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ORIGINAL ARTICLE

CAN PARTIAL SPLENIC EMBOLIZATION BE A PROMISING TREATMENT FOR HYPERSPLENISM–RELATED THROMBOCYTOPENIA IN ONCOLOGICAL PATIENTS REQUIRING SYSTEMIC CHEMOTHERAPY: A RETROSPECTIVE ANALYSIS

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ABSTRACT

Background: Partial splenic embolization has been safely used to improve hypersplenism–related thrombocytopenia by reducing the splenic volume using conventional transarterial superselective embolization technique. Partial splenic embolization provides an increase in hematologic indices to facilitate initiation and continuation of systemic chemotherapy in oncological patients who are not surgical candidates and for whom splenectomy is contraindicated.

Objective: The aim of this study was to evaluate primary, secondary end points, technical parameters, outcomes and complications of partial splenic embolization in oncological patients with hypersplenism-related thrombocytopenia requiring systemic chemotherapy.

Methods: This retrospective study comprised 24 oncological patients (18 males and 6 females; their ages ranged 35–70 years old), they underwent partial splenic embolization for correcting thrombocytopenia in order to initiate (n=6) or continue (n=18) their optimally dosed systemic chemotherapy. The primary endpoint was the achievement of a platelet count >130×10^9/L and the secondary endpoint was the initiation or continuation of systemic chemotherapy.

Results: Mean platelet count prior to partial splenic embolization was 69.08 ± 3.54× 10^9/L (range 62–75× 10^9/L).The percentage of splenic necrosis was estimated by angiography, mean post-embolization splenic infarction percentage was 58.33 ± 8.16 %. Mean platelet counts at days 10, 20 and 30 post-embolization were 273.58±77.30× 10^9/L, 218.54±60.06× 10^9/L and 157.16±44.90× 10^9/L, respectively (P<0.05). Primary and secondary endpoints were reached in 24 (100%) of 24 patients. 16 (66.7%) patients had moderate post-embolization syndrome. No puncture site hematomas, or major complications or severe post-embolization syndrome occurred. No one-month mortality rate among the 24 patients.

Conclusion: Partial splenic embolization is secure and efficient in handling hypersplenism-related thrombocytopenia in oncological patients, facilitating the initiation or continuation of systemic chemotherapy with minimal procedure-related morbidity.

Keywords: partial splenic embolization, hypersplenism, thrombocytopenia, systemic chemotherapy

INTRODUCTION

Thrombocytopenia is defined as low blood platelets level, a normal platelet count ranges from 150× 10^9/L to 450× 10^9/L **(1).**

Hypersplenism-induced thrombocytopenia has different causes, the most common is portal hypertension on top of cirrhosis **(2).**

The reduction in the platelet count in hypersplenism is triggered through augmented splenic sequestration, thrombocytes damage, or thrombopoietin degradation **(3).**

Oncological patients treated with systemic chemotherapy (SC) are liable to hypersplenism and subsequently thrombocytopenia that precludes

administration of SC or necessitates dose attenuation, thus decreasing efficiency of cancer therapy **(4).**

Oncological patients develop thrombocytopenia by different mechanisms; **SC treatments** may cause hepatic damage that leads to portal hypertension and hypersplenism, moreover hepatic affection reduces thrombopoietin production. **Pancreatic tumors** may cause splenic vein thrombosis, portal hypertension then hypersplenism. Also, patients with **hematologic malignancies** develop thrombocytopenia secondary to the disease process or as a complication of SC **(5).**

Platelets transfusion is a temporary and impractical solution for patients with hypersplenism–related thrombocytopenia due to platelets sequestration and destruction **(6).**

If drug treatment is unsuccessful, splenectomy will be the last resort for treatment of thrombocytopenia, however splenectomy has perioperative and postoperative complications especially in patients with poor general condition, so partial splenic embolization (PSE) will be an efficient substitutional to splenectomy **(7).**

PSE has safely improved hypersplenism–related thrombocytopenia by reducing the splenic volume using conventional transarterial superselective embolization technique. PSE increases the hematologic indices, facilitating the initiation and continuation of SC in oncological patients for whom splenectomy is contraindicated **(8).**

The aim of this study **was** to evaluate 1ry end points, 2ry end points, technical parameters, outcomes and complications of PSE in oncological patients with hypersplenism-related thrombocytopenia requiring SC.

PATIENTS AND METHODS

Patients

This retrospective study comprised 24 oncological patients (18 males and 6 females; their ages ranged 35–70 years old), they were referred from Clinical Oncology Department to the Interventional unit in Radiodiagnosis department during the period from December 2019 to June 2020.

They underwent PSE for correcting thrombocytopenia in order to initiate (n=6) or continue (n=18) their optimally dosed SC. The inclusion criteria were oncological patients with hypersplenism, thrombocytopenia (platelet count $\leq 75\times\mathbf{10^9}$/L) and splenomegaly. Exclusion criteria were: (1) allergy to contrast medium, (2) renal insufficiency, (3) life-expectancy <3 months.

All patients underwent history taking, clinical examination, laboratory investigations (CBC, hepatic function test and renal function test), abdominal ultrasound (US) and contrast enhanced multislice computed tomography (MSCT).

Platelets counts were recorded immediately before PSE and 10, 20 and 30 days post PSE. Splenic infarction percentage was evaluated by post PSE angiography.

The 1ry (primary) endpoint was the achievement of a platelet count **$>130\times10^9$/L** and the 2ry (secondary) endpoint was the initiation or continuation of SC.

Post procedure abdominal US was performed in all patients four weeks post PSE for assessment of splenic length, width and splenic volume (calculated using the standard prolate ellipsoid formula; length × width × depth × 0.523) **(9)**.

Technical parameters (duration of scope, hospital discharge and Dose area product DAP) were additionally recorded. No vaccinations were taken prior to the procedure, as the immune protection of the spleen will not be completely eliminated.

The 24 patients were classified into two groups, patients with hematological malignancies (11 patients) and non-hematological malignancies (13 patients).

Written informed consent was obtained from all participants, the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Vascular anatomy of the spleen

The splenic artery arises from the celiac axis **(Figure 1)**, in 8% of patients, it arises directly from the abdominal aorta.

The main splenic artery bifurcates into upper and lower polar divisions, which then divide into 4 to 6 intrasplenic segmental branches.
The dorsal pancreatic and pancreatica magna arteries arise off the proximal and mid-splenic artery and supply the body and tail of the pancreas. Visceral arteries arising from the splenic artery include the left gastroepiploic, short gastric and accessory left colic arteries **(Figure 2)**.
Recognition of the aforementioned collaterals is important to decrease the risk of non-target embolization during splenic artery intervention **(10)**.

PSE technique

In this study, thrombocytopenia precluded the continuation of SC in 18 patients, the median time between the cessation of SC and undergoing PSE procedure was 14 days (mean 17.7 days) .

The procedure was done using high resolution digital subtraction angiography (DSA) C-arm machine **(Siemens Artis-zee)** at **the** interventional unit in **the** Radiodiagnosis department.
All patients received preprocedure intravenous sedative **(2.5 mg of Midazolam)** and antibiotics **(1 intravenous ampoule of Tobramycin 50 mg & 1 intramuscular ampoule of Benzylpenicillin 600,000 *international unit*)** half an hour before the procedure.
The procedure was performed under local anesthesia **(xylocaine)** with strict aseptic conditions. A 5 French Cobra head catheter **(Imager- Boston Scientific, USA)** was inserted into the femoral artery by modified Seldinger method. Celiac angiography and selective splenic arterial angiography were done to detect the splenic arteries and collateral circulation . Then, the tip of the catheter was inserted as distal as possible at the splenic hilum to avoid embolization of pancreatic and short gastric arteries. In 5 cases, a coaxial microcatheter **(Renegade HI-FLO microcatheter, Boston Scientific, USA)** was advanced through the mother cobra catheter to reach the splenic hilum to further subselect the terminal branches (this was not feasible by the cobra catheter due to the marked tortuosity of the hypertrophied splenic artery). Embolization under fluoroscopy control was done using gelatin sponge **(Gelfoam cube, Upjohn, Kalamazoo, USA)** (1–2 mm) suspended in an antibiotic solution **(1 gram cefazolin containing solution)** and contrast medium. Middle and inferior splenic branches were preferred than upper branch to decrease the incidence of pleural effusion and subdiaphragmatic abscess. Immediate post-embolization arteriogram was done after each injection. A final arteriogram was performed to achieve a splenic infarction percentage of 50-70% to avoid sever post embolization syndrome.
Manual vascular compression was applied for at least thirty minutes.

Evaluation of the splenic infarction percentage during the procedure is subjective and depends on the experience of the operator.

Post-PSE supportive care

All patients were hospitalized (mean hospital discharge was 4.16±1.68 days after PSE, range 2–7 days) for appropriate post-procedure care including hydro-electrolytic infusion, systemic antibiotics **(amoxicillin clavulanate 3 gram/day and ofloxacin 400 mg/day)** for at least 5 days after PSE and analgesics **(paracetamol in 5 patients / morphine in 3 patients;** 8 patients (33.3%) had abdominal pain**).**

Statistical analysis

Quantitative variables were expressed as mean ± SD & median (range). Qualitative variables were expressed as absolute frequencies (number) & relative frequencies (percentage). Paired samples t-test compared 2 dependent groups of normally distributed data. Repeated measurements ANOVA test compared more than 2 dependent groups of normally distributed data. Student's t-test compared 2 groups of normally distributed data while Mann-Whitney U test was used for non-normally distributed data. Categorical data were compared using Chi-square test. P-value <0.05 was considered statistically significant.

RESULTS

Patients characteristics

24 oncological patients (18 males and 6 females, median age 45 years, range 35-70

years) were recruited in this study, primary malignancies included: lymphoma (n=7), leukemia (n=4), pancreatic carcinoma (n=3), hepatocellular carcinoma (HCC) (n=6), bronchogenic carcinoma (n=3) and gastro-esophageal junction (GEJ) carcinoma (n=1) (Table 1).

All patients had documented splenomegaly and hypersplenism-induced thrombocytopenia based on clinical, laboratory and imaging criteria.

The etiology of hypersplenism included: **[1]** hematological malignancies (n=11), **[2]** portal hypertension including: hepatic cirrhosis (n=6) & portal / splenic vein compromise (n=3) **[3]** chemotherapy- associated hepatic injury (n=4).

All 6 patients with cirrhosis had HCC on top of cirrhosis, the 3 cases of portal / splenic vein compromise resulted from compression/ invasion by pancreatic tumors.

In this study, thrombocytopenia precluded the initiation (n = 6) or continuation (n = 18) of SC. An average of 3.75 regimens (range 1–7 regimens) were administered before the procedure in 18 cases, the p***re-procedural*** administered chemotherapeutic drugs were 6-mercaptopurine (n=4), cyclophosphamide (n=9), vincristine (n=11), gemcitabine (n=9), fluorouracil (n=3), cisplatin (n=7), Rituximab (n=5), L-asparaginase (n=3) and methotrexate (n=4).

Pre-procedural data (Table 2)

Pre-procedural MSCT revealed a mean splenic width of 167. 45 ± 24.82 mm (range 136–212 mm) and a mean splenic volume of 1009.79 ± 432.70 cm^3 (range 405–1730 cm^3) confirming splenomegaly.

The mean platelet count prior to PSE was 69.08 ± 3.54 $\times 10^9$/L (range 62–75$\times 10^9$/L) which is consistent with low platelet count for all patients prior to PSE.

Post-procedural data (Table 2)

Post-procedural US revealed a mean splenic width and volume of 166.41 ± 24.74 mm (range 135–210 mm) and 1144.70 ± 478.31 cm^3 (range 470–2100 cm^3), respectively. The percentage of splenic necrosis was estimated by angiography, mean post- ***procedural*** splenic infarction percentage was 58.33 ± 8.16 % (range 50–70%).

Mean platelet counts at days 10, 20 and 30 post-PSE were 273.58±77.30$\times 10^9$/L (range 132– 380 $\times 10^9$/L), 218.54±60.06$\times 10^9$/L (range 105–330 $\times 10^9$/L) and 157.16±44.90$\times 10^9$/L (range 100–270 $\times 10^9$/L), respectively (P <0.05) (Figure 3).

The mean duration of scope was 25.79 ± 6.24 minutes (range 15–35 minutes). Mean DAP was 418.12 ± 140.16 Gy* cm^2 (range 180–625 Gy* cm^2). Mean hospital discharge was 4.16±1.68 days.

Outcome and complications *(Table 3)*

Technical success was done in 24 (100%) of 24 patients with one-single procedure. 1ry and 2ry endpoints were reached in 24 (100%) of 24 patients.

16 (66.7%) patients had moderate post-embolization syndrome (PES) [low to moderate abdominal pain in 8 patients (33.3%), low-grade fever in 6 patients (25%) and nausea in 6 patients (25%)]. No puncture site hematomas, or major complications or severe post-embolization syndrome occurred.

No one-month mortality rate (related to the procedure) among the 24 patients after PSE.

Post PSE, all patients (n=24) were able to initiate or continue SC, and the average time to the initiation or continuation of SC was 30 days (range, 10–80 days).

(Table 4 & Table 5) show that the splenic width, splenic volume, post PSE platelet count increase, duration of scope and post PSE complications were significantly different between hematological and non-hematological groups (P<0.05)**.**

Table (1): Basic characteristics of the studied patients (N=24)

Basic characteristics	patients (N=24)	
	No.	%
Sex		
Male	18	75%
Female	6	25%
Age (years)		
Mean±SD	49.91	±8.94
Median (Range)	45	(35 – 70)
<50 years	13	54.2%
≥50 years	11	45.8%
Primary malignancy		
Hematological	11	45.8%
Leukemia	4	16.7%
Lymphoma	7	29.1%
Non-hematological	13	54.2%
Bronchogenic carcinoma	3	12.5%
GEJ carcinoma	1	4.2%
Pancreatic carcinoma	3	12.5%
HCC	6	25%

Categorical variables were expressed as number (percentage).Continuous variables were expressed as mean ± SD & median (range).

Table (2): Pre-procedural & post-procedural data among the studied patients (N=24).

Parameters	Mean	±SD	Median	(Range)	Test	p-value
Splenic width (mm)						
Pre-PSE	167.45	±24.82	163.50	(136 – 212)	25.000*	<0.001
Post-PSE	166.41	±24.74	162.50	(135 – 210)		
Splenic volume (cm^3)						
Pre-PSE	1009.79	±432.70	1000	(405 – 1730)	-7.844*	<0.001
Post-PSE	1144.70	±478.31	1120	(470 – 2100)		
Splenic infarction (%)						
Post-PSE	58.33	±8.16	60	(50 – 70)	----	----
Platelet count ($\times 10^9$/L)						
Pre-PSE	69.08	±3.54	69	(62 – 75)	123.739•	<0.001
10 days after PSE	273.58	±77.30	285	(132 – 380)		
20 days after PSE	218.54	±60.06	220	(105 – 330)		
30 days after PSE	157.16	±44.90	150	(100 – 270)		
Duration of scope (min)	25.79	±6.24	26.50	(15 – 35)	----	----
DAP (Gy* cm^2)	418.12	±140.16	430	(180 – 625)	----	----
Hospital discharge (days)	4.16	±1.68	4	(2 – 7)	----	----

Continuous variables were expressed as mean ± SD & median (range); * Paired samples t-test; • Repeated measurements ANOVA test; p-value<0.05 is significant.

Table (3): Outcome and complications among the studied patients (N=24).

Outcome and complications	All patients (N=24)	
	No.	%
Technical success		
No	**0**	**0%**
Yes	**24**	**100%**
Primary endpoint		
Failure	**0**	**0%**
Success	**24**	**100%**
Secondary endpoint		
Failure	**0**	**0%**
Success	**24**	**100%**
Complications		
Puncture site hematoma	**0**	**0%**
Major complications	**0**	**0%**
Moderate post-embolization syndrome	**16**	**66.7%**
Severe post-embolization syndrome	**0**	**0%**
One-month mortality	**0**	**0%**

Categorical variables were expressed as number (percentage).

Table (4): Comparison between hematological and non-hematological malignancies regarding splenic width, splenic volume, splenic infarction, platelet count and technical parameters.

Parameters	Malignancies		Test	p-value
	Hematological (N=11)	Non-hematological (N=13)		
Splenic width (mm)				
Pre-PSE				
Mean±SD	156.45±15.88	155.45±15.88	2.243*	0.037
Median (Range)	156 (136 – 181)	155 (135 – 180)		
Post-PSE				
Mean±SD	176.76±27.67	175.69±27.56	2.245*	0.036
Median (Range)	186 (138 – 212)	185 (137 – 210)		
Splenic volume (cm^3)				
Pre-PSE				
Mean±SD	624.09±158.44	1336.15±293.56	-4.150•	<0.001
Median (Range)	600 (405 – 900)	1250 (1000 – 1730)		
Post-PSE				
Mean±SD	742.72±204.06	1484.84±361.02	-6.315*	<0.001
Median (Range)	700 (470 – 1200)	1360 (1030 – 2100)		
Splenic infarction (%)				
Post-PSE				
Mean±SD	57.27±7.86	59.23±8.62	-0.557•	0.578
Median (Range)	60 (50 – 70)	60 (50 – 70)		
Platelet count ($\times 10^9$/L)				
Pre-PSE				
Mean±SD	68.27±3.63	69.76±3.46	-1.030*	0.314
Median (Range)	68 (62 – 75)	70 (65 – 75)		
10 days after PSE				
Mean±SD	202.36±45.51	333.84±33.79	-8.113*	<0.001
Median (Range)	210 (132 – 270)	340 (280 – 380)		
20 days after PSE				
Mean±SD	167.72±38.16	261.53±36.47	-6.146*	<0.001

Parameters	Malignancies		Test	p-value
	Hematological (N=11)	Non-hematological (N=13)		
Median (Range)	170 (105 – 220)	250 (210 – 330)		
30 days after PSE				
Mean±SD	126.81±21.47	182.84±43.83	-3.857*	0.001
Median (Range)	130 (100 – 160)	190 (110 – 270)		
Technical parameters				
Duration of scope (min)				
Mean±SD	21.63±5.33	29.30±4.66	-3.761*	0.001
Median (Range)	20 (15 – 30)	30 (21 – 35)		
DAP (Gy* cm^2)				
Mean±SD	400±157.09	433.46±128.57	-0.574*	0.572
Median (Range)	400 (180 – 620)	440 (220 – 625)		
Hospital discharge (days)				
Mean±SD	3.90±1.70	4.38±1.70	-0.681*	0.503
Median (Range)	4 (2 – 7)	5 (2 – 7)		

Continuous variables were expressed as mean ± SD & median (range); * Independent samples Student's t-test; • Mann Whitney U test; p-value<0.05 is significant.

Table (5): Comparison between hematological and non-hematological malignancies regarding complications.

Complications	Malignancies				Test	p-value
	Hematological (N=11)		Non-hematological (N=13)			
	No.	%	No.	%		
Moderate post-embolization syndrome						
No	0	0%	8	61.5%	1.154‡	0.002
Yes	11	100%	5	38.5%		

Categorical variables were expressed as number (percentage); ‡ Chi-square test; p<0.05 is significant.

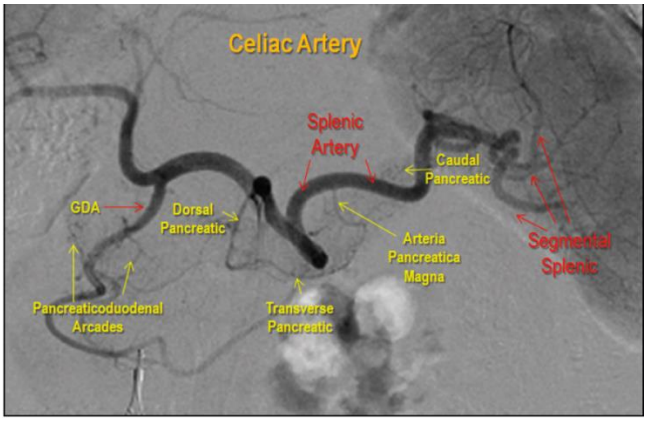


Figure (1): Splenic artery anatomy. Digital subtraction angiogram (DSA) demonstrates celiac arterial anatomy. The dorsal pancreatic and pancreatica magna arteries arise off the proximal and mid-splenic artery **(10).**

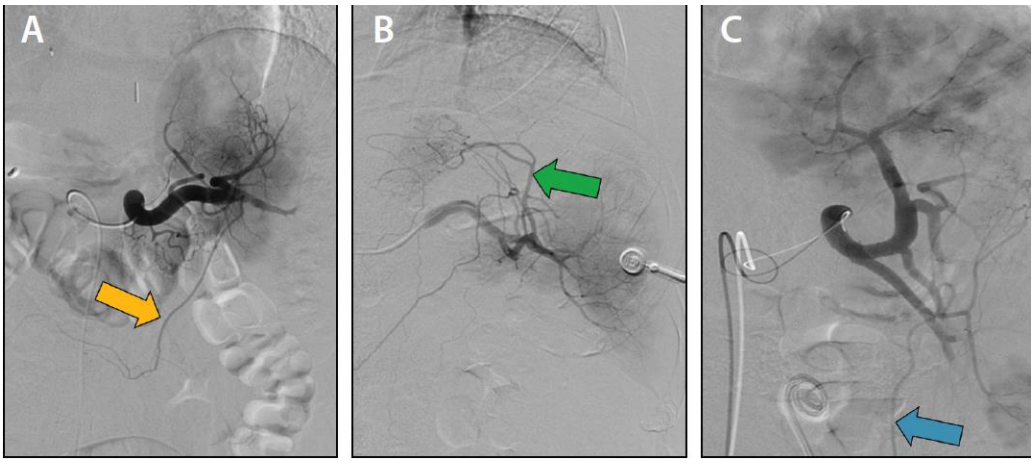


Figure (2): Common collaterals arising from the splenic artery. Left gastroepiploic artery (yellow arrow) arises from the inferior polar splenic artery (A). Short gastric arteries (green arrow) arise from an intrasplenic segmental splenic artery (B). Accessory left colic artery (blue arrow) arises from an inferior intrasplenic segmental artery (C) **(10).**

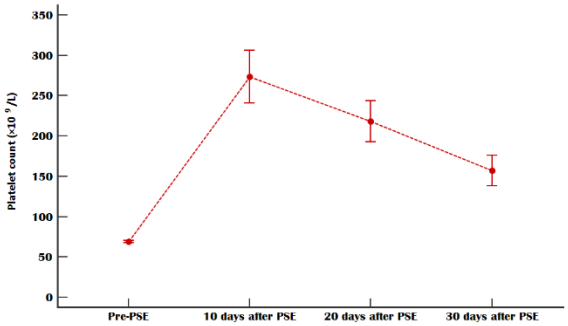
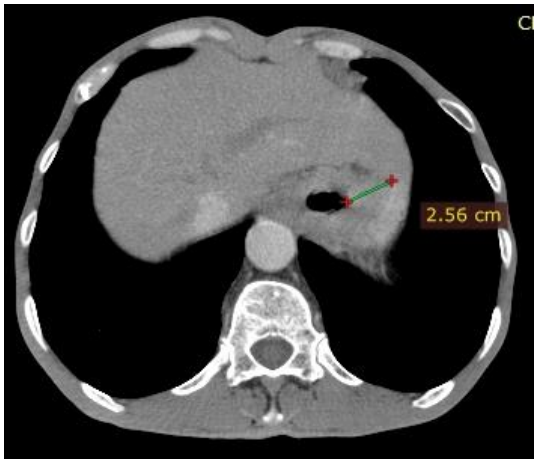


Figure (3): Error Marker chart with connecting line shows platelet count pre and post-PSE; Marker represents mean, Y-error bar represents 95%CI (Confidence interval) around mean.



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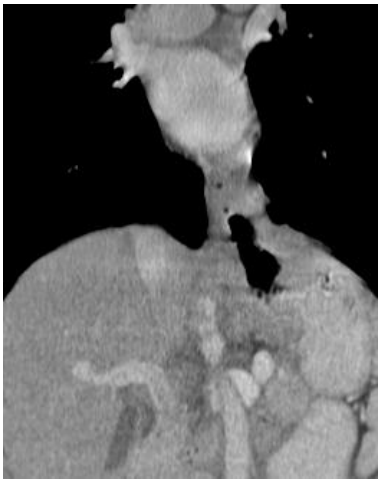

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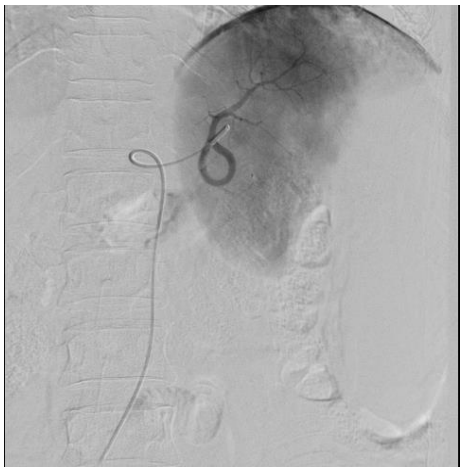

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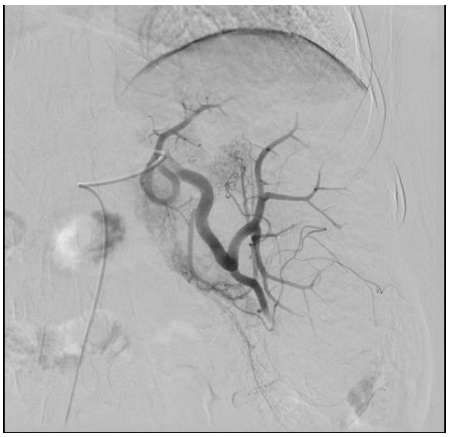

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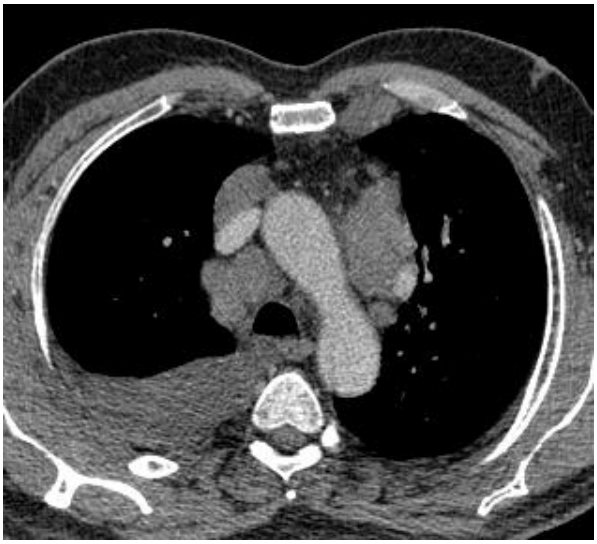
Figure (4): A 46-years-old male patient with GEJ carcinoma, initial assessment before systemic chemotherapy was decided. Splenomegaly and hypersplenism with thrombocytopenia (a platelet count of 70 $\times 10^9$/L) were identified. It was decided to treat thrombocytopenia with selective PSE.

The patient was hospitalized for 3 days after PSE to treat post-embolization syndrome. The patient presented with left upper quadrant pain for 72 hours after embolization that was successfully treated by morphine, with no other adverse effects reported. Ten days after PSE, a control visit showed a platelet count of 300×10^9/L, so that systemic chemotherapy could be begun.

Figure (A) Axial & (B) coronal contrast-enhanced MDCT images show circumferential irregular mural thickening of GOJ (white arrow) measuring 2.56 cm in its maximum thickness.

Figure (C): Pre embolization angiogram.

Figure (D): Control angiogram post embolization shows **70 %** reduction of the splenic perfusion.



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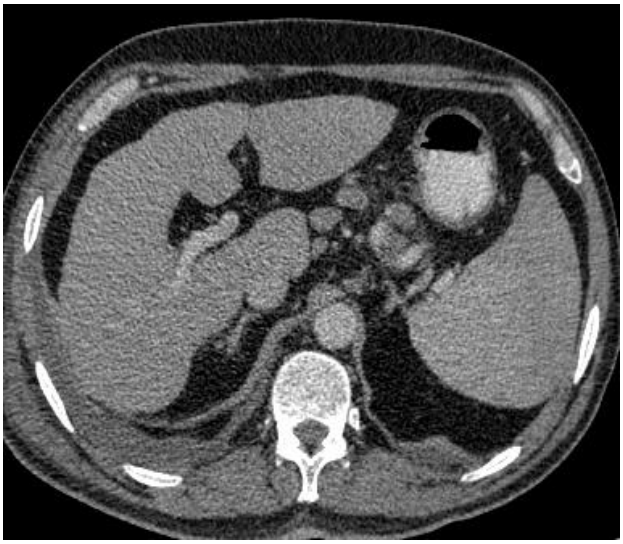

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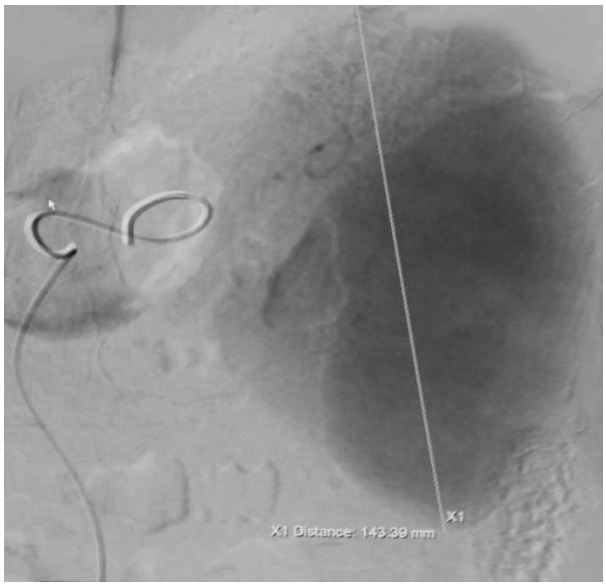

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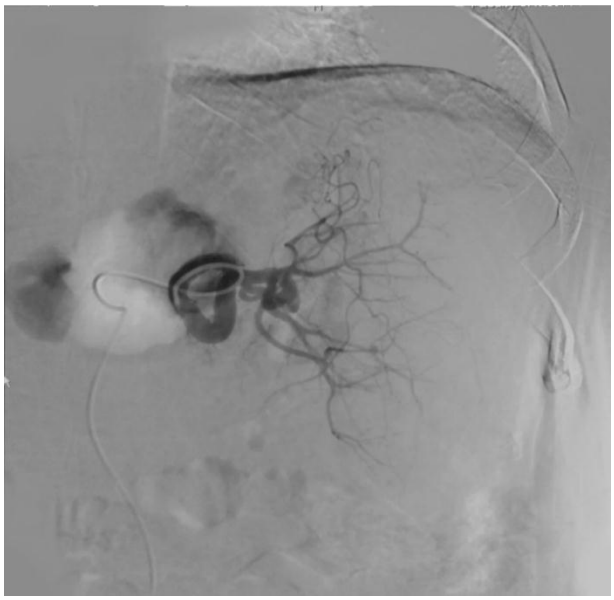


D

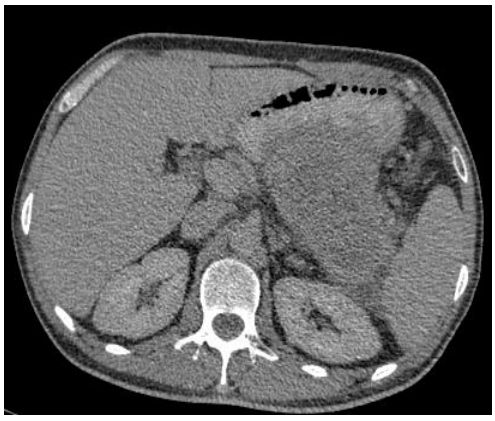
Figure (5): A 62-years-old male patient with lymphoma, the patient was given 3 cycles of cyclophosphamide, vincristine and rituximab, with a regimen given in 3 weeks apart. The patient developed hypersplenism-related thrombocytopenia, and the platelet count was 65×10^9/L contraindicating continuation of systemic chemotherapy. It was decided to treat thrombocytopenia with selective PSE.

The platelet count returns to normal level (250 $\times10^9$/L) 10 days after the procedure. The postoperative outcome included 38◦hyperthermia and low abdominal pain for 48 hours that was treated with paracetamol.

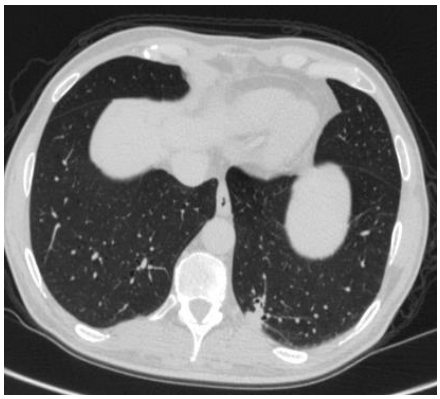
Figure (A) & (B) Axial contrast-enhanced MDCT images show multiple variable sized enlarged mediastinal and upper abdominal LNS, associated with bilateral pleural effusion.

Figure (C): Splenic artery angiography shows enlarged spleen (Splenic span = 143 mm).

Figure (D): Splenic arteriogram after PSE shows devascularization of **70 %** of the spleen.



A



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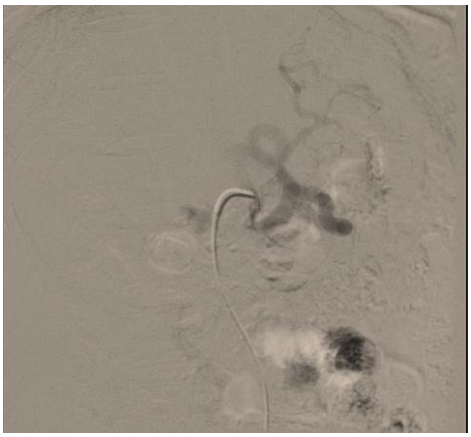

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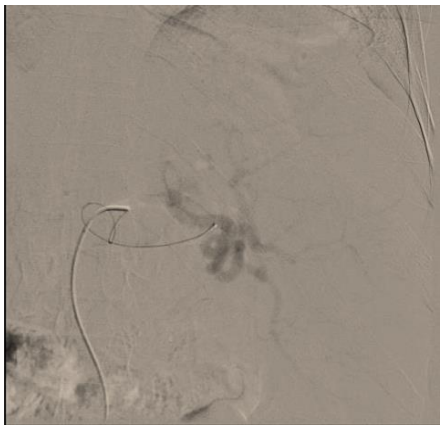

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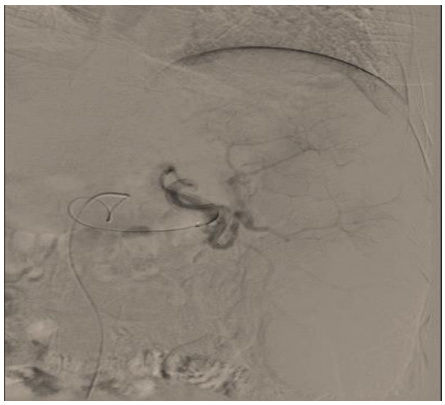


E

Figure (6): Male patient 53 years presented with cancer pancreatic tail. At 2 months, lung metastases developed. Chemotherapy was modified to fluorouracil and gemcitabine regimen. The patient developed portal hypertension, hypersplenism with thrombocytopenia (a platelet count of 72 $\times 10^9$/L) contraindicating the participation in a new treatment protocol. It was then decided to treat thrombocytopenia with selective PSE.

PSE had done selectively using microcatheter due to multiple kinks in the course of splenic artery. 10 days after embolization, the platelet count had reached 200 $\times 10^9$/L.

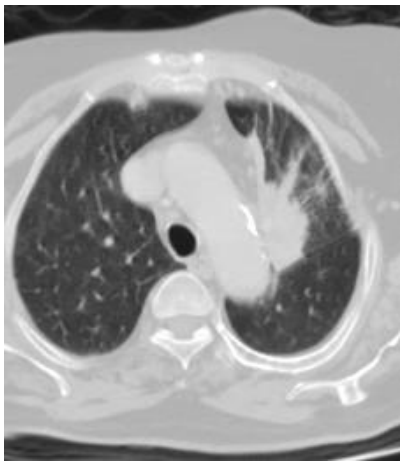
Figure (A): Axial MDCT image shows an ill-defined heterogeneously enhanced soft tissue density mass involving the pancreatic tail, infiltrating the greater curvature of the stomach and surrounding fat planes associated with small peri-pancreatic LNs.

Figure (B): Axial MDCT image (lung window) shows a soft tissue nodule with irregular margin in the posterior segment of the left lower lobe.

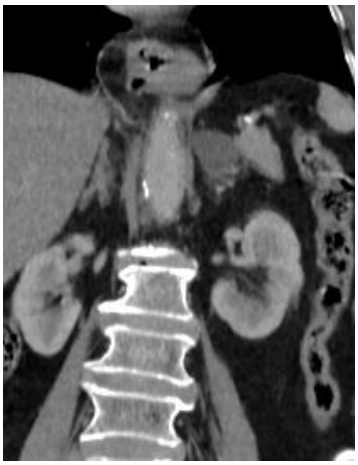
Figure (C): Splenic artery angiogram shows dilated and tortous splenic artery.

Figure (D): Shows microcatheter advanced distally in the splenic artery.

Figure (E): Post embolization control angiogram with microcatheter shows reduction of splenic blood flow (70% splenic ischemia).



A



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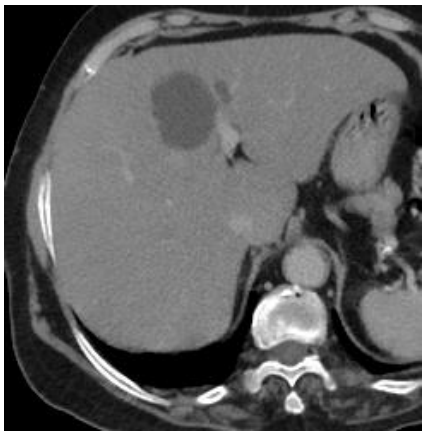

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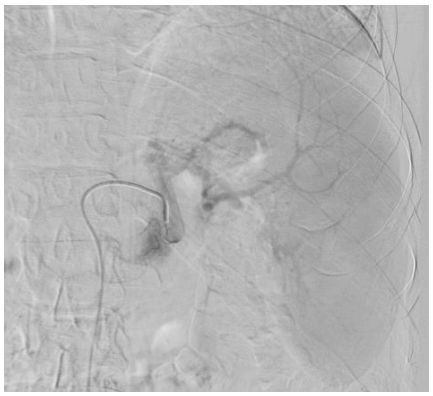

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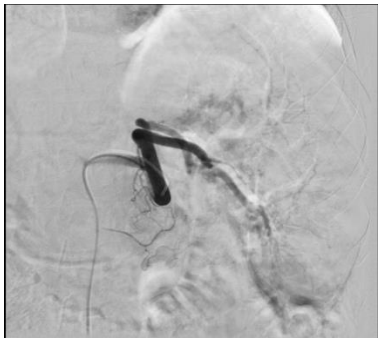

E

Figure (7):A 42-years-old male patient with left bronchogenic carcinoma. Liver metastases and left adrenal lesions developed. 3 Cycles of chemotherapy with a cyclophosphamide - methotrexate regimen were taken. The patient then developed portal hypertension resulting in hypersplenism with thrombocytopenia and a platelet count of 62 $\times 10^9$/L contraindicating continuation of chemotherapeutic cycles.

It was then decided to treat thrombocytopenia with selective PSE. The postoperative outcome included low abdominal pain that was treated with paracetamol as well as 39◦hyperthermia for 48 hours. Ten days post-PSE, the platelet count stabilized at 320×10^9/L, so that SC was begun again.

Figure (A): Axial MDCT image (lung window) shows an ill-defined heterogeneous soft tissue density mass involving the left upper lung lobe with irregular margins, it abuts the aortic arch associated with irregular septal thickening denoting lymphangitis carcinomatosis.

Figure (B): Coronal MDCT image shows a hypodense soft tissue mass involving the left adrenal gland. Small hiatus hernia is noted.

Figure (C): Axial MDCT image shows two hypodense non enhanced hepatic focal lesions involving the left hepatic lobe.

Figure (D): Splenic arteriogram shows enlarged spleen.

Figure (E): Control opacification post embolization (Pre splenic bifurcation of the main splenic artery is noted) shows 50% splenic ischemia.

DISCUSSION

In oncological patients with thrombocytopenia, spontaneous episodes of bleeding are life-threatening**.** Moreover, treatments such as interferon, antiangiogenics and major surgeries can be contraindicated **(11).**

When splenomegaly and platelets sequestration develop throughout cancer regimens administration, the consequential thrombocytopenia forces dosage reduction or interrupts patient regimen, decreasing the efficiency of SC **(12)**. Prescription attenuation or chemotherapy suspension occur when thrombocytopenia reaches **≤ 75 ×10^9**/L during the course of SC treatment **(13).**

After the failure of medical therapy, splenectomy is indicated for reducing splenic cell hyperdestruction. However, severe complications and septic events, in particular pneumococcus or meningococcus occur in 9.6 to 26.6% of the cases **(14).**

PSE has become an effective choice for the treatment of hypersplenism-related thrombocytopenia in oncological patients who are often poor candidates for splenectomy. Successful management of their low platelet count is important to proceed in cancer regimens administration **(15).**

In this study, PSE was done in 24 patients (18 males and 6 females; median age 45 years, range 35–70 years) with one-single procedure for each patient.

Togasaki et al. (16) stated in his study that PSE was done 36 times in 33 patients, 13 men and 20 women, mean age 58.8 years, median age 59 years.

In this study, vaccinations against pneumococcus, Haemophilus influenza, and Neisseria meningitides are not taken. This is in agreement with **Elfeki et al. (17)** who reported that vaccination against encapsulated bacteria is not routinely provided, because unlike splenectomy, the immune activity of the spleen continues through the remaining functioning splenic parenchyma after embolization.

In this study, the 1ry and 2ry endpoints were achieved when a platelet count increased **>130×10^9/L** and the initiation of SC occurred, respectively. This is in agreement with **Bhatia et al. (7)** who found in his study that a platelet count **>130 ×10^9/L** is a safe value for administration of the proposed oncological regimens.

In this study, the 1ry and 2ry endpoints were achieved in 24 (100%) of 24 patients. The mean platelet count significantly increased post- PSE ($P<0.05$) and peaked at 273.58±77.30×10^9/L (range, 132–380 ×10^9/L) 10 days post PSE.

Luz et al. (3) reported in his study that 94% achieved their 1ry endpoints. The percentages of patients reaching the 1ry endpoints were 39%, 86%, 63%, and 46% in weeks 1, 2, 3, and 4, respectively. Mean platelet counts at weeks 1, 2, 3, and 4 post-PSE were 141×10^9/L, 188 ×10^9/L, 154×10^9/L and 122 ×10^9/L, respectively. 31 of 33 patients could reinitiate SC, and the median time to return to treatment was 14 days (mean 17.7 days). Platelets count new decline, started at the 3rd week, that was coincide with the return of patients to SC treatment.

Loffroy et al. (8) found that the most frequent method used to describe PSE success, was the achievement of a significant platelet count increase, choosing a platelet count of 150 K/UL as a sufficient value above the minimum values used in clinical practice for the safe SC administration.

In this study, the percentage of splenic necrosis was estimated by angiography, mean post-PSE splenic infarction percentage was 58.33 ± 8.16 % (range 50–70%)**.**

Kis et al. (12) reported in his study that post embolization angiography was used to monitor the percentage of splenic parenchymal occlusion with a mean of 65% occlusion (range, 25–80%) was achieved.

DuBois et al. (18) stated that PSE is a safe procedure, however acute pancreatitis, left subphrenic abscess, reactional pleural effusion, splenic rupture, pneumonia and splenic or portal veins thrombosis have been reported in their studies. The incidence of severe complications depends on the percentage of splenic infarction, if the infarctus is > 70% of the splenic volume, severe complications develop in 50% of

cases, and if the infarctus is 50-70% , severe complications develop in 8.8% of cases. These results were similar to those mentioned by **Ozturk et al. (19)** and **Heianna et al. (20).**

In this study, the mean hospital stay was 4.16 ± 1.68 days (range 2–7 days).

Helaly et al. (21) mentioned that 100% of patients were kept overnight for symptomatic treatment, this is not convenient with studies done by **Ahuja et al. (22)** who stated that PSE was an outpatient procedure in 60% of cases.

In this study, 16 (66.7%) patients had moderate post-embolization syndrome [low to moderate abdominal pain in 8 patients (33.3%), low-grade fever in 6 patients (25%) and nausea in 6 patients (25%)]. No puncture site hematomas, or major complications or severe post-embolization syndrome occurred. No one-month mortality rate (related to the procedure) among the 24 patients.

Kim et al. (23) reported that PES including nausea, low-grade fever and abdominal pain, occurred in 62.5% of patients and is considered a common complication after embolization of any solid organ.

Our study had some limitations: small number of patients, short follow-up time, no control group aiming for a smaller splenic infarcted volume to determine the best embolization percentage.

CONCLUSION

PSE is secure and efficient in handling hypersplenism-related thrombocytopenia in oncological patients. It achieves a 50–70% splenic infarction percentage. It allows sufficient platelet count increase facilitating the initiation or continuation of SC with minimal procedure-related morbidity.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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