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Contrast-enhanced imaging features and differentiation of benign and malignant focal splenic lesions

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ABSTRACT

To assess the value of imaging features for differentiating malignant from benign focal splenic lesions, 79 pathologically proved cases with contrast-enhanced CT or MRI were retrospectively studied. The morphological characteristics were assessed and the enhancement patterns were classified into five categories. After multivariate logistic analysis, the lesion margin and enhancement patterns were significantly different between benign and malignant lesions. The combination of ill-defined margin and hypovascular enhancement for suggesting malignant lesions had a good specificity (94.9%) and accuracy (89.9%). Morphological and enhancement characteristics on CT/MRI may be valuable in differentiating malignant from benign focal splenic lesions.

1. Introduction

The conspicuity of atraumatic splenic lesions has been increased with the development in imaging technology, however, it is still difficult to differentiate malignant from benign focal splenic lesions. The incidence of focal lesions within spleen is low, and most of them are incidental findings on abdominal imaging examinations for unrelated diseases, which lead to the non-specificity of clinical symptoms. Besides, the classical imaging features of some diseases are often absent in splenic lesions. For example, the typical nodular enhancement with centripetal filling of hepatic hemangiomas is uncommon in splenic hemangiomas [1–3]. Therefore, splenic biopsy or splenectomy is often considered for the histopathological confirmation of a splenic mass, especially in those with extrasplenic malignancies. However, invasive procedure of the spleen may have some severe complications such as bleeding, pneumothorax and even immune function impairment.

As a result, it is important to distinguish between malignant and benign splenic lesions noninvasively on imaging, and avoid unnecessary splenectomy in benign pathologies. Beyond case reports and description of single disease entity, there have been only a few studies about imaging differentiation of malignant and benign splenic lesions in the literature up to now [4–11], most of which were ultrasound studies [4–8]. Although CT and MRI were major imaging modalities in abdomen, studies on them were rare, and no recognized consensus criteria were reached.

In this study, we investigated and compared the contrast-enhanced CT and/or MRI findings of focal splenic lesions. Our purpose was to extract the imaging features valuable for differentiating malignant from benign focal splenic lesions.

2. Materials and methods

2.1. Study population

The reporting databases for CT and MRI examinations of two large general hospitals between July 2011 and June 2016 were reviewed and searched for reports that mentioned splenic focal lesions or masses. Only patients who had a histopathological examination (biopsy or partial/total splenectomy) of the splenic lesions within 3 months after enhanced CT/MR scan were included in the study. Simple cystic lesions that had a homogeneous CT value of 0-20HU or isointense to cerebrospinal fluid on MRI without septa/thickened walls were excluded, since these lesions were almost all benign revealed in previous literature [10,12].

2.2. Image examination

CT imaging was performed using a SOMATOM Definition AS 40 helical scanner or a SOMATOM Sensation 16 helical scanner (Siemens Healthcare, Erlangen, Germany). The scanning range was from the right diaphragmatic dome to the inferior pole of kidneys. The scanning parameters were as follows: 120 kV, 180–210 mAs, 300–400 mm field

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of view (FOV), and 5-mm slice thickness reconstruction. The arterial-phase and portal-phase images were obtained 25–30 s and 60–70 s after the intravenous bolus (3 ml/s) administration of 1.0 ml/kg of an iodinated nonionic contrast agent, iopromide (Ultravist, 370 mgI/ml; Bayer Schering, Berlin, Germany). Some patients also had a 120–150 s equilibrium-phase scan.

MRI was performed on a GE Discovery MR750 3.0 T MR scanner (GE Healthcare, Little Chalfont, UK) or a Siemens Magnetom Avanto 1.5 T MR scanner (Siemens Healthcare, Erlangen, Germany). The scan parameters of 3.0 T MRI were as follows: 1) T2-weighted fast spin echo (FSE) sequence: respiratory-triggered; repetition time (TR), 2 respiratory cycles; echo time (TE), 91 ms; flip angle (FA), 110°; slice thickness, 5.0 mm; FOV 320–400 mm. 2) T1-weighted FSE sequence: TR/TE, 255/3.6 ms; FA, 80°; slice thickness, 5.0 mm; FOV, 320–400 mm. 3) contrast-enhanced liver acquisition with 3D volume acceleration (LAVA) sequence: TR/TE, 4.2/1.9 ms; FA, 12°; slice thickness, 3.0 mm; FOV, 320–400 mm. The scan parameters of 1.5 T MRI: 1) T2-weighted FSE sequence: TR, 1 respiratory cycle; TE, 87 ms; FA, 132°; slice thickness, 6.0 mm; FOV, 320–400 mm. 2) T1-weighted in- and opposed-phase sequence: TR/TE 160/2.2 ms(in-), 160/4.9 ms (opp-); FA, 70°; slice thickness, 6.0 mm; FOV 320–400 mm. 3) contrast-enhanced volumetric interpolated breath-hold examination (VIBE) sequence: TR/TE, 4.7/2.3 ms; FA, 10°; slice thickness, 3.0 mm; FOV, 320–400 mm. An intravenous dose of 0.1 mmol/kg of contrast agent (Gadolinium-diethylenetriamine pentaacetic acid, Gd-DTPA; Magnevist; Bayer Schering, Berlin, Germany) was administered, and the arterial-, portal-, equilibrium- (if one existed) phase images were obtained after 30 s, 60 s, 130 s after injection.

2.3. Image assessment

Two radiologists with > 5 years of experience in diagnostic imaging, who were blinded to the clinical information and pathological results, assessed CT and MRI images. CT images of all the patients were reviewed first, and MR images were evaluated a month later. For patients with multiple, similar coexisting focal lesions, image evaluation were focused on the largest lesion. If there were any inconsistencies, a consensus would be achieved through discussion by a group consisting of three observers (the above two observers and a third radiologist with 20 years of experience in abdominal imaging).

The enhancement patterns of lesions on dynamic enhanced imaging were classified as follows: 1) no enhancement; 2) cysts with septa/wall enhancement, but without enhancement of nodular or mass-like soft tissue; 3) hypovascular enhancement of solid part (mild enhancement, and hypo-density/signal intensity (SI) compared to the normal spleen throughout all phases of enhancement); 4) delayed hypervascular enhancement of solid part (hypo-density/SI compared to spleen in arterial-phase, with partial or entire iso-/hyper-enhancement in portal- and/or equilibrium-phase); 5) arterial hypervascular enhancement (partial/entire lesion showing iso-/hyper-enhancement in arterial-phase, with persistent enhancement or washout in portal-/equilibrium-phase).

Other imaging features of each case were recorded: number of lesions (single, multiple), size of the largest lesion (maximum diameter), margin (smooth and well-defined, rough and ill-defined; for a lesion with cystic portion, the inner surface of the cyst was also included into assessment), the presence of splenomegaly (maximum width, length, or thickness at the splenic hilum > 12 cm), calcification (only assessed on CT images), hemorrhage (only on MR images, except hemosiderin deposition spots) within lesion, perilesional splenic infarction, and perisplenic fluid. Some extrasplenic findings, such as intraperitoneal/retroperitoneal lymphadenopathy and lesions with similar imaging features in other abdominal organs, were also assessed. Lymphadenopathy was defined as a lymph node with the shortest diameter ≥ 1.0 cm and homogeneous or heterogeneous enhancement.

2.4. Statistical analysis

The statistical analysis was performed with SPSS 19.0 software (IBM Corp., Armonk, NY, USA). Inter-observer agreement was calculated by using the kappa coefficient. For qualitative comparisons between malignant and benign lesions, the χ^2 test or Fisher exact test was used. The Mann-Whitney test was used for continuous variables. Multivariate logistic regression analysis was performed on statistically significant imaging features in univariate analysis. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of significant variables were then calculated. A P value < 0.05 was considered statistically significant.

3. Results

A total of 79 patients were finally identified, including 35 males and 44 females, with a mean age of 50 years (range, 19–80 years). Seventy-seven cases had partial/total splenectomy, and the other two patients underwent ultrasound-guided biopsy. There were 59 benign cases (24 males and 35 females; mean age, 48 years; range, 19–80 years) and 20 malignant lesions (11 males and 9 females; mean age, 56 years; range, 40–80 years). The histopathological results of all the cases were listed in Table 1.

Among all the 79 patients, 70 cases received CT examinations (25 with triple-phase enhancement scanning and 45 with dual-phase enhancement scanning), and 24 cases received MRI (9 with triple-phase and 15 with dual-phase enhancement scanning). The mean delay between histopathological examination and CT/MR scan was 15 days (range, 2–64 days).

3.1. Imaging findings of malignant and benign focal splenic lesions

The comparison of imaging findings between malignant and benign focal splenic lesions were conducted, and the results were described in Table 2. The inter-observer agreement of all the imaging features was almost perfect (all the kappa coefficients > 0.8). In univariate analysis, there were significant differences in lesion margin, enhancement patterns, the presence of perilesional splenic infarction and splenomegaly between malignant and benign cases (P < 0.05). Compared with benign lesions, focal malignancies more frequently showed ill-defined margin, coexisting splenic infarction and splenomegaly (Fig.1). The most common enhancement pattern of malignancies was hypovascular

Table 1
Included cases with focal splenic lesions.

Histopathological diagnosis	No. of cases
Benign	
Hemangioma	16
Cyst	10
Hemolymphangioma	7
Lymphangioma	6
SANT	6
Littoral cell angioma	5
Granulomatous disease	4
Abscess	3
Hamartoma	2
Malignant	
Metastases	
Colorectal carcinoma	5
Ovarian carcinoma	2
Hepatocellular carcinoma	1
Renal clear cell carcinoma	1
Colon cancer direct invasion	1
Lymphoma	7
Angiosarcoma	1
Carcinosarcoma	1
IPT-like-FDCT	1
Total	79