term effects of coil embolization of the splenic artery in patients with liver cirrhosis and hypersplenism.

Material and Methods: Forty-nine patients with liver cirrhosis and hypersplenism underwent coil embolization of the main splenic artery. The coils were deployed in the mid- or distal segment of the splenic artery to allow collateral blood flow to the spleen. The following data were collected from 2 weeks to 4 years after the embolization: technical success, length of hospital stay, white blood cell count, platelet count, splenic volume, and complication.

Results: The technical success rate of splenic artery coil embolization was 100%. The post embolization syndrome rate was 75% (36/49) with no incidence of major complications. The mean length of hospital stay was 9 days. After embolization, the patient’s white blood and platelet counts increased significantly, peaked at 2 weeks, and gradually decreased during the 4-year follow-up period, but remained at significantly higher levels than pre-embolization levels. Follow-up CT scans demonstrated a gradual increase in the volume of the enhanced portions of the spleen with a decrease in the volume of unenhanced portion. No significant changes occurred in the red blood cell count and liver function after the embolization.

Conclusion: Embolization of the mid-and distal main splenic artery with coils is a safe and effective treatment of hypersplenism in cirrhosis with long-term hematologic benefits.

Keywords: Liver cirrhosis, hypersplenism, coil embolization, splenic artery

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Ron C. Gaba, Jeremy R. Katz, Ahmad Parvinian, Steven Charles A. Owens, M. Grace Knuttinen, James T. Bui

MATERIALS AND METHODS
A total of 50 patients (male:female, 33:17; mean age, 49 years) who underwent 50 SAEs between 1998 and 2011 were retrospectively studied. The procedure indications included aneurysm or pseudoaneurysm (n=15), gastric variceal hemorrhage (n=15), preoperative reduction of surgical blood loss (n=9), or other (n=11). In total, 22 procedures were elective, and 28 procedures were urgent or emergent. The embolic agents included coils (n=50), gelatin sponges (n=15), and particles (n=4). The measured outcomes were the technical success of the procedure, efficacy, side effects, and the 30-day morbidity and mortality rates.

RESULTS
All embolizations were technically successful. The procedure efficacy was 90%; five patients (10%) had a recurrent hemorrhage requiring a secondary intervention. Side effects included hydrothorax (n=26, 52%), thrombocytosis (n=16, 32%), thrombocytopenia (n=13, 26%), and postembolization syndrome (n=11, 22%). Splenic infarcts occurred in 13 patients (26%). The overall and procedure-specific 30-day morbidity rates were 38% (19/50) and 14% (splenoportal thrombosis, 3/50; encapsulated bacterial infection, 1/50; splenic abscess, 1/50; femoral hematoma requiring surgery, 1/50; hydrothorax requiring drainage, 1/50). The overall and procedure-specific 30-day mortality rates were 8% (4/50) and 0%. The multivariate analysis showed that advanced patient age (P = 0.037), postprocedure thrombocytopenia (P = 0.008), postprocedure hydrothorax (P = 0.009), and the need for a secondary intervention (P = 0.004) predicted the 30-day morbidity, while renal insufficiency (P < 0.0001), preprocedure hemodynamic instability (P = 0.044), and preprocedure leukocytosis (P < 0.0001) were prognostic factors for the 30-day mortality.

CONCLUSION
SAE was performed with high technical success and efficacy, but the outcomes showed nontrivial morbidity rates. Elderly patients with advanced comorbidities had higher rates of complications.
Efficacy of splenic artery embolization for refractory ascites in the post-liver transplant patient

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Purpose: Refractory ascites (RA) in advanced liver disease is known to carry a poor prognosis. Although liver transplantation is usually effective for the treatment of RA, there are rare cases where transplantation is not effective. Previously, TIPS has been used for RA but TIPS is not as effective in liver transplant patients as in native liver patients. Given the high morbidity and mortality associated with RA, a safe intervention that reduces the incidence of this complication is warranted.

Materials and Methods: Retrospective chart review evaluating the efficacy of splenic artery embolization (SAE) in post-transplant patients for the treatment of RA. Proximal SAE was performed with either an Amplatz vascular plug or embolic coils. Frequency of large volume paracentesis, volume of paracentesis, and calculation of pre-embolization splenic volume on abdominal CT were calculated. Splenic volume calculations were performed to determine if larger splenic volume predicted improved response to SAE (Volume=30+0.58{(Max Width × Max Thickness × Max Length)}).

Results: Five post-transplant patients with RA received proximal SAE at a single center in 2013-2014. Four patients were treated with an Amplatz plug and one patient, due to limitations in anatomy, was treated with embolic coils. The results are listed in the table below. No patients presented with post-embolization complications.

Conclusion: SAE is a safe and effective treatment for refractory ascites. Currently, there is limited data in the literature regarding efficacy of SAE for the treatment of RA in the post-liver transplant population. This case series represents the second largest cohort of patients in the literature, with the largest cohort representing six patients. Given the high morbidity and mortality associated with RA and decreased effectiveness of TIPS in this population, SAE represents a safe alternative treatment for post-liver transplant refractory ascites.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Pre-SAE volume/ event (mL)</th>
<th>Post-SAE volume/ event (mL)</th>
<th>Frequency of paracentesis pre-SAE</th>
<th>Frequency of paracentesis post-SAE</th>
<th>Splenic volume pre-SAE (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3,000-10,200</td>
<td>1,000-2,200</td>
<td>Weekly</td>
<td>3 events in 11 months</td>
<td>909</td>
</tr>
<tr>
<td>2</td>
<td>4,200-9,100</td>
<td>4,700-7,700</td>
<td>Biweekly</td>
<td>7 events in 9 months</td>
<td>670</td>
</tr>
<tr>
<td>3</td>
<td>3,750-7,950</td>
<td>3,900-9,600</td>
<td>Monthly</td>
<td>9 events in 10 months</td>
<td>Not available</td>
</tr>
<tr>
<td>4</td>
<td>1,500-5,000</td>
<td>1,100-2,200</td>
<td>Weekly-Biweekly</td>
<td>10 events in 11 months</td>
<td>1,003</td>
</tr>
<tr>
<td>5</td>
<td>4,100-6,700</td>
<td>3,700-6,700</td>
<td>Weekly</td>
<td>12 events in 6 months</td>
<td>587</td>
</tr>
</tbody>
</table>
Proximal Splenic Artery Embolization in Chemotherapy-Induced Thrombocytopenia: A Retrospective Analysis of 13 Patients

Shivank S. Bhatia, MD, Shree Venkat, MD, Ana Echenique, MD, Caio Rocha-Lima, MD, Mehul H. Doshi, MD, Jason Salsamendi, MD, Katuska Barbery, MD, and Govindarajan Narayanan, MD

- 4M/9F 39-79 yo (mean age, 63±11 years)

- Pancreatic (n=6); Cholangiocarcinoma (n=5); Rectal (n=1) and Gall bladder (n=1)
MRI – PRE AND POST

PLATELET COUNT PRE: 118  PEAK POST PROCEDURE: 271
RESULTS

• All the patients were able to receive systemic chemotherapy.

• Average time to initiation of systemic therapy was $22.0 \pm 17.5$ days (range 4-58 days)

• Patients received average $8.2 \pm 4.2$ (n=12; range: 2-19 cycles) cycles of chemotherapy after the TSAE procedure.

• None of the patients required hospitalization post procedure.
RESULTS – PLATELET COUNTS

Mean platelet counts at different time points:

- Pre-chemotherapy: 162
- Nadir: 45
- Pre-TSAE: 88
- Post TSAE peak count at short term f/up (mean 35 days): 210
- Post TSAE peak count at long term f/up (mean 9.2 months): 152

Mean platelet count (10^3/mcL) for n=13
Mean pre SAE splenic volume was \( 547.9 \pm 384.5 \text{cc} \) (\( n=12 \); range: 127-1556 cc). Post procedure peak splenic volume reduction at mean follow up of 5.4\( \pm \)3.9 months (range: 0.5-12 months) was \( 358.7 \pm 233.9 \text{cc} \) (\( n=12 \); range: 90-968 cc). (\( p<0.01 \)).

The mean splenic infarction was 29.5 % at 0.5-12 month follow up.
30 Day mortality was zero.

There were no major complications.

Minor complications:
- 5/13 reported LUQ pain controlled by oral pain medications
- 1/13 patients was admitted for 23 hours observation for IV medications for pain control
PSE FOR CIT

- Retrospective review of 28 patients underwent PSE to correct thrombocytopenia to facilitate the initiation or resumption of ST.
- The mean platelet count was 81 K/UL immediately before PSE and peaked at 293 K/UL after PSE.
- The mean hospital stay was 4.5 days. Fever was documented in 16 patients and pulmonary consolidation/atelectasis or effusion was documented in 10 patients.
- 17/23 patients were able to receive ST (no follow up on 5 patients) and 6 patients had recurrence interfering with ST. 2 patients had repeat embolization.
Post procedure PLT and WBC counts were higher in the group that underwent Proximal rather than Distal (p=0.001)

Post procedure residual splenic volume was less in those that underwent Proximal rather than Distal (p=0.001)
Proximal SAE is safe, effective and well tolerated procedure.

Location of coil correlates with volume reduction

Long term response is not sustained

Re-embolization?

Distal embolization is associated with higher complication rate

Sustained long term response

Volume of infarct: <70% (?<50%)

Multiple sessions should be considered

PHP, RA, CIT, Trauma
THANK