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Partial Splenic Artery Embolization as a Nonsurgical Alternative for Hypersplenism: A Review

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Abbreviations:
PSE: Partial Splenic Artery Embolization;
WOS: Web of Science Core Collection;
TIPS: Transjugular Intrahepatic
Portosystemic Shunt.

Rezumat

Embolizarea splenică parțială ca alternativă de tratament nechirurgical al hipersplenismului: un review

Hipersplenismul este o complicație frecventă a bolii hepatice cronice şi poate provoca citopenii semnificative. Apare la peste 50% dintre pacienții cu ciroză hepatică şi hipertensiune portală, constituind totodata un factor de prognostic nefavorabil. Embolizarea parțială a arterei splenice a apărut ca o alternativă mai puțin invazivă la splenectomie, oferind ameliorări hematologice în special pe linie trombocitară, cu păstrarea funcției imune splenice. Aceasta procedură intervenționala angiografică a fost introdusă în anii 70 de către Maddison. Embolizarea se consideră eficientă atunci când se obține infarctizarea a cel puțin jumătate din volumul splinei. Consecința principală este creşterea semnificativă a numărului de trombocite. De asemenea, au fost raportate creşteri inconstante ale hemoglobinei şi ale numărului de leucocite. Procedura constă în cateterizarea sub control fluoroscopic a arterei splenice şi embolizarea temporară sau definitivă a unor ramuri arteriale cu substanțe emboligene: gelfoam, particule de polivinil alcool, polimeri acrilici sau spirale de platină. Rezultatele embolizării parțiale splenice sunt similare splenectomiei în ceea priveşte ameliorarea parametrilor hematologici, dar cu o rată mai redusă de complicații. Complicațiile postprocedurale sunt de regulă uşoare şi tranzitorii iar rata acestora este direct proporțională cu volumul splenic infarctizat. Există şi unele complicații severe, cum ar fi abcesul splenic, tromboza de venă portă, hemoragia digestivă, sufuziuni pleurale. Embolizarea parțială a splinei poate fi folosită şi în afecțiuni hematologice, fără a fi însă standardizată, precum şi în traumatismele splenice. Sunt necesare studii suplimentare pentru extinderea indicațiilor, clarificarea rolului acestei tehnici în controlul hemoragiei digestive variceale şi eventual integrarea sa în ghidurile terapeutice.

Cuvinte cheie: embolizare splenică parțială, trombocitopenie, intervenție chirurgicală

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Abstract

Hypersplenism is a common complication of chronic liver disease that can cause significant cytopenias. It occurs in more than 50% of patients with liver cirrhosis and portal hypertension, representing an unfavorable prognostic factor. Partial splenic artery embolization (PSE) has emerged as a less invasive alternative to splenectomy, providing hematologic improvement particularly in platelet count, while preserving splenic immune function. This interventional angiographic technique was introduced in the 1970s by Maddison. Embolization is considered effective when infarction of at least half of the splenic volume is achieved. The main consequence is significant increase in platelet count. At the same time, inconsistent increases in hemoglobin and leukocyte count have also been reported. The procedure involves fluoroscopy-guided catheterization of the splenic artery and temporary or permanent embolization of selected arterial branches using embolic agents such as gelfoam, polyvinyl alcohol particles, acrylic polymers or platinum coils. The hematologic benefits of PSE are comparable to those of splenectomy, but with a lower complication rate. Post-procedural complications are generally mild and transient, and their frequency is directly proportional to the infarcted splenic volume. Severe complications, although less frequent, include splenic abscess, portal vein thrombosis, gastrointestinal bleeding and pleural effusions. PSE may also be applied in certain hematological conditions, although yet not standardized, as well as in splenic trauma. Further studies are required to expand the indications of the technique, to clarify its role in controlling variceal gastrointestinal bleeding and potentially integrate it into therapeutic guidelines.

Keywords: splenic artery embolization, thrombocytopenia, surgical intervention

Introduction

Hypersplenism is clinically defined by the presence of peripheral cytopenia in association with splenomegaly and a hypercellular or normocellular bone marrow, with subsequent improvement upon reduction of splenic volume. It is highly prevalent among patients with chronic liver disease and portal hypertension. For example, in a cohort of 303 cirrhotic patients, hypersplenism was identified in 61.5% of cases, strongly correlating with ascites, hematemesis, melena, and advanced stages of liver disease (1). Severe hypersplenism characterized by platelet counts below 75,000/mm^3 and leukocyte counts under 2,000/mm^3 is particularly problematic in advanced cirrhosis due to its complex, multifactorial pathophysiology (2). Thrombocytopenia in chronic liver disease affects up to 78% of patients, while leukopenia prevalence ranges from 5% to 61% (3,4) These hematologic disturbances can complicate clinical management, leading to delays in initiating antiviral therapy, surgical procedures, or chemotherapy (5). Partial splenic artery embolization (PSE) has gained increasing recognition as an effective, minimally invasive alternative to surgical splenectomy. Since its introduction in the 1970s, numerous studies have confirmed its ability to raise platelet, white blood cell, and hemoglobin levels, while preserving immune function and minimizing associated risks (6,7). Beyond its therapeutic applications, research on PSE has expanded significantly. A search of the Web of Science Core Collection (WOS), conducted on April 30, 2025, identified 211 articles published between January 1, 2019, and April 1, 2025, focused on splenic artery embolization. This reflects growing multidisciplinary interest in the field. Topics explored include comparative analyses of embolic materials, innovations in procedural techniques, and long-term outcomes across various indications - such as trauma, splenic artery aneurysms, liver transplantation, hematologic disorders, and malignancy-associated complications. This review aims to provide a comprehensive and structured synthesis of current evidence regarding PSE, emphasizing its role in cirrhotic patients with hypersplenism and highlighting broader indications. Additionally, it seeks to clarify areas of clinical consensus, identify gaps in knowledge, and propose directions for future research to optimize patient outcomes and clinical practice.

Methods

Brief History

Splenic embolization was first performed by Frank Maddison in 1973 to treat esophageal bleeding secondary to nonalcoholic cirrhosis, which had proven refractory to splanchnic vasopressor therapy administered via the splenic

artery (8). Using an autologous clot as the embolic agent, Maddison successfully occluded the splenic artery. Although this initial attempt was associated with multiple complications including splenic abscesses and both pulmonary and systemic sepsis—the procedure laid the groundwork for further development (9). In 1979, Professor Spigos, a pioneer in interventional radiology, introduced the transcatheter approach to partial splenic embolization (PSE) with the goal of reducing postprocedural complications and improving procedural safety (10). This advancement marked a turning point, as the technique proved both safe and effective, and it has since been increasingly adopted worldwide. Over time, PSE has gradually emerged as a viable alternative to splenectomy in a variety of clinical scenarios, as explored in subsequent sections of this review.

A Comparison of Splenic Artery Embolization and Splenectomy

In patients with cirrhosis and hypersplenism, splenectomy is often challenging due to factors such as thrombocytopenia, hepatic insufficiency, malnutrition, sarcopenia, and heightened susceptibility to infection (11). Although splenectomy is associated with a more rapid increase in platelet counts and a lower incidence of splenic abscesses, PSE provides comparable hematologic outcomes with fewer and less severe complications and is generally better tolerated. Comparative studies do not generally differentiate between laparoscopic and open splenectomy, probably attributing the outcome difference to the residual splenic volume more than on the invasiveness of the intervention. In a recent meta-analysis combining 1849 hypersplenism patients, the mean difference was -61.58(CI -80.35,-42.82) for intraoperative blood loss, -2.98(CI -4.07,-1.88) for the length of the hospital stay and nearly half the risk of complications for PSE patients (6). Similarly, in the setting of trauma, PSE has also demonstrated clear advantages, including better preservation of immune function with a lower risk of infection, malignancy, thromboembolism, and all-cause mortality (12). A Dutch study found splenic embolization to be cost-effective in over 95% of cases compared to the surgical option (13). However, a limitation of embolization is that, in cases of recurrent hypersplenism after PSE, subsequent splenectomy may become more challenging. In a study comparing 40 patients who underwent splenectomy after prior embolization with 281 who underwent primary splenectomy, the latter group had significantly shorter hospital stays, less intraoperative blood loss, and reduced operative times (14). Nevertheless, repeated embolization is a useful alternative for managing recurrence (15).

Proximal and Distal Splenic Embolization

There is inconclusive evidence that supports the choice of partial (distal) or total (proximal) splenic embolization. In a 2012 study involving 27 and 34 patients who underwent proximal and distal embolization, respectively, platelet and leukocyte counts remained significantly higher for up to 4 years after the procedure in those who received total embolization. These patients also experienced fewer complications, possibly due to a smaller residual splenic volume combined with collateral arteries that prevented complete splenic infarction (16). Two larger studies found no significant differences in blood cell count increases between proximal and distal embolization, although the proximal group experienced significantly less abdominal pain and no splenic abscesses (15,17). While neither study showed a statistically significant difference in abscess rates individually, pooled data reveals a significant disparity: abscesses occurred in 9 of 163 patients after partial embolization, compared to none of 147 after total embolization ($p< 0.05$). However, as one study involved embolization for blunt injury and the others for hypersplenism, further research is needed to clarify the differences between the two techniques.

PSE Technique

PSE is a nonsurgical, minimally invasive procedure, performed using Seldingertechnique(18). Through a percutaneous femoral artery approach, the splenic artery is catheterized via celiac trunk, and after that the catheter is introduced into the splenic arterial branches (*Fig. 1*). Modifications of this approach have been reported in notable case reports - for example, distal embolization via the pancreaticoduodenal arcade in cases of celiac axis stenosis (19), and splenic embolization through the gastroepiploic artery following splenic artery ligation during liver transplantation (20).

Various embolic materials have been used over time, including temporary agents such as gelatin sponge (Gelfoam), and permanent agents like polyvinyl alcohol (PVA) particles, PVA hydrogel

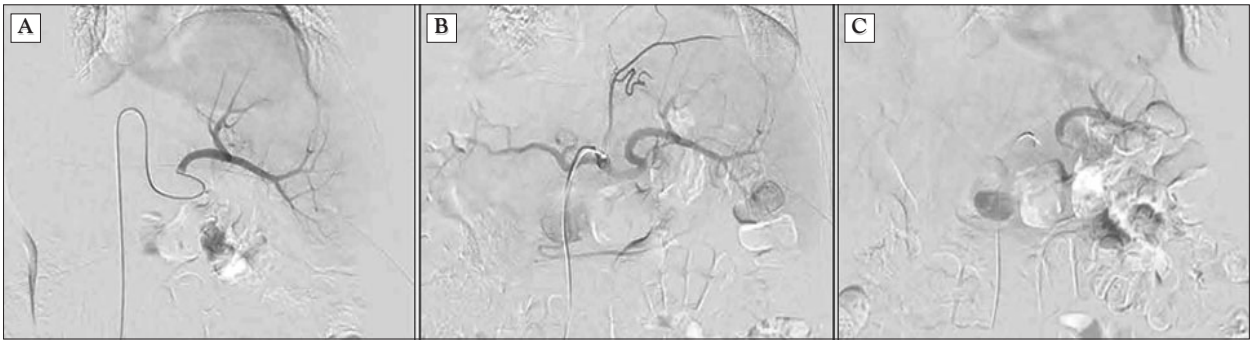

Figure 1. Splenic vein embolization at St. John Emergency Hospital, Angiography Department. **(A)** Unselective injection with visualization of celiac trunk and its emergent branches. **(B)** Supraselective catheterization of the splenic artery with visualization of the superior and inferior branches. **(C)** Injection of the embolic material into inferior splenic branch followed by the absence of its visualization.

beads coated with acrylic polymer, triacyl gelatin microspheres (Embospheres), and platinum microcoils, typically employed for larger vessels (21). A recent meta-analysis reported that vascular plugs achieved faster vessel occlusion and resulted in lower radiation exposure compared to coils (22). All embolic agents are mixed with contrast media to allow real-time imaging control during the procedure; the embolization ratio is measured via digital subtraction angiography, computed tomography angiography, or, more recently, cone beam computed tomography (23). Regarding their dimensions, PVA particles and embospheres particles are smaller, with 300-500 micrometer diameter, allowing a better distal penetration in small vessels(21). Permanent agents are associated with good results regarding the improvement of hypersplenism, but at the same time they are responsible for greater abdominal pain. This issue is related in fact to the infarction volume, which is lowest when temporary agents are used, comparing to permanent agents that have a durable occluding effect in distal splenic artery branches (21). Regarding the target of splenic volume to embolize, it is stated that almost 50%-70% of splenic parenchyma needs to be devitalized during the procedure for hypersplenism to decline, while avoiding severe complications (21). This can be achieved either through a one-step approach or a less invasive two-step strategy, starting with embolization of less than 50% of the splenic volume, followed by dynamic monitoring of hematological parameters and repeat intervention if necessary (2). Interestingly, when comparing different studies, the cutoff for the spleen embolization rate that avoids major complications is very close or even below the cutoff for a two-fold platelet increase (24,25). Patient-specific computer modelling has been recently proposed for optimizing the location of the embolization, particle size and release timing, in order to improve patient outcomes (26).

Indications

Gastroenterological applications

In hypersplenism, PSE has been shown to significantly increase platelet counts, a response associated with elevated levels of interleukin-6, thrombopoietin, and platelet-associated immunoglobulins (27). Significant increases in leukocyte and hemoglobin levels are less consistent, but have been frequently reported (28). While blood cell counts may decline gradually in the months and years following the procedure, their temporary improvement provides meaningful therapeutic benefits (28). For instance, in hepatitis C virus infection - the major cause of cirrhosis-related mortality in developed countries (1) - thrombocytopenia may represent a barrier to initiating antiviral therapy (29). Although viral eradication may itself lead to improved platelet counts, PSE remains a viable therapeutic option to address thrombocytopenia when other possibilities are not feasible (30,31). PSE is also beneficial for patients with cirrhosis in the context of significant portal hypertension, due to its role in reducing esophageal and gastric variceal bleeding. Refractory bleeding to standard therapy, represented by interventional endoscopy techniques or TIPS can be approached by a combined intervention of splenectomy and esophagogastric devascularization (14). Although splenic embolization is not included in last guideline on endoscopic diagnosis and management of

esophagogastric variceal hemorrhage of European Society of Gastrointestinal Endoscopy (ESGE), this procedure could be used as a rescue therapy in patients with acute or recurrent variceal bleeding, where TIPS placement is contraindicated (18,32). Splenic artery embolization significantly reduces the hepatic venous pressure gradient and improves hepatic function, thus lowering the Child-Pugh score (33), with a concomitant improvement of muscle and fat mass (34). In a recent meta-analysis on the use of PSE for variceal bleeding, the mortality rate was 0.5% (3 out of 531 patients). Complete resolution of varices was observed in 26% of cases, and improvement in variceal grade in 78%. The analysis reported a risk difference for rebleeding of –0.86 and a standardized mean difference in platelet count at 12 weeks of 1.15, with the improvement persisting for at least 3 months (28). The benefit of additional PSE compared with endoscopy alone was also significant in randomized control trials(35,36). Although generally considered as a salvage alternative to TIPS, combination of TIPS and PSE can further reduce rebleeding rates, allow for the use of smaller-caliber shunts, and improve platelet counts (37). Although the two procedures can be performed simultaneously or during the same hospital stay, a recent retrospective study suggested better outcomes when PSE is considered 1–3 months after TIPS in cases where platelet counts fail to improve. This delayed approach may help mitigate the risks of worsening hepatic perfusion and the potential contribution of PSE to hepatic encephalopathy, which remains incompletely understood (37). Gastric varices, in the context of left-sided portal hypertension - primarily caused by thrombotic obstruction of the splenic vein in certain pancreatic conditions - and stomal varices can both be effectively treated with PSE (38). Moreover, PSE has been used for the treatment of refractory ascites(39,40) and portal hypertensive gastropathy(41). Another issue in cirrhotic patients with severe thrombocytopenia is the burden of surgical disease and elective interventions. The minimum platelet count threshold in advanced liver cirrhosis for safely performing surgical intervention is generally 50000 elements /mm^3. Under such circumstances, PSE plays an important part, in order to elevate the platelet number and facilitate a scheduled invasive procedure (42). Splenic artery steal syndrome belongs to liver transplantation complications and arises in 5% of patients undergoing this intervention. Following liver transplantation, hepatic arterial resistance may increase, leading to a reduction in hepatic blood flow. This phenomenon can be reversed by PSE, which may also provide additional benefits in managing refractory ascites, hepatic hydrothorax, hypersplenism, and small-for-size graft syndrome (43,44). Neoplastic conditions, including hepatocellular carcinoma,develop hypersplenism through multiple mechanisms: portal venous hypertension, thrombosis of portal system due to the hypercoagulable state accompanying malignant disease with secondary portal congestion, tumoral thrombosis. In addition, chemotherapeutic drugs may induce thrombotic complications, for instance sinusoidal obstruction syndrome related to oxaliplatin (45). PSE proved to be efficient in these particular situations, increasing hematological indices for long periods of time (46,47). It has been suggested to use PSE synchronously with systemic chemotherapy to obtain better results and avoid discontinuation of chemotherapy (48). Other indications are splenic vascular abnormalities (hemangiomas, splenic artery aneurysms and pseudoaneurysms) and, rarely, splenic pregnancy (49,50).

Extra-digestive applications

Possible unstandardized applications are idiopathic thrombocytopenic purpura, autoimmune hemolytic anemia, splenic hematoma and rare causes of cytopenia (51,52).

Splenic injury

PSE was first introduced in the treatment of splenic trauma by Sclafani in 1981 in order to limit the immunological unfavorable consequences related to the absence of spleen (53). In the before mentioned WOS search of recent articles on splenic artery embolization, a quarter focused on its use in trauma, and high-quality guidelines commonly recommend this strategy (54). Beyond trauma, PSE has also been successfully used to manage a range of rare but serious splenic pathologies, including iatrogenic splenic injury or splenic artery aneurysms following colonoscopy and pancreatectomy, splenic rupture after mitral valve replacement or in the context of Behçet's disease and Ehlers-Danlos syndrome, and splenic artery dissection (55–60).

Complications

The most common adverse event is post-embolization syndrome, which is almost universally prevalent and is characterized by abdominal pain,

fever and nausea (61). Most complications are transient and mild; however, some patients may develop serious adverse events, including pulmonary complications (such as large or refractory left pleural effusion and pneumonia), splenic or left subphrenic abscesses, portal vein thrombosis, upper gastrointestinal bleeding due to coil migration, or even death (61,62). The rate of complications seems directly related to the volume of devitalized spleen, and, overall, the procedure is safe, effective and associated with low morbidity and mortality (61). In liver cirrhosis, besides the role of residual splenic tissue, an independent prognostic factor for post procedural complications is considered the degree of liver failure, quantified through Child – Pugh classification (63). A protocol containing prophylactic antibiotherapy is mandatory to avoid septic complications. The combined use of dexamethasone and low-molecular weight heparin can reduce the incidence of post-embolization syndrome and portal vein thrombosis, and was not associated with a higher risk of rebleed, although further studies are needed (64,65).

Further Research

The previously mentioned search of the WOS database for studies published in January 2019 - April 2025 revealed 78 case reports or case series, 10 systematic reviews or meta-analyses, 7 narrative reviews, 3 surveys, 1 case-control study, and 4 prospective observational studies. The remaining publications were retrospective observational studies, of which only 11 involved more than 150 patients, while half included fewer than 50 participants. Important areas where stronger evidence is still needed include the comparison between proximal and distal embolization, the role of thromboprophylaxis, and the optimal timing of PSE when combined with TIPS, and the optimal rate of embolization. A recent meta-analysis on PSE for hypersplenism pointed out that the results were based on retrospective cohort studies or case control studies, with only two randomized controlled trials limited by a lack of description of the methodology. Furthermore, the inter-study heterogeneity was high for most of the outcomes, the follow up times were insufficient and most of the studies were conducted in China (6). Another recent meta-analysis on the role of PSE in variceal bleeding highlighted the potential risk of publication bias for the studies with significant reductions in bleeding and a high heterogeneity in follow-up durations and procedural approaches and availability of liver-disease Child Pugh stadialization (28). Moreover, the effect of PSE in immune thrombocytopenia has been explored mostly in uncontrolled studies, generally of moderate to low quality, many of the rarer conditions in which PSE is used to improve platelet counts or as an alternative to splenectomy still lack robust supporting evidence and would benefit from further study (52). In addition, new technologies such as patient-specific computational fluid dynamics have been proposed to refine embolization technique and improve outcomes (26). Further research is needed to validate these approaches and to build stronger evidence for the integration of PSE into clinical guidelines, particularly for upper gastrointestinal bleeding and other relevant indications.

Conclusions

PSE has emerged as a noninvasive procedure mainly to improve life-threatening hemorrhage due to severe thrombocytopenia in advanced liver disease and to facilitate the access to surgical interventions in cases where extremely low platelet count contraindicates it. Over the years, PSE demonstrated a low rate of complications compared to the consequences that develop after surgical spleen removal. Among the extended indications that arose gradually for PSE, advanced liver disease associated with portal hypertension and hypersplenism plays the main part, improving blood cell counts and liver function while preserving the immunological function of the spleen. It could emerge as a solution for refractory variceal bleeding as an alternative to TIPS or in sequential use. An optimal embolization rate, identified by further research and personalized approaches, could improve outcomes. Several complications have been reported, but the majority are mild. PSE is a good option in various medical conditions but requires a careful selection of patients to diminish the possible drawbacks. Despite the growing body of literature, many aspects of PSE remain underexplored, especially regarding optimal embolization strategies, long-term outcomes, or its role in the treatment of digestive bleeding. Further high-quality research, including high quality randomized trials and a standardization of techniques, is essential to define PSE's place in future clinical guidelines and maximize patient outcomes across its diverse indications.

Conflicts of Interest

The authors declare no conflict of interest.

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