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The Role of Angiography and Embolization in Blunt Splenic Trauma

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Rezumat

Rolul angiografiei și embolizării în traumatismele contuzive splenice

Splina este unul dintre cele mai vulnerabile organe în cadrul traumatismelor abdominale. Prezervarea splinei şi, bineînțeles, a funcțiilor sale a reprezentat o continuă provocare nu numai a chirurgilor familiarizați cu trauma, dar şi a tuturor celor pentru care integritatea acestui organ a reprezentat un obiectiv bine întemeiat. Astfel tratamentul nonoperator (TNO) al leziunilor traumatice ale splinei a cunoscut o continuă dezvoltare, devenind treptat opțiunea de primă intenție în unitățile medicale de profil. Odată cu dezvoltarea mijloacelor tehnologice moderne a devenit posibilă atât urmărirea documentată a evoluției leziunilor contuzive splenice, cât şi abordarea terapeutică miniminvazivă. Dintre acestea angiografia şi embolizarea consecutivă câştigă tot mai mult teren dată fiind experiența în continuă creştere şi rezultatele convingătoare raportate constant în ultimii ani.

Cuvinte cheie: traumatism splenic, tratament nonoperator, embolizare splenică, angiografie

Abstract

The spleen is one of the most vulnerable organs in the event of an abdominal trauma. Preservation of the spleen and of course its functions has been a continuing challenge familiar not only for trauma surgeons but also for all those for whom the integrity of this organ was a well-founded goal. Therefore nonoperative management (NOM) of spleen trauma injury has faced a continuous development, gradually becoming an option of healing by first intention among Trauma Centers. Through the development of modern technology it has become possible to keep observation documents on the evolution of blunt splenic injuries and, also, minimally invasive therapeutic approach has become possible. Out of these approaches angiography and consecutive embolization are gaining more and more ground considering the increasing experience and the convincing results that have been constantly reported in the last few years.

Key worlds: splenic trauma, nonoperative management, angiography, splenic embolization

Introduction

In 1919 Morris and Bullock highlighted the importance of spleen resistance to infection. The authors performed an experiment on splenectomized rats injected with a microbial strain that causes plague and found an increased mortality. "Probably ... the human body which lacks the spleen seems to show an increased susceptibility to infections and some progress towards a fatal evolution ... assigned to infection ... maybe due to splenectomy (1). In 1929 - O'Donnell reports a

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case of "acute" poisoning, fatal to a 6-year-old boy appeared 2 years after splenectomy (performed for haemolytic anemia); the patient's father also died of hyperseptic pneumonia occurred after a previously performed splenectomy (2). Pearl and Marmorston in 1935 discuss the role of the spleen in resistance to infection and King and Shumacker in 1952 report 5 cases of splenectomised children for congenital spherocytosis, who developed severe infection with 2 deaths; authors establish a direct link between severe sepsis and splenectomy in children (3). Smith performed the first study on the emergence of OPSI (Overwhelming Post Splenectomy Infection) after splenectomy for trauma in 1957 (4).

According to Redman's opinion, angiography was used for the first time in abdominal contusions in 1957 by Malchiodoni for the evaluation of a renal trauma. The author reports 8 cases of trauma patients with splenic contusions that were diagnosed by angiography and concludes that angiography is important in trauma patients which have unclear visceral lesion extension and to avoid a nontherapeutic laparotomy (5). In 1975 Chuang and Reuter conducted an experimental study on animals (dogs) that after the occurrence of a splenic injury bleeding was controlled by injecting an embolic material into the splenic artery. The angiography performed before animal slaughter showed that the arteries that irrigate the secondary splenic infarction area were permeable; the traumatic splenic area could not be identified anymore. Histological examination of the injured area showed a healing wound and resolution of the infarcted area. The authors concluded that selective splenic embolization is an efficient method to control bleeding in a posttraumatic spleen which can be used in patients who are not candidates for splenectomy (6).

Angiographic treatment in trauma started with the embolization with Gelfonam (Katzen 1976) and temporary vascular occlusion with a balloon (Wholey 1977), performed to stop the bleeding prior to splenectomy (7). In 1981 Sclafani describes the usefulness of arteriography in trauma. Also, Sclafani in 1995 introduces the concept of proximal splenic embolization in splenic trauma by blunt mechanism. In patients with splenic trauma and active bleeding at angiography examination the author practiced proximal splenic embolization with 97% success (8). Currently, it is believed that angiography (diagnostic and therapeutic) is part of the NOM (nonoperative management) of splenic trauma (9,10). Angiographic procedures are both diagnostic and therapeutic, the last being performed with the intention of vascular embolization and to stop the bleeding. Digital subtraction angiography allows rapid and accurate diagnosis, representing the standard in trauma (11); the method leads to a reduced time required for examination, decreased use of CM (Contrast medium) and irradiation dose. SAE (splenic angioembolization) increased NOM success by stopping bleeding and preventing a delayed rupture of the spleen (11). The procedure is used in hemodynamically stable / slightly stabilizedpatients under careful surgical supervision and with the possibility of performing surgery at any time. A particular advantage of angiography is the possibility of concomitant treatment of other vascular lesions (including implantation of prostheses). It is to be understood from the beginning that AE (Angioembolization) is a procedure that requires time and increased volume of contrast medium. Selectively implementing SAE as nonoperative management for splenic trauma cases in patients at risk decreased the failure of this method to values of 2-4% (8,12). Currently, the use of SAE resulted in a decreased number of splenic operations (11), the frequency of emergency interventions performed having decreased from 33.3% to 11.9% after the introduction of this method (13). However, only 5-7% of the patients with splenic contusions require angioembolization (14). The disadvantages of the method are: difficult monitoring and resuscitation (in the angiography lab.) the need for an interventional radiologist, time-consuming procedure (bearing the risk of a possible hemodynamic decompensation of the patient), the possible need of a high volume of contrast medium.

Indications for splenic angiography *(15,16,17,18):*

- grade 3, 4, 5 splenic injuries;
- vascular lesions visible on initial CT scan regardless of the degree of splenic injury;
- active bleeding upon CT scan or contrast blush in a hemodinamically stable patient (upon repeated CT scans);
- unexplained decrease of hematocrit level when no other lesions are present;
- large haemoperitoneum.

Vascular lesions

Vascular lesions revealed by this method are represented by: (19,20,21,22)

- extra- or intrasplenic contrast medium extravasation (increased risk of failure of SAE) (23);
- vascular lesions of terminal arteries: superior, inferior, superior and inferior or middle artery (complete vascular section);
- vascular occlusion; thrombotic caused. The vascular lesion may be represented by section, spasm, intimal damage. Post traumatic coagulopathy may prevent the formation of a new thrombus after the previous resorption, so the occurrence of a secondary hemorrhage is possible;
- intraparenchymalarterio-venous fistula;
- intrasplenicpseudoaneuvrysm;
- vascular branche movement secondary to subcapsular hematoma;
- variable degree of lack of vascularity and irregularities in the accumulation of the contrast medium (including Seurat spleen = an angiographic appearance seen following blunt trauma to the spleen; multiple small punctate regions of intraparenchymal contrast extravasation lead to a spotted appearance).

Only 5-7% of patients with blunt splenic injuries present angiographic contrast medium extravasation. Clinically, SAE should be performed as early as the finding of contrast

medium extravasation (seen in abdominal CT examination) and before the onset of hemodynamic deterioration (17). According to Schurr and Bhullar the presence of "contrast blush" increases 22 to 24 times the risk of TNO failure (24,25).

SAE can be performed:

- *in emergency* ("acute"); In hemodynamically stable patients with an active bleeding lesion or severe lesion degree (III-V);
- *delayed* ("subacute"); Indications are represented by lower Hb values during NOM or finding a pseudo-aneurysmprogression (> 1.5 cm) or the occurrence of a new "contrast blush" in repeated CT examination.

In conclusion, SAE indications are (11):

- *absolute*
  - grade IV-V injury, regardless of other findings;
  - perisplenic extravasation of contrast medium;
- *relative*
  - grade I-III injury in the presence of "contrast blush" in tomography;
  - intrasplenic vascular injury (pseudoaneurysm, arterio-venous fistula);
  - large haemoperitoneum;
  - decrease in hemoglobin values during hospitalization.

But contradictions still remain on SAE indication in blunt splenic trauma; Fu considers that early surgical intervention should be considered in blunt splenic injured patients with intraperitoneal contrast extravasation and ISS (injury severity score) ≥ 25 (26). A "therapeutic alliance" between the trauma surgeon and the interventional radiologist allows optimal standard of care for patients requiring AE, and its incorporation into the trauma team is a necessity (21).

Angioembolization - technical variants:

Currently, various materials have been used for splenic embolization, such as metallic coils, fragments of hemostatic agents ("Gelfoam pledgets", TachoSil®) with a diameter of more than 1,000 μm, which injected through the catheter occlude the vessel achieving hemostasis (special MRI - compatible coils were created which would allow further MRI examinations) or microspheres. The main advantage of these hemostatic agents is that after a few weeks, they are reabsorbed through the action of macrophages, thus achieving repermeabilization of the blood vessel (27). However, due to this exact characteristic, some authors (10,23,27,28) actually contra-indicate these hemostatic agents (increased rate of re-bleeding). Similarly, Smith (10) reported excellent results with the use of metal coils. Haan (23) reported an increased frequency of splenic infarction after using Gelfoam.

Splenic angioembolization can be performed:

- proximal;
- distal;
- combined;
- repeated ("second-look" angiography).

Proximal angioembolization (the trunk of the splenic artery, distal to the dorsal pancreatic artery) is performed with metal coils or absorbable hemostatic materials (Gelfoam-Pharmacia, Kalamazoo, MI; TachoSil®) and achieves hemostasis by decreasing arterial blood flow and intra-splenic pressure, which promotes clot formation and wound healing. The spleen viability is ensured by collateral circulation (branches of the left gastric artery, gastro-epiploic arteries, omental, pancreatic, short gastric arteries) as shown by experimental animal studies (22). In human studies, it was found that there was a decline of intrasplenic pressure by 47-58% (Bessoud cit. 29). Sclafani (8) believes that this procedure is compatible with the maintenance of splenic immune function and even if surgery is necessary, splenorrhaphy is facilitated. Proximal SAE is faster, easier to perform and is associated with a lower NOM-related failure rate and a reduced incidence of post-procedural complications (splenic infarction, abscess). According to Van der Vlies (11) the only drawback of proximal SAE is that, in the event of a possible re-bleeding, supraselective embolization is difficult / impossible to perform.

Distal angioembolization (supraselective) - is achieved by isolating the damaged vessel, maintaining normal blood flow to an important splenic area, but it requires an increased time for conducting it and excellent technical skills (30).

Combined angioembolization (proximal + distal).

Repeated angioembolization ("second-look "angiography) is indicated after an initial negative angiography (10%) (31).

Proximal SAE indications:

- hilar lesions;
- >3 separate peripheral vascular lesions;
- an injury affecting > 50% of spleen;
- an arterio-venous fistula, pseudoaneurysm;
- a vascular injury with angiographic appearance of amputation (suggestive lesion associating vascular spasm);
- a technical impossibility of performing distal SAE.

Selective SAE indications:

- limited splenic vascular lesions; benefits: ensures hemostasis and normal perfusion of the remaining organ.

Combined SAE indications:

- multiple vascular lesions (severe injury degrees)
- intraperitoneal extravasation,
- splenicpseudoaneurysm (PSA).

PSA embolization must avoid distal bleeding ("back-door bleeding") secondary to collateral blood flow; vessel occlusion proximal and distal to the lesion is indicated (21,32). After SAE, repeated CT (post procedure) focuses on finding: persistent vascular injury, pseudoaneurysm formation, infarcted area size, evidence of local infection (splenic abscess). Hagiwara (22) recommends a repeated CT scan (in patients with SAE)

between days 10 and 15 post-SAE in order to assess perfusion and splenic blood flow through collateral circulation. The splenic reticuloendothelial function was investigated by scintigraphy with colloid sulphur Tc-99m having been performed between days 10 and 15 as well.

Angioembolization complications:

Were classified into major (can cause death/severe disability) and minor.

- Major (19% -28.5%);
  - Bleeding;

It is the most common complication; causes: late diagnosis of pseudoaneurysm and/or pseudoaneurysm late formation; has a frequency between 2.7% - 9% (33). Recurrent bleeding may occur in 11% of cases. According to Haan (23), patients with active splenic intraperitoneal bleeding detected by CT have an increased risk regarding angioembolization failure.

- Omitted injuries; - usually diaphragmatic, pancreatic;
- Infection; splenic abscess (4 to 4.3%), sepsis.

Sepsis was defined as the presence of clinical SIRS criteria associated with positive cultures (bronchoalveolar lavage, blood cultures, urine culture, intra-abdominal abscess). Delayed splenic abscesses occur most frequently at 6 weeks after AE. The germs involved were Clostridium perfringens α-hemolytic streptococci. Therapeutic CT-guided drainage or splenectomy are indicated. Very rarely intravenous antibiotic therapy is useful. Johnson (34) describes the development of a persiplenic abscess 4 months after embolization explained by infection of a perisplenic hematoma where the cultures revealed Streptococcus intermedius.

- Total splenic infarction;
- Splenic atrophy;
- Acute pancreatitis.

Splenic abscess and acute pancreatitis (with sterile collections) were observed more frequently after the embolization with Gelfoam ® and especially after proximal embolization (36). Acute necrotizing caudal pancreatitis is a specific complication of proximal SAE. Paul and Opalek (35) showed 2 cases where splenectomy and distal pancreatectomy were necessary; exploratory laparotomy was performed based on symptoms and clinical signs (fever syndrome, signs of peritoneal irritation). Previously, Hamers (36) reported a treated nonoperative case. Authors' explanation is that the pancreas vascularization is provided by branches of the splenic artery, essential dorsal pancreatic artery and great pancreatic artery (pancreatic magna artery) that anastomoses with the transverse pancreatic artery for the distal pancreas. For this reason embolization will be made distal to the origin of the dorsal pancreatic artery. Ischemic lesions secondary to reperfusion represent an important mechanism in the pathogenesis of acute pancreatitis, and in particular in the progression from simple, mild, edematous forms to severe, necrotic forms (Sakorafas cit. 36).

- Iatrogenic arterial injury (1-3%) more common in children (small calibre artery) and the elderly (atherosclerosis);
- Nephropathy after administration of contrast medium;
- It is considered that in trauma patients there is a risk in this regard, given the amount of administered contrast medium;
- Deep vein thrombosis.

- Minor (23% - 61.9 %)
  - Splenic infarction: 27% after distal SAE; 20% after proximal SAE.

Most of them are asymptomatic but it is believed that a splenic infarction is significant when a devascularisation of $>25\%$ of splenic parenchyma occurs (upon repeated CT scans); classical tomographic image is represented by a wedge splenic area not loaded with dye. Occurs in all patients within 3 months (CT or ultrasound examination) and is not evidenced at the 6 months control (17).

- Migration of embolic material: a spiral that migrates in proximal SAE needs extraction; true incidence of this complication is not known;
- Angiographic vascular dissection: it is usually asymptomatic and non-occlusive (femoral artery, splenic artery);
- Vascular damage when inserting the catheter (arterio-venous fistula); ilio-femoral pseudoaneurysm (37);
- Persistent pain at the catheter insertion site;
- Hematoma of the puncture site;
- Fever (38);
- Prolonged ileus (39);
- Pleuro-pulmonary complications (particularly pleural effusions);
- ARDS (Acute Respiratory Distress Syndrome - 40);
- Thrombocytosis;
- Allergic reaction to contrast material (Bauer - 21);
- Left upper quadrant pain.

Conclusions

- NOM is "the best way for liver and spleen contusive injuries in hemodynamically stable children and adults regardless of the lesion degree."
- NOM failure increases with lesion grade while SAE failure does not vary significantly with it.
- SAE is effective on severe splenic lesions (grade IV-V).
- Severe splenic injuries require surgical treatment or routine angiography (41,42).
- Embolization maintains immunological function of the spleen (21).
- The splenic immune function after SAE depends of the actual technique, blood vessel size and long-term development of collateral circulation.
- However, current studies do not consider vaccination necessary after performing SAE for splenic trauma (43,44).
- The presence of "contrast blush" is not an absolute surgical / angiographic indication (45,46).
- Hypotension as a single parameter is not a prognostic factor for the failure of TNO (47).
- Post angioembolization pain without imagistic correla-

tion doesn't impose splenectomy (classically it is resolved with Acetaminophen).

- Choosing the material for angioembolization is dictated by two considerations: vessel calibre to be occluded and whether this will be permanent or temporary. (21) (At Bucharest Emergency Hospital Gelfoam and TachoSil are used).
- "Second-look" angiography – repeating angiography in case of failure in stopping the bleeding represents a good option (48).
- NOM and angioembolization is also possible in the case of pathological spleen trauma (49).

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