




Impact of Pre-Interventional Observational Management Duration on Outcomes of Embolization for Splenic Injuries: Experience from Two Centers

Van Thang Nguyen ^{1,2,*}, Thanh Dung Le ^{3,4,*}, Hong Duc Pham ^{1,5,*}, Quang Loc Tran ^{3,4,*}

¹Radiology Department, Hanoi Medical University, Hanoi, Vietnam; ²Radiology Department, Hai Duong Medical Technical University, Hai Duong, Vietnam; ³Radiology Department, VNU University of Medicine and Pharmacy, Hanoi, Vietnam; ⁴Radiology Department, Viet Duc University Hospital, Hanoi, Vietnam; ⁵Radiology Department, Saint Paul Hospital, Hanoi, Vietnam

*These authors contributed equally to this work

Correspondence: Van Thang Nguyen, Department of Radiology, Hai Duong Medical Technical University, Hai Duong, Vietnam, Email nguyenvanthang@hmtu.edu.vn

Objective: To evaluate the clinical and technical success of splenic artery embolization (SAE) in the management of splenic trauma and factors affecting treatment outcomes.

Materials and Methods: A retrospective and prospective study was conducted at two centers from December 2019 to December 2023, including 400 patients with splenic trauma (grade III–V according to the American Association for the Surgery of Trauma (AAST) - 2018 classification) and the Abbreviated Injury Scale (AIS) 2005 change from the AIS-1998. Factors affecting the effectiveness of embolization were determined by logistic regression analysis with $p < 0.05$ considered statistically significant. Technical success in SAE means successfully accessing the artery, deploying the embolic agent, and stopping blood flow to the injury site on angiography. Clinical success was defined as patient survival until discharge, absence of bleeding symptoms, and spleen preservation.

Results: Of the 400 patients, 262 were nonoperative management with observation (NOM-obs), 110 were splenic artery embolization (SAE), and 28 were surgical management (SM). The splenic preservation efficacy of SAE and NOM-obs was 98.2% and 97.7%, respectively ($p > 0.05$). Cranial Abbreviated Injury Scale (AIS) score ≥ 3 (OR: 0.104; 95% CI: 0.013–0.882; $p = 0.032$) and time from admission to embolization (OR: 0.953; 95% CI: 0.930–0.976; $p < 0.001$) were significant factors affecting the efficacy of embolization. There was no association between age, gender, mechanism of injury, and splenic injury severity with the embolization's effectiveness. Higher cranial AIS Score (OR, 1.633; 95% CI: 0.956–2.788; $p = 0.043$), more need for red blood cell transfusion (OR, 1.112; 95% CI: 0.998–1.134; $P = 0.006$), were associated with higher rates of treatment with SM compared with SAE for splenic injury. For other variables, faster heart rate (OR, 1.372; 95% CI: 0.950–1.994; $P = 0.013$), slightly higher red blood cells transfusion requirement (OR, 1.321; 95% CI: 1.000–1.435; $P = 0.042$), lower Hemoglobin (OR, 0.803; 95% CI: 0.722–1.190; $P = 0.012$), and lower hematocrit (OR, 0.676; 95% CI: 0.518–0.882; $P = 0.004$) were all associated with higher odds of SAE treatment compared with NOM-obs for splenic injury.

Conclusion: SAE is a safe and effective method for managing grade III–V splenic injuries, demonstrating high rates of splenic preservation. Notably, the timing of the embolization plays a critical role in treatment outcomes; earlier intervention from hospital admission to embolization significantly correlates with improved success rates. Prompt action in performing embolization is essential for optimizing patient outcomes.

Keywords: splenic trauma, splenic artery embolization, non-operative management, trauma management

Introduction

Due to its anatomical location and structure, the spleen is the most frequently injured solid organ (approximately 46%) in blunt abdominal trauma.¹ Splenectomy was previously the only option for spleen injuries. However, the spleen plays an essential role in the body's immune mechanisms and functions, including blood storage and phagocytosis of blood cells. Due to advances in treatment and resuscitation, spleen-protective approaches have become important in recent years.

NOM-obs have been successfully applied for grade I–III blunt spleen injuries and SAE showed lower treatment failure rates, reducing the need for additional interventions compared with NOM-obs.² There is also a study that shows that in the evaluation of the effectiveness of treatment of grade IV and V splenic injuries by SAE compared with splenectomy according to AAST, the overall mortality rate was 12.7% in the splenectomy group and 5.4% in the SAE group ($p < 0.001$).³ The major benefits of SAE include avoiding laparotomy, reducing the rate of intra- and postoperative complications, reducing the need for transfusion, maintaining immune function, and shortening the hospital stay. With the improvement of computed tomography (CT) and the application of SAE, a success rate of up to 98.5% of cases.^{4–8}

There are several significant consequences for patients treated for SAE including the risk of secondary splenic rupture and rebleeding. Therefore, identifying possible predictors and risk factors, including age, gender, mechanism of injury, timing of intervention, vascular intervention material, etc., will increase the success rate of SAE. This study aimed to evaluate the effectiveness of SAE compared with NOM-obs and SM in the treatment of splenic injury and the risk factors that affect the effectiveness of SAE in the treatment of splenic injury.

Materials and Methods

Research Participants

The study is retrospective and prospective studies were conducted from December 2019 to December 2023. The Institutional Review Board for Ethics in Biomedical Research - Hanoi Medical University approved this study (Approval No: 633/GCN-HDDDNCYSH-DHYHN, dated April 26, 2022). The requirement for patient consent to review their medical records has been waived by the Hanoi Medical University Institutional Review Board (IRB). This waiver has been granted based on the review being necessary for the research objectives. We assure that all patient data will be handled with the utmost confidentiality and in compliance with the Declaration of Helsinki, which emphasizes the importance of ethical principles for medical research involving human subjects. All efforts will be made to protect the privacy of participants and the integrity of their personal information. The STROBE guidelines were followed.⁹

Patients who met all of the following criteria were selected for the study:

- Patients with splenic trauma who were hemodynamically stable upon admission or after initial resuscitation, and underwent CT with intravenous contrast.
- Splenic injuries were graded according to the 2018 revision of the American Association for the Surgery of Trauma-Organ Injury Scale (AAST-OIS).¹⁰
- Patients with indications for vascular intervention underwent angiography and embolization when vascular lesions were seen on angiography.
- Indications for angiography include: grade III or higher splenic injury, excluding abdominal organ injuries requiring surgery, especially without signs of hollow organ rupture.

Exclusion Criteria

- Patients with splenic injuries who have undergone abdominal surgery or SAE at a previous level.
- CT scan without contrast, or not include at least two phases after injection.
- The injury occurred more than 30 days before hospital admission.

Angiography Technique

Angiography was performed at the Monoplane Angiography Unit SHIMADZU, Philips Allura Xper FD20, and Philips Azurion FD20, Philips Medical Systems, Netherlands.

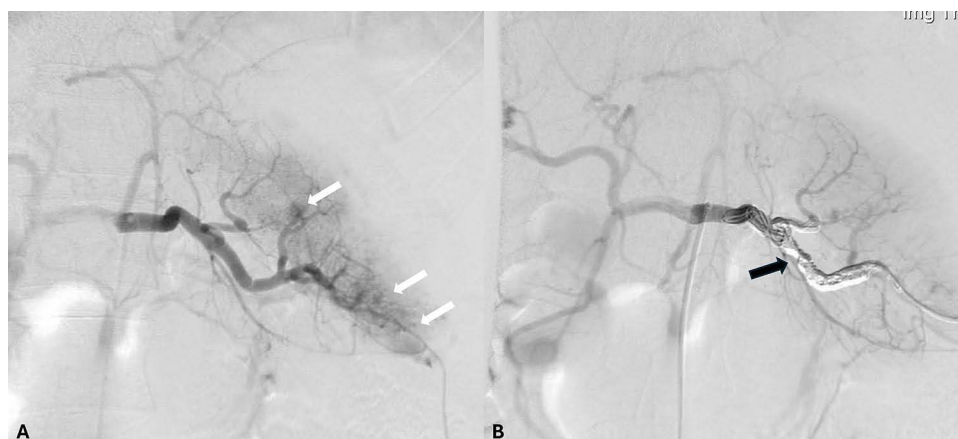


Figure 1 A 30-year-old female patient with a grade III splenic injury according to AAST 2018 caused by a traffic accident. **(A)** Angiography of the celiac trunk revealed multiple pseudoaneurysms located in the two-thirds of the spleen (white arrow). **(B)** The patient underwent coil embolization of the proximal splenic artery (black arrow) to reduce blood flow to the splenic parenchymal lesions.

The catheter was inserted into the celiac trunk or superior mesenteric artery (if the splenic artery from the superior mesenteric artery) and injected with 6mL/s, a total of 15mL of contrast. After selectively probing the celiac trunk, a digital subtraction angiography was performed to visualize the anatomy of the splenic artery and the level, size, and kind of splenic vascular injury. The lesion was embolized with interventional material via a microcatheter.

Proximal embolization is defined as the embolization of the main splenic artery extending beyond the origin of the dorsal pancreatic artery (Figure 1). Distal embolization is defined as the embolization of a branch of the splenic artery at the splenic hilum or smaller branches within the parenchyma (Figure 2).¹¹

The embolization materials used include sponge, polyvinyl alcohol (PVA), and coils, which may be used individually or in combination.

Technical success of SAE: Completion of the embolization procedure, as determined by angiography with successfully access the target splenic artery or arteries, identify the bleeding site or pseudoaneurysm, deploy the embolic agent (coils, particles, glue, etc.) at the intended location and achieve complete or near-complete cessation of blood flow to the injured area on post-embolization angiography.

Clinical success: The patient survived upon discharge, showed no signs of ongoing bleeding, and the spleen remained in its anatomical position.

Statistical Analysis

Evaluate the relationships between age, gender, intervention time, materials, and effectiveness ($p < 0.05$ was set as statistically significant). Multinomial logistic regression was used to examine adjusted associations between the aforementioned characteristics and initial treatment, using SAE as the reference category. Separate adjusted odds ratios (ORs) were calculated to reflect the relative odds of SAE versus NOM-obs, as well as SM versus SAE, for each reported predictor. Logistic regression was used to examine the association between clinical, laboratory, and treatment factors with the likelihood of clinical success.

Results

In total, 400 patients were enrolled (NOM-obs, $n = 262$; SAE, $n = 110$; SM, $n = 28$), and the mean age of the study group was 32.2 ± 16 (3–84) years old; in which the mean age of the NOM-obs, SAE, and SM groups were 31.0 ± 15.7 (3–84); 36.2 ± 16.3 (7–72); and 27.0 ± 14.8 (3–67), respectively, with the age of the SM group being lower than that of the other groups ($p = 0.004$). The overall male/female ratio of all three treatment groups was 315/85, with the ratio in the NOM-obs group being $\sim 4/1$; the SAE group being $\sim 3/1$; and the SM group being 6/1, with no gender differences between treatment groups ($p = 0.322$). In the SAE group, there were 14 patients with ISS > 25 (12.7%); 12 patients (10.9%) had

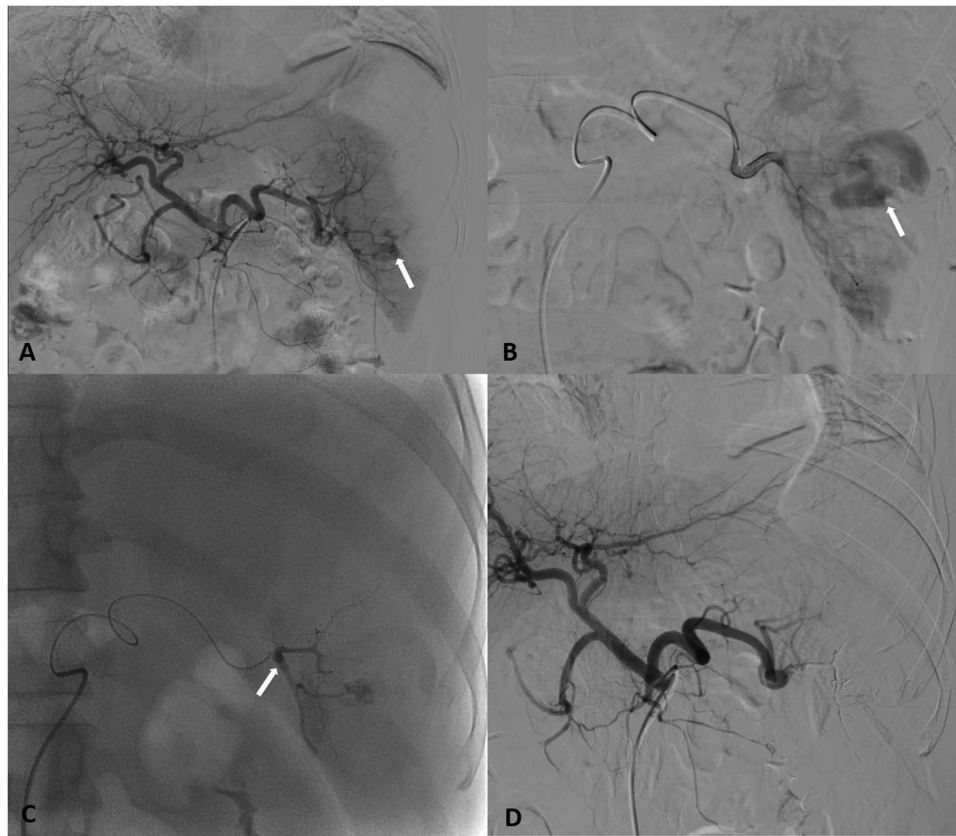


Figure 2 A 46-year-old male patient with grade IV splenic trauma (AAST, 2018) caused by a traffic accident. **(A)** Angiography of the celiac trunk revealed a pseudoaneurysm located in the lower third of the spleen. **(B)** Selective angiography showed a pseudoaneurysm with an arteriovenous fistula. **(C)** Selective embolization of the lesion was performed using a Histoacryl-lipiodol mixture at a 1:3 ratio (0.5 mL Histoacryl). **(D)** Post-intervention celiac trunk angiography showed no remaining lesions, and the healthy vascular branches were preserved.

cranial AIS ≥ 3 : traffic accidents in 83 patients (75.5%), occupational accidents in 11 patients (10%), work accidents in 16 patients (14.5%); the number of patients using alcohol at the time of the accident was 22 patients (20%); Time from admission to CT scan was 2.9 ± 2.2 (0.5–19.5) hours;

Discussion

The mean age of the study group was 32.2 ± 16.0 (3–84) years. There was a difference in age between the NOM-obs, SAE, and SM groups ($p < 0.05$), in which the SAE group had the highest mean age of 36.2 ± 16.3 years. In the epidemiological study of Yong Chen during the period 2000–2009, a total of 7807 patients with splenic trauma were admitted to Chinese military hospitals. The mean age in the study group was 34.4 ± 13.7 years.¹² Sunil Kumar retrospectively reviewed 164 cases of splenic trauma at a single center, showing that patients in the age group of 12–30 years old accounted for the highest proportion with 45.73%.¹³ The studies showed that splenic trauma is common in young people, in the working age group (16–55 years old), who often participate in more unsafe activities (heavy physical labor, traffic accidents). Andrew B. Peitzman's study showed that the surgical group's mean maximum blood pressure (90 ± 30 mmHg) was significantly lower than that of the successful conservative group (112 ± 23 mmHg), demonstrating that hemodynamically unstable patients are more likely to undergo surgery.¹⁴ This finding supports the view that surgery is often the preferred method when patients present with severe, unstable hemodynamics. Similarly, in our study, Tables 1 and 2 showed that the shock index in the NOM-obs and SAE patient groups was lower than that in the SM group (0.80 ± 0.21 ; 0.86 ± 0.27 ; 1.00 ± 0.29 ; $p < 0.001$) and higher cranial AIS score (OR, 1.633; 95% CI: 0.956–2.788; $p = 0.043$), more need for red blood cell transfusion (OR, 1.112; 95% CI: 0.998–1.134; $P = 0.006$), were associated with higher rates of treatment with SM compared with SAE. In Nguyen Van Thang's study of patients with

Table 1 The General Condition of the Patient (n = 400)

		NOM-obs n = 262, (%)	SAE n = 110, (%)	SM n = 28, (%)	p
Consciousness	Mild (Glasgow 13–15)	237 (90.5%)	95 (86.4%)	26 (92.9%)	0.544 ^a
	Moderate (Glasgow 9–12)	16 (6.1%)	7 (6.4%)	1 (3.6%)	
	Severe (Glasgow 3–8)	9 (3.4%)	8 (7.3%)	1 (3.6%)	
Systolic BP (mmHg) (min – max)		113.5 ± 15.8 (60–190)	113.7 ± 23.6 (70–220)	105.8 ± 16.7 (70–131)	0.094 ^b
Diastolic BP (mmHg) (min – max)		69.7 ± 10.4 (30–100)	69.6 ± 14.0 (40–105)	64.4 ± 9.5 (50–80)	0.063 ^b
Pulse Rate (bpm) (min – max)		88.7 ± 13.2 (63–140)	93.7 ± 16.9 (63–170)	101.8 ± 16.1 (80–130)	< 0.001 ^b
Shock index (min – max)		0.80 ± 0.21	0.86 ± 0.27	1.00 ± 0.29	< 0.001 ^b
Temperature (°C) (min – max)		36.8 ± 0.3 (36–38)	36.8 ± 0.3 (36–37.3)	36.7 ± 0.4 (36–37.3)	0.328 ^b

Notes: ^aChi square test. ^bOne – way ANOVA test. Most patients had no or only mild cognitive impairment, including 237 (90.5%) in the NOM-obs group, 95 (86.4%) in the SAE group, and 26 (92.9%) in the SM group. Hemodynamic instability was 30 (7.5%). The percentage of patients with hemodynamic instability and the mean shock index in the SM group was the highest among the three treatment groups, with p < 0.05. There were no cases of fever above 38°C or body temperature below 36°C.

Table 2 Multinomial Logistic Regression for Initial Treatment

Variables	SM vs SAE		SAE vs NOM-obs	
	Odds Ratio	p	Odds Ratio	p
Age	1.029 (0.989–1.072)	0.495 ^a	0.978 (0.958–0.999)	0.053 ^a
Gender	5.387 (0.938–30.949)	0.160 ^a	0.459 (0.209–1.006)	0.052 ^a
Heart rate	0.994 (0.955–1.035)	0.059 ^a	1.372 (0.950–1.994)	0.013 ^a
Systolic Blood Pressure	0.995 (0.968–1.022)	0.769 ^a	1.001 (0.984–1.018)	0.927 ^a
Cranial AIS Score	1.633 (0.956–2.788)	0.043 ^a	0.921 (0.672–1.263)	0.611 ^a
ISS	0.949 (0.886–1.016)	0.134 ^a	1.038 (0.989–1.091)	0.132 ^a
Red Blood Cells	1.112 (0.998–1.134)	0.006 ^a	1.321 (1.000–1.435)	0.042 ^a
Hemoglobin	0.932 (0.815–1.067)	0.309 ^a	0.803 (0.722–1.190)	0.012 ^a
Hematocrit	1.241 (0.787–1.958)	0.353 ^a	0.676 (0.518–0.882)	0.004 ^a
Platelets	0.997 (0.991–1.003)	0.289 ^a	1.003 (0.999–1.007)	0.175 ^a

Notes: ^aMultinomial Logistic. Adjusting for all covariates in the study model, higher Cranial AIS Score (OR, 1.633; 95% CI: 0.956–2.788; p = 0.043), more need for Red Blood Cells transfusion (OR, 1.112; 95% CI: 0.998–1.134; P = 0.006), were associated with higher rates of treatment with SM compared with SAE for splenic injury. For other variables, faster Heart rate (OR, 1.372; 95% CI: 0.950–1.994; P = 0.013), more Red Blood Cells transfusion requirement (OR, 1.321; 95% CI: 1.000–1.435; P = 0.042), lower Hemoglobin (OR, 0.803; 95% CI: 0.722–1.190; P = 0.012), and lower Hematocrit (OR, 0.676; 95% CI: 0.518–0.882; P = 0.004) were all associated with higher odds of SAE treatment compared with NOM-obs for splenic injury.

splenic injury who underwent endovascular intervention, the author did not mention the hemodynamics of this group, nor did they compare it to the groups treated with NOM-obs or SM.¹⁵ Many authors have analyzed different hemodynamic parameters, including blood pressure, heart rate, and shock index. When a patient is in shock and presents with accompanying intra- or extra-abdominal symptoms, or when there are contraindications to conservative treatment, such as hypothermia, coagulopathy, or severe comorbidities, immediate surgery is required.¹⁶

In Table 3, the splenic trauma grading in the SAE and SM groups was mainly grade IV, with 85 patients (77.3%) in the SAE group and 11 patients (39.3%) in the SM group. Studies have also shown that splenic parenchymal lesions are mainly assessed in the portal venous phase. The density of parenchymal lesions depends on the amount of blood and contrast. Still, parenchymal contusions generally are hypodense compared to normal, homogeneous enhanced splenic tissue in the portal venous phase. Parenchymal lesions are divided into lacerations, subcapsular hematomas, and intraparenchymal hematomas and are best assessed in the portal venous phase.¹⁷ Studies have confirmed the high possibility of intra-abdominal trauma in patients with lower rib fractures. The spleen is injured mostly by direct impact force, and the lower left ribs protect this organ, so the force applied to these ribs is also powerful. Fractures of the lower ribs from the 10th to the 12th are considered high-energy injuries, and intra-abdominal organ injury must be suspected in these patients for a thorough examination.¹⁸

In Table 4, A mixture of histoacryl and lipiodol was the main material used in most cases (79.7%), with a 1:3 ratio being the most commonly used (57.1%). Histoacryl (biological glue) mixed with lipiodol helps ensure precision and flow control during embolization. Coils and Spongels were also used, but much less frequently. The use of single materials was predominant (81.3%), demonstrating the effectiveness of each material when used separately, without the need for a combination of multiple materials. A study by Steven Tran (2022) showed that when signs of active bleeding were

Table 3 Splenic Injury Characteristics on CT Scan (n = 400)

CT Findings		NOM-obs n = 262, (%)	SAE n = 110, (%)	SM n = 28, (%)	p
Parenchymal Injury	Subcapsular Hematoma	6 (2.3)	4 (3.6)	0	0.510 ^a
	Parenchymal Laceration	210 (80.2)	84 (76.4)	23 (82.1)	0.660 ^a
	Intraparenchymal Hematoma	16 (6.1)	24 (21.8)	2 (7.1)	< 0.001 ^a
	Perisplenic Hematoma	43 (16.4)	40 (36.4)	9 (32.1)	< 0.001 ^a
Vascular Injury	Active Bleeding	1 (0.4)	44 (40.0)	6 (21.4)	< 0.001 ^a
	Pseudoaneurysm	9 (3.4)	59 (53.6)	3 (10.7)	< 0.001 ^a
	Arteriovenous Fistula	1 (0.4)	4 (3.6)	2 (7.1)	0.007 ^a
	Venous Thrombosis	1 (0.4)	0	0	0.768 ^a
	Arterial Thrombosis	2 (0.8)	0	0	0.589 ^a
AAST-OIS 2018	Grade III	213 (81.3)	7 (6.4)	8 (28.6)	< 0.001 ^a
	Grade IV	48 (18.3)	85 (77.3)	11 (39.3)	< 0.001 ^a
	Grade V	1 (0.4)	18 (16.4)	9 (32.1)	< 0.001 ^a

Notes: ^aChi square test. Among the characteristics of splenic vascular injury, pseudoaneurysm, and active bleeding had the highest rates, both of which were mainly found in the SAE group, 44 (40.0%) and 59 (53.6%), respectively, with p < 0.05. The degree of splenic injury in the SAE and SM groups was mainly grade IV with 85 (77.3%) in the SAE group and 11 (39.3%) in the SM group. In the NOM-obs group, the injury was mainly grade III with 213 (81.3%), the difference in the injury rate according to the splenic trauma levels in the treatment groups was statistically significant, with p < 0.05.

Table 4 Embolization Procedure Characteristics (n = 110)

Technical Characteristics		n (%)
Artery Access	Right femoral	109 (99.1)
	Left femoral	1 (0.9)
Catheter size (F)	5	94 (85.5)
	6	16 (14.5)

(Continued)

Table 4 (Continued).

Technical Characteristics		n (%)
Microcatheter (F)	1.8	6 (5.4)
	1.9	1 (0.9)
	1.98	1 (0.9)
	2.2	36 (32.7)
	2.4	1 (0.9)
	2.6	38 (34.5)
	2.7	31 (28.1)
Embolization site	Proximal embolization	17 (15.5)
	Distal embolization	93 (84.5)
Materials	Histoacryl and lipiodol	89 (80.9)
	Coil	16 (14.5)
	Sponges	18 (16.4)
	PVA	3 (2.7)
The ratio of histoacryl: lipiodol	1:2	5 (4.5)
	1:3	55 (50.0)
	1:4	29 (26.4)
Time from admission to intervention (hours)		8.81 ± 10.24 (1.5–76)
Time of intervention (minutes)		50.07 ± 47.06 (15–480)
Technical success		110 (100)
Clinical success		106 (96.4)

Notes: The time from admission to intervention was 8.81 ± 10.24 (1.5–76) hours, with an average intervention time of 50.07 ± 47.06 (15–480) minutes. The technical success rate was 100%. Two cases had no vascular lesions on angiography, 1 case had simultaneous intervention of the left renal artery and the treatment results were successful. The clinical success rate was 106 cases (96.4%), 4 instances failed clinically with 2 cases transferred to surgery and 1 case died in the hospital, 1 case was in severe condition and asked to go home.

detected at the time of angiography, the decision to perform embolization was clear. However, this may be due to venous bleeding for patients with arterial lesions on CT but no signs of arterial lesions on angiography.¹⁹ In such cases, angiography will be negative. The second reason may be that small fragments of solid organs may have been misinterpreted as extravasation of contrast on CT scans. The third reason is spontaneous intrinsic hemostasis, which may have stopped bleeding before angiography, including post-traumatic vasospasm, thrombosis due to endothelial injury, or in cases of vasoconstriction due to hypovolemic shock due to failure to respond to resuscitation. Some other authors support non-selective embolization even when there are no signs of arterial injury during angiography. A study by Kuo-Ching Yuan showed that embolization of the main splenic artery in cases negative on angiography (7 patients) and without clinical symptoms of shock achieved 100% clinical success, and for cases negative on angiography and no embolization (2 patients), there was 1 case of clinical success (50%). The authors suggested that coil embolization of the main splenic artery, used to reduce blood flow, has been considered superior to embolization of the distal splenic artery because the distal embolization results in more infarction.²⁰ However, in our study, all patients who underwent distal

embolization had no major complications; 2 cases with negative angiography were clinically successful after treatment without embolization, suggesting that the sample size of the studies evaluating the effectiveness of treatment with negative angiography cases is small, possibly these cases had physiological hemostasis before angiography.

In Table 5, age, gender, and pre-injury alcohol consumption were not significantly associated with the severity of blunt splenic injury.

As shown in Table 6, the cranial AIS score is a risk factor affecting the effectiveness of embolization. However, the Glasgow score is not related to the efficacy of embolization treatment ($p > 0.05$). According to the study by P Renzulli⁸ in 206 patients, Glasgow's score below 11 points is related to the failure of non-surgical treatment of splenic trauma patients. Elan Jeremitsky studied 499 splenic trauma patients and found that the Glasgow score in the ventricle preservation group was lower than in the successful preservation group ($p < 0.001$).²¹ A study by Andrew B. Schneider on 10,812 patients with splenic trauma showed that the Glasgow score was related to the success rate of embolization.²² The shorter the time from admission to vascular intervention, the more effective the vascular intervention was, with $p < 0.05$.

In Table 7, for the characteristics of time from admission to CT scan and time to intervention, there was no association with the effectiveness of embolization treatment, with $p > 0.05$. In the study of D C Olthof, the mean time from admission to intervention in group hemodynamically stable patients was 105 (IQR 77–188) minutes, and in group hemodynamically unstable patients: 58 (IQR 41–99) minutes.²³ Subsequently, a consensus study by Dominique C Olthof on 30 surgeons and endovascular interventionists recommended that embolization in a stable patient with endothelial contrast extravasation should be initiated within 60 minutes (according to 19 of 24 experts).²⁴ However, the author Melike N. Harfouche studied 226 cases, of which 76 (33.6%) were in the group that was embolized within 6 hours and 150 (66.4%) were in the group that was delayed for more than 6 hours.²⁵ Nguyen Van Thang et al showed that splenic angiography and embolization were performed within 24 hours of admission for 86% of patients (mean, $27.7 \pm$

Table 5 Regression Analysis of Factors Associated with Splenic Injury Severity (n = 110)

Characteristics	Beta	95% Confidence Interval	p
Age > 55	0.495	0.048–5.073	0.553 ^a
Gender	1.077	0.108–10.784	0.950 ^a
Mechanism of Injury	0.419	0.141–1.245	0.118 ^a

Note: ^aLinear.

Table 6 Clinical Factors Associated with the Success Rate of Embolization

Clinical Factors	OR	95% Confidence Interval	p
Glasgow Score < 9	4.714	0.432–51.422	0.203 ^a
Systolic BP < 100 mmHg	1.630	0.160–16.570	0.680 ^a
Heart Rate > 100 bpm	0.698	0.069–7.063	0.761 ^a
Shock Index ≥ 1	0.293	0.039–2.189	0.231 ^a
ISS Score > 25	0.419	0.041–4.338	0.466 ^a
Cranial AIS Score ≥ 3	0.104	0.013–0.882	0.032 ^a

Notes: ^aBinary logistic. Cranial AIS score ≥ 3 points is a risk factor affecting the effectiveness of embolization ($p < 0.05$). Glasgow score, hemodynamics, and ISS score are not related to the efficacy of embolization ($p > 0.05$).

Table 7 Time-Related Factors and the Success Rate of Embolization

Time-Related Factors	OR	95% Confidence Interval	p
Time from admission to CT scan (hour)	1.032	0.895–1.190	0.666 ^a
Time from admission to Embolization (hour)	0.953	0.930–0.976	< 0.001 ^a
Duration of embolization (minute)	1.007	0.989–1.025	0.443 ^a

Notes: ^aBinary logistic. The shorter the time from admission to vascular intervention, the more effective the vascular intervention was with $p < 0.05$. The time before intervention was not related to the treatment effectiveness, with $p > 0.05$.

68.5 hours), which is longer than the current study, where the mean angiography time was 8.81 ± 10.24 hours (range 1.5–76 hours). However, the Nguyen Van Thang et al study did not demonstrate a relationship between the time from admission to intervention and the effectiveness of splenic artery embolization. Additionally, the previous study did not show any significant correlation between factors such as gender and alcohol use before splenic injury, further limiting the ability to predict outcomes based on these variables.¹⁵

In Table 8, the efficacy of vascular intervention and surgery was higher than that of NOM-obs in the treatment of patients with arterial injury ($p < 0.05$). This suggests that, in addition to high-grade lesions, the presence of vascular lesions, such as active bleeding or intraparenchymal or extraparenchymal pseudoaneurysms, as demonstrated on abdominal CT, is closely related to the failure of medical treatment. With the increasing use of contrast-enhanced CT, splenic vascular lesions can be depicted, which may indicate the severity of the injury and facilitate early embolization or surgery.

The initial group had a higher AAST grade, a larger amount of hemoperitoneum on CT, and a 3.9-fold higher rate of late splenectomy ($p = 0.046$). The embolization time was shorter in the group that failed to save the spleen (5 vs 10 hours, $p = 0.051$). In multivariate analysis, the embolization time did not affect spleen preservation.²⁵ Our study is consistent with the consensus of Dominique C Olthof that the time to access embolization of the patient under 1 hour increases the treatment efficiency and with the studies that have shown that performing embolization in critically ill patients should be done quickly to achieve maximum hemostasis and reduce patient mortality.

Table 8 Comparison of Success Rates for Embolization and Other Treatment Modalities Based on AAST Splenic Injury Grade

AAST		NOM-obs (1) n = 262, (%)	SAE (2) n = 110, (%)	SM (3) n = 28, (%)	p
Grade III		182 (85.4)	7 (100)	6 (75.0)	$p_{1,2} = 0.276^a$ $p_{2,3} = 0.467^b$
Grade IV	Arterial injury	8 (72.7)	77 (96.2)	4 (100)	$p_{1,2} = 0.003^a$ $p_{2,3} = 0.693^a$
	No arterial injury	34 (91.9)	5 (100)	6 (85.7)	$p_{1,2} = 0.509^b$ $p_{2,3} = 0.377^b$
Grade V	Arterial injury	-	16 (94.1)	5 (83.3)	$p_{2,3} = 0.462^b$
	No arterial injury	1 (100)	1 (100)	3 (100)	-

Notes: ^aChi square test. ^bFisher exact test. Splenic trauma grade IV with vascular involvement has a higher success rate with embolization compared to medical management, with a statistically significant difference ($p < 0.05$). For splenic trauma grade III and V splenic injuries, there is no difference in treatment effectiveness between the groups ($p > 0.05$).

Limitations of the Study

Collecting data from medical records may lead to incorrect information or missing important data. Although the study included 400 patients, the number of patients in the SM group (n = 28) was relatively small, which may affect the generalizability of the results. Treatment outcomes were only evaluated in the short term, and complications or long-term efficacy of embolization were not analyzed. The study was conducted at two centers, which may have had differences in treatment techniques and standards, leading to variability in results.

Conclusion

This study demonstrates SAE as an effective method in the treatment of splenic trauma, especially in patients with grade III–V injuries, with high spleen preservation rates. In particular, the timing of intervention is very important, with shorter times from admission to intervention improving treatment outcomes, highlighting the importance of a timely medical response in trauma cases. Factors such as cranial AIS score also play an important role in determining treatment efficacy. The study results help to provide timely intervention strategies to improve the quality of treatment of patients with splenic trauma.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Yıldız A, Özpek A, Topçu A, Yücel M, Ezberci F. [Künt dalak travma: nonoperatif başarısızlık oranını etkileyen prediktör ve risk faktörlerin analizi] Blunt splenic trauma: analysis of predictors and risk factors affecting the non-operative management failure rate. *Ulusal travma ve acil cerrahi dergisi*. 2022;28(10):1428–1436. doi:10.14744/tjtes.2022.95476
2. Nann S, Clark M, Kovoor J, Jog S, Aromataris E. Prophylactic embolization vs observation for high-grade blunt trauma splenic injury: a systematic review with meta-analysis. *JBI Evidence Synth*. 2025;23(2):208–243. doi:10.11124/jbies-24-00110
3. Aiolfi A, Inaba K, Strumwasser A, et al. Splenic artery embolization versus splenectomy: analysis for early in-hospital infectious complications and outcomes. *J Trauma Acute Care Surg*. 2017;83(3):356–360. doi:10.1097/ta.0000000000001550
4. Haan JM, Biffl W, Knudson MM, et al. Splenic embolization revisited: a multicenter review. *J Trauma*. 2004;56(3):542–547. doi:10.1097/01.ta.0000114069.73054.45
5. 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. doi:10.1097/TA.0b013e3181f2a92e
6. Miller PR, Chang MC, Hoth JJ, et al. Prospective trial of angiography and embolization for all grade III to V blunt splenic injuries: nonoperative management success rate is significantly improved. *J American College Surg*. 2014;218(4):644–648. doi:10.1016/j.jamcollsurg.2014.01.040
7. 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. *Military Med Res*. 2017;4(1):17. doi:10.1186/s40779-017-0125-6
8. Ahmad MU, Lee D, Tennakoon L, Chao TE, Spain D, Staudenmayer K. Angioembolization for splenic injuries: does it help? Retrospective evaluation of grade III–V splenic injuries at two level I trauma centers. *Trauma Surg Acute Care Open*. 2024;9(1):e001240. doi:10.1136/tsaco-2023-001240
9. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet*. 2007;370(9596):1453–1457. doi:10.1016/s0140-6736(07)61602-x
10. Morell-Hofert D, Primavesi F, Fodor M, et al. Validation of the revised 2018 AAST-OIS classification and the CT severity index for prediction of operative management and survival in patients with blunt spleen and liver injuries. *Eur Radiol*. 2020;30(12):6570–6581. doi:10.1007/s00330-020-07061-8
11. Gill K, Aleman S, Fairchild AH, et al. Splenic artery embolization in the treatment of blunt splenic injury: single level I trauma center experience. *Diagn Interventional Radiol*. 2024. doi:10.4274/dir.2024.242789
12. Chen Y, Qiu J, Yang A, Yuan D, Zhou J. Epidemiology and management of splenic injury: an analysis of a Chinese military registry. *Exp Ther Med*. 2017;13(5):2102–2108. doi:10.3892/etm.2017.4208
13. Kumar S, Katiyar V, Sharma S, Srivastava VK, Bhartiya SK, Mishra SP. A clinical review and experience of splenic trauma in north India: a retrospective observational study. *Cureus*. 2024;16(3):e55384. doi:10.7759/cureus.55384
14. Peitzman AB, Heil B, Rivera L, et al. Blunt splenic injury in adults: multi-institutional study of the eastern association for the surgery of trauma. *J Trauma*. 2000;49(2):177–189. doi:10.1097/00005373-200008000-00002
15. Nguyen VT, Pham HD, Phan Nguyen Thanh V, Le TD. Splenic artery embolization in conservative management of blunt splenic injury graded by 2018 AAST-OIS: results from a hospital in Vietnam. *Int J Gene Med*. 2023;16:1695–1703. doi:10.2147/ijgm.S409267
16. Fransvea P, Costa G, Massa G, Frezza B, Mercantini P, Balducci G. Non-operative management of blunt splenic injury: is it really so extensively feasible? A critical appraisal of a single-center experience. *Pan African Med J*. 2019;32(1). doi:10.11604/pamj.2019.32.52.15022
17. Shi H, Teoh WC, Chin FWK, Tirukonda PS, Cheong SCW, Yiin RSZ. CT of blunt splenic injuries: what the trauma team wants to know from the radiologist. *Clin Radiol*. 2019;74(12):903–911. doi:10.1016/j.crad.2019.07.017

18. Davoodabadi A, Mosavibioki N, Mashayekhili M, Gilasi H, Kashi EA, Haghpanah B. Correlation of rib fracture patterns with abdominal solid organ injury: a retrospective observational cohort study. *Chinese J Traumatol*. 2022;25(1):45–48. doi:10.1016/j.cjtee.2021.07.007
19. Tran S, Wilks M, Dawson J. Endovascular management of splenic trauma. *Surg Pract Sci*. 2022;8:100061. doi:10.1016/j.sipas.2022.100061
20. Yuan KC, Wong YC, Lin BC, Kang SC, Liu EH, Hsu YP. Negative catheter angiography after vascular contrast extravasations on computed tomography in blunt torso trauma: an experience review of a clinical dilemma. *Scandinavian J Trauma Resuscitation Emerg Med*. 2012;20(1):46. doi:10.1186/1757-7241-20-46
21. Jeremitsky E, Kao A, Carlton C, Rodriguez A, Ong A. Does splenic embolization and grade of splenic injury impact nonoperative management in patients sustaining blunt splenic trauma? *American Surg*. 2011;77(2):215–220. doi:10.1177/000313481107700224
22. Schneider AB, Gallaher J, Raff L, Purcell LN, Reid T, Charles A. Splenic preservation after isolated splenic blunt trauma: the angioembolization paradox. *Surgery*. 2021;170(2):628–633. doi:10.1016/j.surg.2021.01.007
23. Olthof DC, Sierink JC, van Delden OM, Luitse JS, Goslings JC. Time to intervention in patients with splenic injury in a Dutch level 1 trauma centre. *Injury*. 2014;45(1):95–100. doi:10.1016/j.injury.2012.12.021
24. Olthof DC, van der Vlies CH, Joosse P, van Delden OM, Jurkovich GJ, Goslings JC. Consensus strategies for the nonoperative management of patients with blunt splenic injury: a Delphi study. *J Trauma Acute Care Surg*. 2013;74(6):1567–1574. doi:10.1097/TA.0b013e3182921627
25. Harfouche MN, Dhillon NK, Hawley KL, et al. Time to splenic angioembolization does not impact splenic salvage rates. *American Surg*. 2023;89(8):3493–3495. doi:10.1177/00031348231161674

International Journal of General Medicine

Publish your work in this journal

The International Journal of General Medicine is an international, peer-reviewed open-access journal that focuses on general and internal medicine, pathogenesis, epidemiology, diagnosis, monitoring and treatment protocols. The journal is characterized by the rapid reporting of reviews, original research and clinical studies across all disease areas. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/international-journal-of-general-medicine-journal>

Dovepress
Taylor & Francis Group