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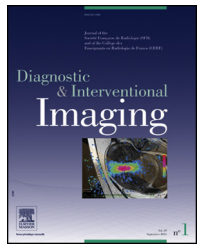

ORIGINAL ARTICLE / *Cardiovascular imaging*

Blunt splenic injury: Outcomes of proximal versus distal and combined splenic artery embolization

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Abstract
Purpose: To assess clinical outcomes of blunt splenic injuries (BSI) managed with proximal versus distal versus combined splenic artery embolization (SAE).
Materials and methods: All consecutive patients with BSI admitted to our trauma centre from 2005 to 2010 and managed with SAE were reviewed. Outcomes were compared between proximal (P), distal (D) or combined (C) embolization. We focused on embolization failure (splenectomy), every adverse events occurring during follow up and material used for embolization.
Results: Fifty patients were reviewed (P $n=18$, 36%; D $n=22$, 44%; C $n=8$, 16%). Mean injury severity score was 20. The technical success rate was 98%. Four patients required splenectomy (P $n=1$, D $n=3$, C $n=0$). Clinical success rate for haemostasis was 92% (4 re-bleeds: P $n=2$, D $n=2$, C $n=0$). Outcomes were not statistically different between the materials used. Adverse events occurred in 65% of the patients during follow up. Four percent of the patients developed major complications and 56% developed minor complications attributable to embolization. There was no significant difference between the 3 groups.
Conclusion: SAE had an excellent success rate with adverse events occurring in 65% of the patients and no significant differences found between the embolization techniques used. Proximal preventive embolization appears to protect in high-grade traumatic injuries.

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The management of hemodynamically stable splenic injuries is currently mostly medical, involving non-operative management with or without splenic artery embolization [1—10]. Debate remains about the embolization techniques and their complications. The splenic artery may be embolized in trauma, proximally or distally, and for either preventative or curative purposes. Embolization is said to be curative when it is used to treat active bleeding and preventative when it is carried out for high-grade traumatic injuries with no signs of bleeding on CT to reduce the risk of secondary bleeding. Proximal embolization is defined by introduction of the embolization material into the splenic artery trunk and distal embolization by embolizing a segmental branch in the intra-parenchymal portion of the organ. Combined embolization is defined by the combination of both techniques [11]. In active haemorrhage, some groups use both embolization techniques, choosing to prefer proximal embolization for high-grade trauma with diffuse splenic bleeding and distal embolization for isolated focal bleeds [7,9,12—16]. Others only use one embolization technique, either proximal [17] or distal [6,8,10] regardless of the splenic injury. Proximal embolization is preferred in high-grade trauma without any focal arterial abnormalities [2,11,12,17,18].

The description and prevalence of complications from embolization of the splenic artery varies between series from 23% [7] to 62% [15]. The type of complications and their severity are often defined arbitrarily [2,7,9,14,15,19—22].

The primary aim of this retrospective study is to assess the efficacy of embolization in the management of splenic injuries, comparing the different embolization technique and materials used. The secondary aim is to provide a detailed description of all of the short and medium term adverse events which occurred.

Materials and methods

Population

This was a single centre, retrospective, observational study recording all consecutive patients with splenic injury treated by embolization between 2005 and 2010 in our University Hospital. The patients were divided into three groups, depending on the embolization technique used: proximal embolization (P), distal embolization (D) and combined embolization (C).

Management algorithm

If the patient was stable, he/she was referred to the radiology department for whole body CT (Brillance 64 or Brillance 40, Philips Medical Systems, Eindhoven, The Netherlands or Sensation 16, Siemens AG, Medical solutions, Erlangen, Germany) with chest, abdominal and pelvic images in the arterial and venous phases. Embolization treatment was reserved for patients with:

- grade 4-5 splenic injury of the American Association for the Surgery of Trauma (AAST) classification (grade 1: hematoma < 10% or laceration < 1 cm, grade 2: hematoma 10—50% or laceration 1—3 cm, grade 3: hematoma > 50% or laceration > 3 cm with de-vascularization < 25%, grade 4: major laceration with de-vascularization > 25%, grade 5: comminutive fracture or complete de-vascularisation [23]);
- a vascular injury (leak/blush, pseudo-aneurism, arteriovenous fistula) regardless of grade;
- a grade 3 injury associated with a large hemoperitoneum (injury involving the peri-splenic space, Morrison's space, the two parieto-colonic gutters and the pelvis) or patients with pre-existing weaknesses.

Hemodynamic instability was an exclusion criterion for embolization treatment.

Embolization techniques

Arteriography was performed in an interventional radiology suite (Allura Integris, Philips Medical Systems, Eindhoven, The Netherlands).

The interventional radiology team was made up of 5 radiologists with 3 to 20 years' experience.

The most common approach was through the right femoral artery. Diagnostic arteriography of the coeliac axis and splenic artery was performed using a 4 or 5 French catheter and possibly a 3 French micro-catheter.

Depending on the splenic artery, three embolization techniques were available, the choice of which was left to the discretion of the interventional radiologist:

- proximal embolization: the embolization materials were positioned as a compact unit in the trunk of the splenic artery, proximal to its dividing branches but distal to the dorsal pancreatic artery. These were either 0.035 inch coils or Amplatzer plugs (St Jude Medical, St. Paul, MN, USA) when the anatomy was favourable. Proximal embolization was used in preference for high-grade injuries without vascular abnormalities, in which case the embolization was preventative. The same technique was used when multiple inaccessible or excessive numbers of vascular abnormalities were present. Technically successful embolization was defined as complete obstruction of the artery treated at the point of the ''packing'' with distal flow provided from collaterals (Fig. 1);
- distal embolization: the embolization materials were positioned in the segmental branches of the splenic artery, within the parenchyma. 0.018 inch micro-coils, resorbable gelatine material or surgical glue was used. The ischemia-producing embolization [24] was intended to cover a limited vascular territory and was selected for patients with an isolated vascular abnormality. Technical success was defined as complete obstruction of the distal arterial branch without returned collateral supply (Fig. 2);
- combined embolization: this technique combines proximal with distal embolization and was reserved for vascular lesions combining AAST high-trade trauma (grade 4 and 5) or a large hemoperitoneum.

Data collection

All imaging investigations were archived in a PACS and were reviewed. Medical details were recorded from the electronic patient medical records by one of the authors who independently reviewed all of the medical and imaging records

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