Original Article
CT and MRI imaging characteristics of unexpected splenic autotransplantation after splenectomy

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Abstract: Objective: To discuss the imaging characteristics of splenosis for improving its diagnostic accuracy. Methods: Twelve patients with splenic autotransplantation were diagnosed by surgical pathology or needle biopsy. Patients underwent CT and MRI plan and enhanced scanning, 2 cases also underwent ⁹⁹mTc-DRBC scanning, and the imaging data were collected. Results: Multiple nodules were found in 8 cases and single nodule was found in 4 cases. The nodules were detected in splenic recess (10 cases), in tail of the pancreas (5 cases), in right liver (3 cases), and in other parts of abdominal cavity (3 cases). The size of nodules was different, and the maximum diameter of 94.57% of the nodules were less than 3 cm. The nodules were all homogeneous and soft without cystic change, calcification or necrosis. Slightly short T1 and short T2 signal were shown in tail of the pancreas in 1 case. Long T1 and long T2 signal were shown in the rest cases. In CT arterial phase, blood supply from abdominal aorta was shown in nodule of right liver in 1 case. The nodules were surrounded by thin layer of low density ring, which showed long T1 and long T2 signal. Homogeneous or inhomogeneous enhancement was shown in the arterial phase, continuous homogeneous enhancement was shown in portal venous phase, and the decline degree of enhancement was significant in delayed phase. The findings of ⁹⁹mTc-DRBC scanning were obviously strong radioactive concentrations in nodules. Conclusion: Multiple nodules were found in abdominal cavity with homogeneous density or signal and clear boundary. The enhanced features were consistent with spleen. The possibility of splenosis should be considered by the history of splenic trauma or splenectomy.

Keywords: Splenosis, CT, MRI, ⁹⁹mTc-DRBC, splenic trauma

Introduction

Splenosis is an autotransplantation of spleen, which is caused by splenic trauma or splenectomy [1]. The spleen tissue usually implants in the abdominal cavity or outside the abdominal cavity, and establishes blood supply for its development. Ectopic growth of spleen tissue debris form space-occupying lesions, so splenosis is also called ectopic spleen planting [2, 3]. Ectopic spleen can be divided into congenital accessory spleen and acquired splenosis [3]. Splenosis has essential difference from accessory spleen and surgery autologous splenic planting [4].

Splenosis secondary to splenic trauma is common, and the incidence rate is 26-67% [1, 5, 6]. The shortest interval time of spleen planting after trauma is 5 months, and the longest interval time is 32 years (average time 10 years) [3]. When the tissue of spleen implantation and organ are closely related, it is easy to misdiagnose as tumors and result in clinical misdiagnosis [7]. On ⁹⁹mTc-DRBC scanning, multiple radioactive lesions can be seen in abdominal cavity, and the locations of multiple masses are consistent with CT results. The theory [8] is that heat-denatured red blood cells (RBC) are first captured by spleen, then are the liver and marrow. The red blood cells are damaged in spleen, and heme in red blood cells are digested and metabolized. Hence, radioactive concentration of the spleen is 2-4 times higher than liver. ⁹⁹mTc-DRBC has a higher sensitivity and specificity for the diagnosis of splenosis [9].

In this study, twelve patients with splenic autotransplantation were diagnosed by surgical pathology or needle biopsy, and the imaging
data were collected for improving its diagnostic accuracy and avoid unnecessary surgeries.

**Materials and methods**

**General information**

From April 2008 to May 2016, information of 12 patients confirmed by surgical pathology or needle biopsy were collected. There were 8 males and 4 females aged 18 to 69 years (median age of 43.7). There were no symptoms in 8 patients, who were detected by abdominal ultrasound or CT reexamination. The other 4 patients were detected by abdominal CT because of jaundice, hematuria, haematemesis and black stool. Six patients underwent splenectomy because of traumatic spleen rupture, and the other six because of cirrhosis and portal hypertension. The splenectomy time was 5 months to 7 years with an average time of 3.5 years. Six patients were confirmed by surgical pathology and the other six were by needle biopsy.

**CT and MRI examinations**

Eight patients underwent CT and MRI plain scanning and dynamic enhanced scanning. In addition, two of them underwent \(^{99m}\)Tc-DRBC scanning, which had higher sensitivity and specificity for diagnosis of splenosis [8, 10]. Four patients only underwent CT plain scanning and dynamic enhanced scanning. 16-slice spiral CT (SIEMENS, Sensation) was used in 5 cases, and 256-slice spiral CT (Philips iCT) was used in 7 cases. Tube voltage was 120 kV, tube current was 220-250 mAs, and the layer thickness was 5 mm. Non-ionic contrast agent (iohexol) was used in CT examinations. The injection dose was 80-100 ml with injection rate of 2.5-3.0 ml/s. Arterial phase, portal venous phase and delayed phase scanning were conducted at 25-30 s, 60 s, 180 s after drug injection, respectively. Siemens 1.0T Harmony MRI scanner was used in 5 cases, and GE SignaHDxt 1.5T double gradient magnetic resonance scanner was used in 3 cases. T1WI and T2WI axial scanning were used, and the three-phase dynamic enhanced scanning of MRI was consistent with CT. The contrast agent was Gd-DTPA in MRI examination. The injection dose was 0.2 mmol/kg with injection.
rate of 2.5 ml/s. Two patients underwent $^{99m}$Tc-DRBC examination.

**Results**

**CT and MRI characteristics**

Thirty-eight nodules were found in the 12 patients. Twenty-one of 38 nodules were found in the left inferior phrenic splenic recess in 10 cases. The nodules were found in tail of the pancreas in 5 cases, and there was only a nodule in each case. The nodules were found in right liver in 3 cases, and there was a nodule in right posterior lobe of liver and 5 nodules in the surface of right liver. The nodules were found in other parts of abdominal cavity in 3 cases, there were 2 nodules in kidney, a nodule in iliac fossa and 3 nodules in posterior peritoneum. Multiple nodules were found in 8 cases, and each case had 2-8 nodules. Single nodule was found in 4 cases, and the 4 patients underwent splenectomy because of liver cirrhosis and portal hypertension. The shape of nodules was round or oval with clear boundary (Figure 1). The size of nodules was different, and the maximum diameter was 0.5-3.6 cm, 94.57% of the nodules were less than 3 cm. The nodules were all homogeneous and soft without cystic change, calcification or necrosis. CT values were 32.3-52.8 HU. In MRI scanning, slightly short T1 and short T2 signal were shown in tail of the pancreas in 1 case (Figure 2). Long T1 and long T2 signal were shown in the rest cases. In arterial phase of enhanced CT scanning, most nodules were significantly homogeneous enhancement, and only 6 nodules were heterogeneous enhancement and showed plaque-like enhancement with CT values of 53.3-90.5 HU. Blood supply from abdominal aorta was shown in nodule of right posterior lobe of liver in 1 case. The nodule was surrounded by thin layer of low density ring, which showed long T1 and long T2 signal (Figure 3).
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Homogeneous enhancement was shown in portal venous phase with CT values of 92.2-115.6 HU, which were higher than arterial phase. The decline degree of enhancement was significant in delayed phase with CT values of 67.5-83.7 HU (Figure 4A-C). The enhanced features of MRI were similar to CT (Figure 5A-C).

**Radionuclide imaging**

Strong radioactive concentrations in nodules were detected in splenic recess, tail of the pancreas and the surface of right liver with clear boundary and homogeneous nuclides (Figure 6).

**Surgical pathology**

There were capsules in nodules. The sections of nodules were dark red or beige, and the nodules were soft and friable. Thick fibrous tissue capsules were covered on the edge of lesions, and there were no significant muscle tissue and elastic fibers. Organizational structure in nodules were similar to spleen, which was mainly consisted of red pulp with hemostasis. There was white pulp consisted of dense lymphocytes, too. Lymphatic sheath and splenic nodules were formed by parts dense lymphocytes around the small arteries. The structure of white pulp in part region was incomplete. So the structure of hilus of spleen was not seen.

**Discussion**

In 1910, Von Kuttner first proposed the concept of splenic implantation after splenic trauma. In 1912, Von StenbenRouc first proved the existence of traumatic heterotopic spleen by animal model. In animal experiment, free spleen tissue could be implanted and survive in any part of the abdominal cavity. Regenerated tissue didn't mean all cells, which only means undifferentiated reticular cells, and ischemic
necrosis would happen to other kind of cells. Once the scaffolds consisted of reticulocytes and fibrous tissues were formed, the cells would differentiate into endothelial sinus, capil-

Figure 5. The same patient of Figure 3. In MRI scanning, inhomogeneous enhancement was visible in the arterial phase (A), continuous homogeneous enhancement was visible in portal venous phase (B), and the decline degree of enhancement was significant in delayed phase (C).

Figure 6. The same patient of Figure 1. Radioactive concentrations were visible in tail of the pancreas, spleen fossa and the surface of right liver with clear boundary and homogeneous nuclides.
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laries, and lymphocytes, and finally form spleen tissues. These spleen tissues had the ability of phagocytosis of spleen.

Most patients with spleen planting do not have symptoms, and they are found by autopsy, abdominal surgery or imaging examination for other reasons [11]. There are few reports about the implanted spleen located in special area. If splenosis occurs in gastrointestinal tract, it will cause stomachache, intestinal obstruction and gastrointestinal bleeding [12, 13]. If splenosis occurs in female pelvic cavity, it will cause chronic pelvic pain, dysmenorrhea and deep sexual intercourse pain [14, 15]. When the tissue of spleen implantation and organ are closely related, it is easy to misdiagnose as tumors and result in clinical misdiagnosis [7]. Splenosis is a compensatory behavior when the body is free from spleen and another form of ectopic spleen. Arroja [12] et al. reported that spleen implanted nodules had compensation function and proliferative function. The common fatal complication after splenectomy was overwhelming infection, and the longest interval time was 40 years, which indicated that patients without spleen might have a lifetime risk of overwhelming infection [2, 16]. For patients with no symptoms, they were suggested not to receive treatment, which needed definite preoperative diagnosis and differentiate from benign and malignant tumors and accessory spleen.

The number of splenic implanted nodules can range from one to hundreds. Even only single nodule was found by imaging examination, there were a large number of dark red inflammatory nodules with a size of soybeans distributed in the peritoneum [17, 18]. It is common in splenic recess, and it also can be seen in the tail of pancreas and the right liver. Because the splenic implanted nodules do not have separated blood supply, so the diameter of 94.57% of the nodules is less than 3 cm [3]. On CT and MRI scanning, the density and signal were similar to normal spleen. The nodules were homogeneous and soft. Homogeneous or inhomogeneous enhancement was shown in the arterial phase, continuous homogeneous enhancement was shown in portal venous phase, and the decline degree of enhancement was significant in delayed phase. If the scanning time in arterial phase was appropriate, plaque-like enhancement could be seen, and the enhanced characteristics was the same as normal spleen, which were consistent with previous reports [2, 3, 6, 14, 17, 18].

Accessory splenosis usually single, and the situation of more than six is rare [19]. It has big size and locates in mesangium surrounding the spleen. The shape is oval with clear boundary. It has one hilus of spleen and thick capsule. Blood supply is supported by the splenic artery. Splenosis is usually multiple and small [20]. The diameter is usually less than 3 cm. It can locate in internal and external of the abdominal cavity, and the spleen tissue debris can distribute to anywhere. When the growing space is limited by surrounding structures, the shape can be variable. There is no hilus of spleen. It has fibrous capsule separated from adjacent organs. A number of blood vessels through thin pseudocapsule can be seen. The difference between accessory spleen and splenosis is that splenosis is almost associated with spleen trauma.

In conclusion, for patients who has splenic trauma or splenectomy, the possibility of splenosis should be considered once the homogeneous soft mass with similar density, signal and enhanced characteristics to spleen is found in abdominal cavity. It is important to know the history and imaging characteristics to avoid unnecessary surgeries. $^{99m}$Tc isotope scanning and percutaneous puncture of the mass will help to diagnose.

Disclosure of conflict of interest

None.

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