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INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

Splenic artery embolization in the treatment of blunt splenic injury: single level 1 trauma center experience

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PURPOSE

To describe the experience of a single level 1 trauma center in the management of blunt splenic injuries (BSI).

METHODS

This is a retrospective study with Institutional Review Board approval. The medical records of 450 patients with BSI treated between January 2016 and December 2022 were reviewed. Seventy-two patients were treated with splenic artery embolization (SAE), met the study criteria, and were eligible for data analysis. Spleen injuries were graded in accordance with the American Association for the Surgery of Trauma Organ Injury Scale. Univariate data analysis was performed, with $P < 0.05$ considered statistically significant.

RESULTS

The splenic salvage rate was 90.3% (n = 65/72). Baseline demographics were similar between the groups ($P > 0.05$). Distal embolization with Gelfoam® had similar rates of splenic salvage to proximal embolization with coils (90% vs. 94.1%, $P > 0.05$). There was no significant difference in the rate of splenic infarction between distal embolization with Gelfoam® (20%, 4/20) and proximal embolization with coils (17.6%, 3/17) ($P > 0.05$). There was no significant difference in procedure length (68 vs. 75.8 min) or splenic salvage rate (88.5% vs. 92.1%) between proximal and distal embolization ($P > 0.05$). There was no significant difference in procedure length (69.1 vs. 73.6 min) or splenic salvage rate (93.1% vs. 86.4%) between Gelfoam® and coil embolization ($P > 0.05$). Combined proximal and distal embolization was associated with a higher rate of splenic abscess formation (25%, 2/8) when compared with proximal (0%, 0/26) or distal (0%, 0/38) embolization alone ($P = 0.0003$). The rate of asymptomatic and symptomatic splenic infarction was significantly higher in patients embolized at combined proximal and distal locations ($P = 0.04$, $P = 0.01$).

CONCLUSION

The endovascular management of BSI is safe and effective. The overall splenic salvage rate was 90.3%. Distal embolization with Gelfoam® was not associated with higher rates of splenic infarction when compared with proximal embolization with coils. Combined proximal and distal embolization was associated with a higher incidence of splenic infarction and splenic abscess formation.

CLINICAL SIGNIFICANCE

Distal splenic embolization with Gelfoam® is safe and may be beneficial in the setting of blunt splenic trauma.

KEYWORDS

Coil, combined, distal, embolization, Gelfoam®, proximal, spleen, trauma

Blunt splenic injuries (BSI) are a common occurrence following traumatic events such as motor vehicle accidents, boating accidents, falls, or altercations.[1] Splenic injuries can result in massive blood loss and high mortality.[2] The management of BSI is aimed toward the preservation of splenic parenchyma, as the spleen serves a key role in the defense against

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encapsulated pathogens.[3] Safe and efficacious treatments to promote spleen salvage are imperative to improve long-term patient outcomes.

Splenic artery embolization (SAE) is a safe and efficacious spleen-salvaging treatment for high-grade splenic injuries.[2] This treatment successfully achieves hemostasis,[4] increases the rate of splenic salvage,[5,6] and preserves both short- and long-term immune function.[3] In the absence of comprehensive guidelines for SAE, the techniques used are often determined by the operator's judgment and experience. At our institution, proximal embolization with coils and distal embolization with Gelfoam® remain the most common SAE techniques for the treatment of BSI. Based on current literature, distal embolization with Gelfoam® is not recommended because embolization with Gelfoam® has been associated with inferior clinical outcomes.

Recent studies have suggested that proximal[7,8] SAE is associated with significantly lower fluoroscopy time[9] and lower rates of major complications such as post-embolization abscess and splenic infarction.[1,2,10] The use of Gelfoam® has been discouraged[11] because of a reported association with an increased risk of recurrent bleeding[12] and infection when compared with coil or plug embolization.[13,14] These findings, however, are inconsistently supported by the literature, and the optimal technique for SAE remains under debate. The purpose of this study is to describe a single level 1 trauma center experience in the management of blunt splenic trauma. A secondary goal is to determine if distal SAE with Gelfoam® is associated with an increased risk of splenic infarction.

Methods

Patient population

A retrospective cohort study of adult patients with BSI treated between January 2016 and December 2022 was performed at a single level 1 trauma center. Patients aged 18 and older with BSI were included. Children, pregnant women, and prisoners were excluded from the study. In total, 450 patients met the study criteria and were included in the medical record review. Of the eligible 450 patients, 72 were treated with SAE and included in the data analysis (Figure 1). This retrospective study was approved by the LSUHSC New Orleans Institutional Review Board (approval: IRB #5040, date: February 28, 2023), and a waiver of consent was obtained.

Main points

- For the treatment of blunt splenic injury (BSI), distal embolization with Gelfoam® was not associated with an increased risk of splenic infarction or other inferior clinical outcomes when compared with proximal embolization with coils.
- Combined embolization was associated with a higher incidence of splenic infarction and splenic abscess formation.
- Splenic embolization is a safe spleen-salvaging treatment for the management of BSI.

Collected variables

The medical record review included the collection of demographic information, embolization techniques and outcomes, and clinical outcomes. The embolization technique was defined by the embolization location and embolization material. Patient charts were reviewed for reported complications or additional interventions up to 90 days following the primary treatment. The clinical outcomes of interest included hospital length of stay, intensive care unit (ICU) length of stay, and readmission within 30 days. The embolization outcomes of interest included procedure length, splenic salvage rate, splenic abscess formation, splenic infarction, and the need for additional intervention. Secondary interventions included SAE following observation, SAE following a previous SAE, or splenectomy following SAE. The diagnosis of splenic abscess formation required clinical symptoms, leukocytosis, and imaging findings on computed tomography (CT). The presence of splenic infarction was evaluated based on imaging findings. Splenic infarction was considered clinically significant if the following symptoms were present: fever, leukocytosis, left upper quadrant pain, nausea, or vomiting.

Injury grading

Spleen injuries identified in surgery or on abdominal CT scans were graded according to the 2018 American Association for the Surgery of Trauma Organ Injury Scale (AAST-OIS).[15] The injury severity score (ISS) was used to provide an overall injury grade for patients with multiple injuries. Each injury is allocated to one of six body regions and rated with an abbreviated injury score (AIS) from 1 to 5, ranging from minor to critical injuries. The ISS is calculated by squaring the AIS of the three most severely injured body regions and combining them, creating a score of 0 to 75.[16]

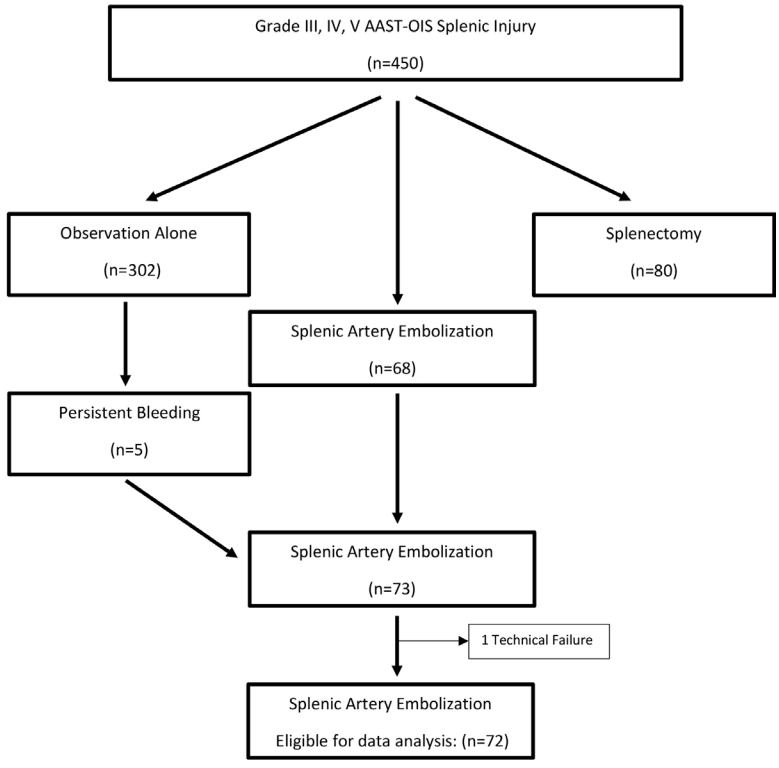

Figure 1. Flowchart. AAST-OIS, American Association for the Surgery of Trauma Organ Injury Scale.

Indications

At our institution, patients with BSI who were hemodynamically unstable were managed with splenectomy. Hemodynamically stable patients were evaluated with contrast-enhanced CT. Patients with AAST-OIS grade III–V BSI, large perisplenic hematoma, contrast extravasation, pseudoaneurysm, or other vascular injuries were referred for SAE. Patients who did not meet the criteria for SAE on their first CT assessment were managed conservatively. These patients were monitored for evidence of ongoing bleeding such as decreasing hematocrit levels or changes in vital signs. Patients with evidence of ongoing bleeding after the initial assessment underwent repeat contrast-enhanced CT scans and were reconsidered for treatment by SAE or splenectomy.

Embolization techniques

All procedures were performed by fellowship-trained interventional radiologists in a state-of-the-art angiography suite. Procedures were performed either under general anesthesia or monitored anesthesia care. Ultrasound guidance was used for arterial access to either the right or left common femoral artery. Selective catheterization of the celiac trunk was performed using standard angiographic catheters. A selective arteriogram of the celiac trunk was performed using a power injector. The anatomy of the splenic artery was delineated, and the angiographic findings were evaluated by the operators (Figure 2). The embolization techniques and materials used were determined during the procedure based on angiographic findings, operator experience, preference, and judgment. Angiographic findings indicating the need for embolization included contrast extravasation, pseudoaneurysm, and contrast blush.

Proximal embolization was defined as embolization of the main splenic artery trunk distal to the dorsal pancreatic artery but proximal to the splenic hilum (Figure 3). Distal embolization was defined as embolization of a splenic artery branch or branches at sites distal to collateral pathways (Figure 4). Embolization was performed using Gelfoam®, particles, coils, and plugs, used either alone or in combination. Embolization was considered complete when contrast extravasation was no longer present. Procedure efficacy was measured using the splenic salvage rate at 30 days. The medical records of patients who underwent embolization were reviewed up to 90 days after the procedure to determine technical and clinical success rates and incidence of complications.

Statistical analysis

Univariate analysis was performed using ANOVA for continuous variables or χ^2 test for categorical variables. Data were analyzed using GraphPad Prism (version 10.0.0, La Jolla, CA, USA). A *P* value of less than 0.05 was considered statistically significant.

Results

Patient population

A total of 302 (67.1%, 302/450) patients were treated by observation alone, 80 (17.8%, 80/450) required splenectomy, and 68 (15.1%, 68/450) underwent SAE. Of the 302 patients initially treated by observation alone, 5 (1.7%, 5/302) showed signs of persistent bleeding and underwent subsequent SAE. One patient underwent a splenic arteriogram, and embolization was attempted but was technically unsuccessful. This patient was excluded, leaving a total of 72 patients treated by SAE eligible for data analysis (Figure 1, Table 1).

Patients treated by SAE had an average ISS of 26.9 ± 11.8 and spleen AAST-OIS grade of 3.5 ± 0.8. The patients were hospitalized for an average of 10.9 ± 9.0 days, with an average of 5.9 ± 5.6 days in the ICU. The SAE procedure averaged 71.7 ± 25.8 minutes and the rate of splenic salvage was 90.3% (n = 65/72). Seven (9.7%, 7/72) patients exhibited evidence of persistent bleeding after SAE and required splenectomy; one (1.4%, 1/72) splenectomy occurred after a second SAE

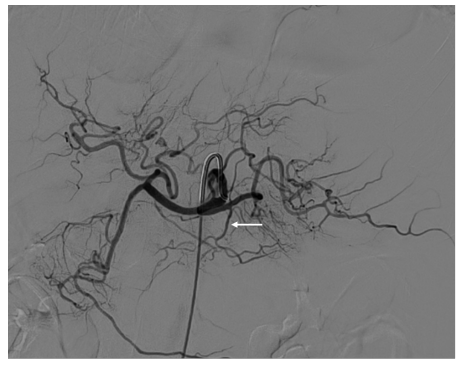

Figure 2. Celiac digital subtraction angiography showing the main splenic artery arising from the celiac trunk. The dorsal pancreatic artery (arrow) arises from the main splenic artery.

Table 1. Splenic artery embolization patient demographics, clinical characteristics, and outcomes

Total	72
Demographics/injury data	
Age, mean (range)	43.2 (18–79)
Male, n (%)	47 (65.3)
Female, n (%)	25 (34.7)
AAST-OIS grade, mean (SD) Grade II, n (%) Grade III, n (%) Grade IV, n (%) Grade V, n (%)	3.5 (0.8) 8 (11.1) 25 (34.7) 34 (47.2) 5 (6.9)
Injury severity score, mean (SD)	26.9 (11.8)
Embolization outcomes, n (%)	
Procedure length, mean min (SD)	71.7 (25.8)
Splenic salvage, n (%)	65 (90.3)
Failed observation SAE, n (%)	5 (6.9)
Repeat SAE splenectomy, n (%)	1 (1.4)
Post SAE splenectomy, n (%)	7 (9.7)
Splenic abscess, n (%)	2 (2.8)
Splenic infarct, n (%)	11 (15.3)
Symptomatic splenic infarct, n (%)	2 (2.8)
Clinical outcomes	
Hospital length of stay mean days (SD)	10.9 (9.0)
ICU length of stay mean days (SD)	5.9 (5.6)
Readmission within 30 days, n (%)	4 (5.6)

SAE, splenic artery embolization; AAST-OIS, American Association for the Surgery of Trauma Organ Injury Scale; SD, standard deviation; ICU, intensive care unit.

was performed. Two patients (2.8%, 2/72) had imaging findings suggestive of splenic abscess on follow-up CT scans. Splenic infarct was identified in 11 patients (15.3%, 11/72); two of these patients (2.8%, 2/72) had symptomatic splenic infarct. Both patients that presented with symptomatic splenic infarcts were treated with combined embolization using Gelfoam® and coils at proximal and distal locations. One patient presented following a second embolization attempt, later developed a splenic abscess, and was then treated by splenectomy. One patient was treated for left upper quadrant pain, and no further complication was identified. There were no in-hospital mortalities following SAE.

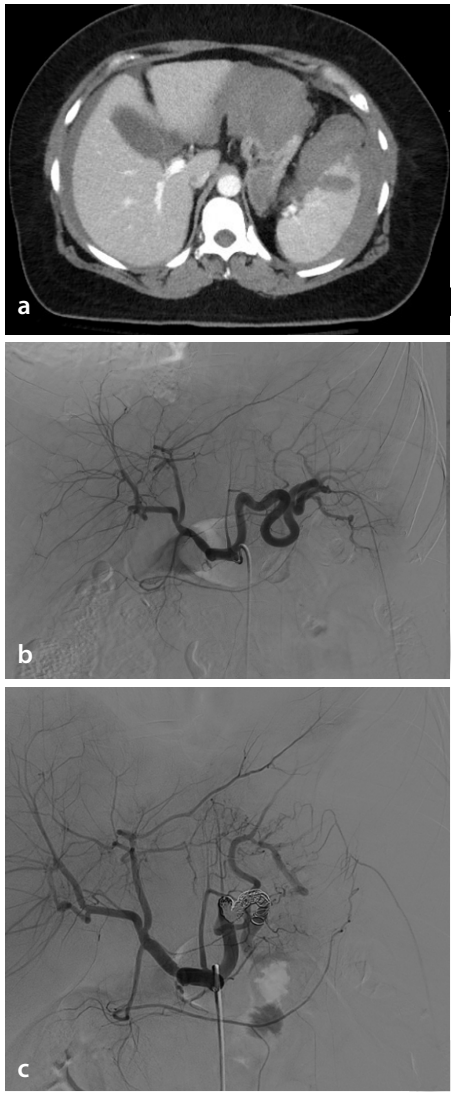

Figure 3. Proximal splenic artery embolization with coils in a 49-year-old woman following a motor vehicle collision. **(a)** Contrast-enhanced computed tomography showing a grade III splenic laceration and significant hemoperitoneum. **(b)** Pre-embolization celiac digital subtraction angiography (DSA) with no contrast extravasation or pseudoaneurysm. **(c)** Post embolization DSA displaying decreased but preserved perfusion to the spleen. Multiple detachable AZUR CX coils (Terumo Interventional Systems, Tokyo, Japan) and pushable Tornado coils (Cook Medical, Bloomington, IN, USA) can be seen in the main splenic artery, distal to the dorsal pancreatic artery.

Embolization technique

Twenty patients (27.8%, 20/72) underwent distal embolization with Gelfoam®, and 17 patients (23.6%, 17/72) underwent proximal embolization with coils. The remaining 35 patients (48.6%, 35/72) were embolized with combinations of embolization material and location and were not included in the data analysis. Baseline demographics, ISS, hospital length of stay, and readmission within 30 days were not significantly different between the groups ($P > 0.05$). There was no significant difference in procedure length or splenic salvage rate between the groups ($P > 0.05$). The mean spleen AAST-OIS grade was significantly higher in patients treated by distal embolization with Gelfoam® (3.75 ± 0.7) than in patients treated by proximal embolization with coils (3.2 ± 0.8) ($P = 0.03$). Splenic infarct was identified on follow-up imaging in four patients (20%, 4/20) treated by distal embolization with Gelfoam® and three patients (17.6%, 3/17) treated by proximal embolization with coils ($P > 0.05$) (Table 2). Two splenic abscesses were reported in patients embolized using a combination of Gelfoam® distally and coils proximally (5.7%, 2/35).

The patients were additionally stratified by embolization location and material. Twenty-six patients (36.1%, 26/72) underwent proximal embolization, 38 patients (52.8%, 38/72) underwent distal embolization, and 8 patients (11.1%, 8/72) underwent combined proximal and distal embolization (Table 3). Twenty-nine patients (40.3%, 29/72) were embolized with Gelfoam®, 22 patients (30.5%, 22/72) were embolized with coils, and 21 patients (29.2%, 21/72) underwent embolization with two or more embolic agents (Table 4).

Combined embolization was performed with Gelfoam® and coils (n = 16, 22.2%), particles and coil (n = 3, 4.2%), and plug and coils (n = 2, 2.8%). Baseline demographics were similar between the groups ($P > 0.05$). The ISS, hospital length of stay, and readmission within 30 days were also similar between the groups ($P > 0.05$). There was no significant difference in procedure length or splenic salvage rate between the groups ($P > 0.05$). Patients embolized with coils had a significantly lower spleen AAST-OIS (3.01 ± 0.9) than those undergoing Gelfoam® embolization (3.7 ± 0.7) and combined embolization (3.6 ± 0.7) ($P = 0.02$). No splenic abscesses were reported for any technique used in isolation.

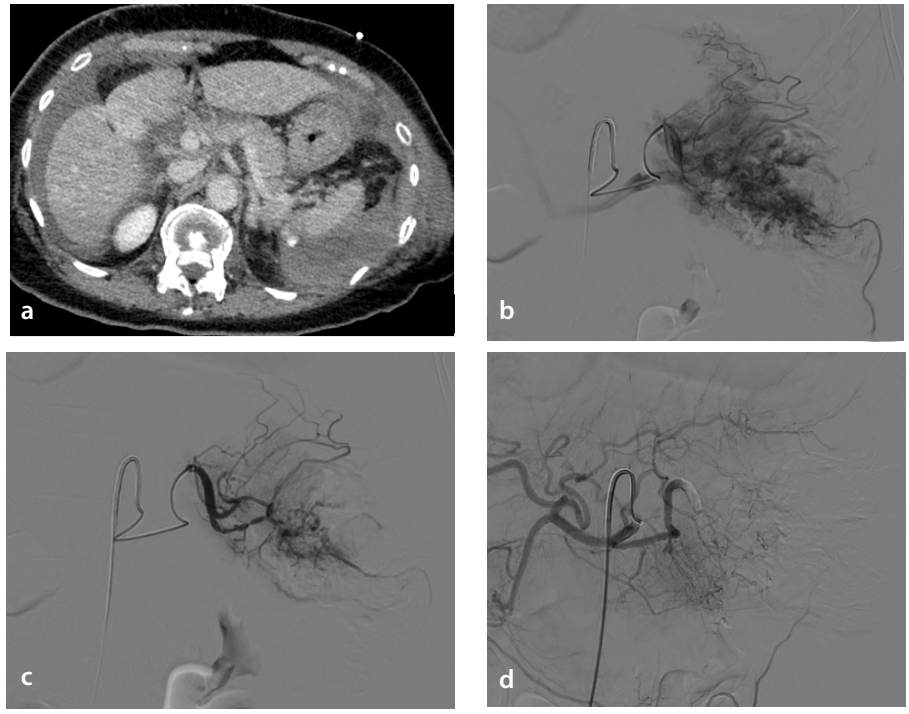

Figure 4. Distal splenic artery embolization with Gelfoam® in a 75-year-old woman following a motor vehicle collision. **(a)** Contrast-enhanced computed tomography showing multiple splenic lacerations with a perisplenic hemoperitoneum and active contrast extravasation. **(b, c)** Pre-embolization celiac digital subtraction angiography (DSA) showing multiple splenic arterial blushes without active contrast extravasation. **(d)** Post-embolization DSA displaying Gelfoam® embolization of splenic artery branches distal to all collateral pathways.

Table 2. Comparison of embolization techniques

	Distal w/Gelfoam® (n = 20)	Proximal w/coil (n = 17)	*P* value
Demographics/injury data			
Age, mean (SD)	44.5 (20.3)	39.8 (16.5)	0.45
Male, n (%)	16 (80)	11 (64.7)	0.46
AAST grade, mean (SD)	3.75 (0.7)	3.2 (0.8)	0.03
Injury severity score, mean (SD)	30.2 (12.4)	24.4 (11)	0.14
Post-embolization outcomes			
SAE procedure length, mean min (SD)	71.4 (25.5)	68.9 (21.7)	0.75
Post SAE splenectomy, n (%)	2 (10)	1 (5.9)	1
Splenic abscess, n (%)	0	0	1
Splenic infarct, n (%)	4 (20)	3 (17.6)	1
Symptomatic splenic infarct, n (%)	0	0	1
Total units of PRBCs, mean (SD)	1.6 (3.4)	0.9 (1.3)	0.43
Clinical outcomes			
Hospital length of stay, mean days (SD)	12 (10.1)	6.8 (4.5)	0.06
ICU length of stay, mean days (SD)	5.3 (4)	4.5 (4.1)	0.55
Readmission within 30 days, n (%)	1 (5)	1 (5.9)	1

SD, standard deviation; AAST, American Association for the Surgery of Trauma; SAE, splenic artery embolization; PRBCs, packed red blood cells; ICU, intensive care unit.

Table 3. Patient population stratified by embolization location

	Proximal (n = 26)	Distal (n = 38)	Combined (n = 8)	*P* value
Demographics/injury data				
Age, mean (SD)	41.8 (17.1)	42.6 (18.2)	50.8 (12.4)	0.42
Male, n (%)	14 (53.8)	28 (73.6)	5 (62.5)	0.26
AAST grade, mean (SD)	3.3 (0.8)	3.6 (0.9)	3.6 (0.5)	0.35
Injury severity score, mean (SD)	25.9 (12.4)	28.1 (11.6)	24.5 (11.3)	0.64
Embolization material				
Gelfoam®	9	20	0	
Coil	17	5	0	
Gelfoam® + coil	0	10	6	
Particles + coil	0	2	1	
Plug + coil	0	1	1	
Embolization outcomes				
Procedure length, mean min (SD)	68.0 (22.9)	75.8 (26.3)	64.4 (31.6)	0.35
Post SAE splenectomy, n (%)	3 (11.5)	3 (7.9)	1 (12.5)	0.86
Splenic abscess, n (%)	0	0	2 (25)	0.0003
Splenic infarct, n (%)	3 (11.5)	4 (10.5)	4 (50)	0.04
Symptomatic splenic infarct, n (%)	0	0	2 (25)	0.01
Total units of PRBCs, mean (SD)	2.9 (6.4)	2.4 (4.5)	1.9 (2.4)	0.87
Clinical outcomes				
Hospital length of stay, mean days (SD)	9.2 (9.0)	12.3 (9.7)	10 (5.5)	0.4
ICU length of stay, mean days (SD)	5.9 (9.0)	6.0 (5.3)	5.8 (4)	0.24
Readmission within 30 days, n (%)	1 (3.8)	2 (5.3)	1 (12.5)	0.64

SD, standard deviation; AAST, American Association for the Surgery of Trauma; SAE, splenic artery embolization; PRBCs, packed red blood cells; ICU, intensive care unit.

The rate of splenic abscess formation was significantly higher for patients embolized at both proximal and distal locations than for those who received either proximal or distal embolization alone ($P = 0.0003$). The rate of asymptomatic and symptomatic splenic infarction was significantly higher in patients embolized at combined proximal and distal locations ($P = 0.04$, $P = 0.01$).

Discussion

SAE is a safe and efficacious treatment option for BSI; the current study revealed an overall splenic salvage rate of 90.3%, which is consistent with the current literature.[2,4,5] At our center, the preferred embolization techniques are distal embolization with Gelfoam® and proximal embolization with coils. There was no significant difference in splenic salvage rates or procedure length between the various embolization techniques. Recent publications have criticized the distal embolization approach, citing longer procedure times and higher complication rates, including splenic abscess formation and splenic infarction, than proximal embolization.[1,2,10] Gelfoam® embolization has been associated with a higher incidence of life-threatening complications and a lower rate of clinical success than coil embolization.[2] In addition, Gelfoam® has been reported to have an increased risk of re-bleeding due to its temporary nature.[12,17,18] These inferior outcomes associated with distal embolization and embolization with Gelfoam® were not found in our study.

Table 4. Patient population stratified by embolization material

	Gelfoam® (n = 29)	Coil (n = 22)	Combined (n = 21)	*P* value
Demographics/injury data				
Age, mean (SD)	44.9 (18.8)	43.5 (17.6)	40.7 (15)	0.7
Male, n (%)	19 (65.5)	15 (68.2)	13 (61.9)	0.97
AAST grade, mean (SD)	3.7 (0.7)	3.1 (0.9)	3.6 (0.7)	0.02
Injury severity score, mean (SD)	30.7 (13.5)	24 (11.0)	22.7 (47.3)	0.54
Post-embolization outcomes				
SAE procedure length, mean min (SD)	69.1 (24)	73.6 (23.4)	73.3 (30.8)	0.78
Post SAE splenectomy, n (%)	2 (6.9)	3 (13.6)	2 (9.5)	0.72
Splenic abscess, n (%)	0	0	2 (9.5)	0.08
Splenic infarct, n (%)	4 (13.8)	3 (13.6)	4 (19.4)	0.84
Symptomatic splenic infarct, n (%)	0	0	2 (19.4)	0.08
Total units of PRBCs, mean (SD)	2.6 (6.4)	2 (3.2)	3 (9.5)	0.81
Clinical outcomes				
Hospital length of stay, mean days (SD)	11.0 (8.8)	10.5 (8.9)	11.2 (10.1)	0.97
ICU length of stay, mean days (SD)	5.2 (4)	7 (6.2)	5.9 (6.7)	0.52
Readmission within 30 days, n (%)	1 (3.4)	1 (4.5)	2 (9.5)	0.63

SD, standard deviation; AAST, American Association for the Surgery of Trauma; SAE, splenic artery embolization; PRBCs, packed red blood cells; ICU, intensive care unit.

In particular, distal embolization with Gelfoam® was not associated with an increased rate of splenic infarction when compared with proximal embolization with coils. Distal embolization is commonly cited as being associated with a higher incidence of splenic infarction than proximal embolization.[1,17,18] This increased risk of splenic infarction is thought to be the result of a lack of collateral blood flow to the spleen, which is commonly preserved by proximal embolization.[1] Although splenic infarction often occurs in the absence of clinical consequences, it may result in sequalae such as splenic abscess or rupture.[19] However, our study found no association between distal embolization and an increased risk of splenic infarct or abscess.

Physicians at our institution often select distal embolization with Gelfoam® because of its many perceived benefits. Distal embolization preserves normal blood flow to a larger portion of the spleen, allowing for a more targeted treatment of focal lesions than proximal embolization.[8] Distal embolization may also be preferentially selected over proximal embolization because of the lack of access for re-intervention distal to the initial site of embolization following proximal embolization.[1] Gelfoam® acts as a temporary agent and may preserve larger portions of splenic parenchyma. This may be especially beneficial for the treatment of trauma patients, who are often younger and have fewer comorbidities that would hinder the healing process. In addition, Gelfoam® represents an inexpensive embolization material when compared with other options, lowering the cost burden for both hospitals and patients.[8,10,20]

In our study, two patients were reported to have follow-up CT scans with findings suggestive of splenic abscess formation following embolization. Both patients were embolized with a combination of Gelfoam® distally and coils proximally. Our study also found that patients treated with combined embolization had a significantly higher rate of symptomatic and asymptotic splenic infarct than patients treated with any embolization technique used in isolation. Combined embolization has previously been associated with higher rates of complications, with one meta-analysis indicating that combined embolization had a complication rate more than double that of proximal or distal embolization alone.[2] The increase in complications following combined embolization may be attributed to the loss of perfusion to greater portions of the spleen. This is supported by our study, which identified no abscesses following embolization with any technique used in isolation yet identified splenic abscesses in 25% of patients embolized with combined proximal and distal embolization.[2,11,12,21,22]

This study demonstrates that distal embolization with Gelfoam® and the use of Gelfoam® or distal embolization alone is safe and may be beneficial in the setting of acute blunt trauma. The limitations of the present study are that it is a retrospective, single-center study. However, the results of our study represent a real-life, level 1 trauma center experience representative of the patient population in our region.

In conclusion, the splenic salvage rate in this study was 90.3%. The results of this study suggest that distal SAE with Gelfoam® is safe, and in our experience, it was not associated with an increased risk of splenic infarction compared with proximal SAE with coils.

Footnotes

Conflict of interest disclosure

Bahri Üstünsöz, MD, is Section Editor in Diagnostic and Interventional Radiology. He had no involvement in the peer-review of this article and had no access to information regarding its peer-review. Alison A. Smith is a paid consultant for Aroa Biosurgery and on the advisory board for Prytime Medical Devices. Other authors have nothing to disclose.

References

1. Quencer KB, Smith TA. Review of proximal splenic artery embolization in blunt abdominal trauma. *CVIR Endovasc.* 2019;2(1):11. [CrossRef]
2. Rong JJ, Liu D, Liang M, et al. The impacts of different embolization techniques on splenic artery embolization for blunt splenic injury: a systematic review and meta-analysis. *Mil Med Res*. 2017;4:17. [CrossRef]
3. Lukies M, Zia A, Kavnoudias H, et al. Immune function after splenic artery embolization for blunt trauma: long-term assessment of CD27(+) IgM B-cell levels. *J Vasc Interv Radiol*. 2022;33(5):505-509. [CrossRef]
4. Lin BC, Wu CH, Wong YC, et al. Splenic artery embolization changes the management of blunt splenic injury: an observational analysis of 680 patients graded by the revised 2018 AAST-OIS. *Surg Endosc*. 2023;37(1):371-381. [CrossRef]
5. Cretcher M, Panick CEP, Boscanin A, Farsad K. Splenic trauma: endovascular treatment approach. *Ann Transl Med*. 2021;9(14):1194. [CrossRef]
6. Aoki M, Onogawa A, Matsumoto S, Matsushima K. Recent trends in the management of isolated high-grade splenic injuries: A nationwide analysis. *J Trauma Acute Care Surg*. 2023;94(2):220-225. [CrossRef]
7. Ahuja C, Farsad K, Chadha M. An overview of splenic embolization. *AJR Am J Roentgenol*. 2015;205(4):720-725. [CrossRef]

8. Raikhlin A, Baerlocher MO, Asch MR, Myers A. Imaging and transcatheter arterial embolization for traumatic splenic injuries: review of the literature. *Can J Surg*. 2008;51(6):464-472. [CrossRef]
9. Brahmbhatt AN, Ghobryal B, Wang P, Chughtai S, Baah NO. Evaluation of splenic artery embolization technique for blunt trauma. *J Emerg Trauma Shock*. 2021;14(3):148-152. [CrossRef]
10. Ekeh AP, Khalaf S, Ilyas S, Kauffman S, Walusimbi M, McCarthy MC. Complications arising from splenic artery embolization: a review of an 11-year experience. *Am J Surg*. 2013;205(3):250-254. [CrossRef]
11. Habash M, Ceballos D, Gunn AJ. Splenic artery embolization for patients with high-grade splenic trauma: indications, techniques, and clinical outcomes. *Semin Intervent Radiol*. 2021;38(1):105-112. [CrossRef]
12. Smith HE, Biffl WL, Majercik SD, Jednacz J, Lambiase R, Cioffi WG. Splenic artery embolization: have we gone too far? *J Trauma*. 2006;61(3):545-546. [CrossRef]
13. Abada HT, Golzarian J. Gelatine sponge particles: handling characteristics for endovascular use. *Tech Vasc Interv Radiol*. 2007;10(4):257-260. [CrossRef]
14. Lopera JE. Embolization in trauma: review of basic principles and techniques. *Semin Intervent Radiol*. 2021;38(1):18-33. [CrossRef]
15. Kozar RA, Crandall M, Shanmuganathan K, et al. Organ injury scaling 2018 update: Spleen, liver, and kidney. *J Trauma Acute Care Surg*. 2018;85(6):1119-1122. [CrossRef]
16. Javali RH, Krishnamoorthy, Patil A, Srinivasarangan M, Suraj, Sriharsha. Comparison of injury severity score, new injury severity score, revised trauma score and trauma and injury severity score for mortality prediction in elderly trauma patients. *Indian J Crit Care Med*. 2019;23(2):73-77. [CrossRef]
17. Imbrogno BF, Ray CE. Splenic artery embolization in blunt trauma. *Semin Intervent Radiol*. 2012;29(2):147-149. [CrossRef]
18. Schnüriger B, Inaba K, Konstantinidis A, Lustenberger T, Chan LS, Demetriades D. Outcomes of proximal versus distal splenic artery embolization after trauma: a systematic review and meta-analysis. *J Trauma*. 2011;70(1):252-260. [CrossRef]
19. Entriken C, Weed Z, Parikh PP, Ekeh AP. Complications following splenic embolization for trauma: have things changed over time? *J Surg Res*. 2022;277:44-49. [CrossRef]
20. Lin BC, Wu CH, Wong YC, et al. Comparison of outcomes of proximal versus distal and combined splenic artery embolization in the management of blunt splenic injury: a report of 202 cases from a single trauma center. *Surg Endosc*. 2023;37(6):4689-4697. [CrossRef]
21. Liu PP, Lee WC, Cheng YF, et al. Use of splenic artery embolization as an adjunct to nonsurgical management of blunt splenic injury. *J Trauma*. 2004;56(4):768-773. [CrossRef]
22. Franco F, Monaco D, Volpi A, Marcato C, Larini P, Rossi C. The role of arterial embolization in blunt splenic injury. *Radiol Med*. 2011;116(3):454-465. [CrossRef]