

An alternative imaging modality to scintigraphy in noninvasive diagnosis of splenosis in patients with post-traumatic splenectomy: Diffusion weighted imaging

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ÖZET

Posttravmatik splenektomi hastalarındaki splenozisin noninvaziv tanısında sintigrafiye alternatif bir görüntüleme yöntemi: Difüzyon ağırlıklı görüntüleme
Amaç: Bu çalışmadaki amacımız, posttravmatik splenozis tanısında difüzyon ağırlıklı görüntülemenin (DAG) rolünü değerlendirmektir.

Yöntem: Çalışmamızda, splenozis açısından şüpheli batın kitlesi bulunan 26 posttravmatik splenektomi olgusunun (19 erkek ve 7 kadın; ortalama yaş 29.4 yıl) DAG sekansı da içeren manyetik rezonans (MR) görüntüleme Bulguları geriye dönük olarak değerlendirildi. Onüç olgunun sintigrafik tetkiki de mevcuttu. Kontrol grubunda ise 30 kişinin (20 erkek ve 10 kadın; ortalama yaş 33.1 yıl) dalak ortalama apparent diffusion coefficient (ADC) değerleri hesaplandı. Düşük b değerindeki perfüzyon kontaminasyonunu engellemek için, 1000 s/mm²'lik b değeri kullanıldı.

Bulgular: Kiteller ve dalağın ortalama ADC değerleri sırasıyla, 0.790±0.087x10⁻³mm²/s ve 0.8075±0.084x10⁻³mm²/s olarak bulundu. Tüm kiteller, DAG'de hiperintens, ADC haritasında hipointens olarak izlendi. Kitellerin ortalama ADC değeri ile dalağın ortalama ADC değeri benzerlik gösterdi. Onüç olguda sintigrafi sonuçları splenozis yönünden pozitifti. DAG, medikal hikaye ve MR görüntüleme Bulgularına ek olarak splenozis tanısının koyulmasına katkı sağladı.

Sonuç: Ortalama ADC ölçümü, bilinen bir hastalığı olmayan şüpheli posttravmatik splenozis olgularının tanısında, sintigrafie alternatif bir görüntüleme modalitesi olabilir.

Anahtar Kelimeler: Görünen difüzyon katsayısı, Difüzyon ağırlıklı görüntüleme, Manyetik rezonans görüntüleme, Sintigrafi, Splenozis.

SUMMARY

Aim/background: To assess the role of diffusion weighted imaging (DWI) in diagnosis of post-traumatic splenosis.

Methods: We retrospectively evaluated 26 post-traumatic splenectomy patients (19 men and 7 women; mean age 29.4 years) with abdominal mass(es) suspicious for splenosis on magnetic resonance imaging (MRI) including DWI. The thirteen of these patients had scintigraphic imaging. The other thirteen patients had only MRI. In control group, 30 individuals (20 men and 10 women; mean age 33.1 years) were enrolled for investigating the mean ADC value of spleen. The b value of 1000 s/mm² was preferred due to perfusion contamination of low b values.

Results: The mean ADC value of masses and spleen were 0.790±0.087x10⁻³mm²/s and 0.8075±0.084x10⁻³mm²/s respectively. All of the masses appeared hyperintense on DWI and hypointense on ADC map, and the mean ADC value of masses were showed similarity with the mean ADC value of spleen. The thirteen patients showed positive Results for splenosis on scintigraphy. In addition to medical history and conventional MRI of the masses, DWI allowed the diagnosis of splenosis to be assigned in all patients.

Conclusion: Measurement of the mean ADC value in suspected post-traumatic splenosis patients otherwise healthy may be an indicator in the determination of splenosis as an alternative imaging modality to scintigraphy.

Key words: Apparent diffusion coefficient, Diffusion weighted imaging, Magnetic resonance imaging, Scintigraphy, Splenosis.

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Introduction

Splenosis is defined as heterotopic autotransplantation of splenic tissue (1). Traumatic rupture of the capsule of the spleen and splenectomy are the major causes of splenosis. It is usually asymptomatic and found incidentally on imaging studies. While treatment is unnecessary unless it has reached big in size and caused symptoms, it is important to distinguish splenosis from other benign or malignant masses. Ultrasonography, computed tomography (CT), magnetic resonance imaging (MRI) and scintigraphy may be used in noninvasive diagnosis of splenosis. In this study, we aimed to investigate the role of diffusion weighted imaging (DWI) with the mean apparent diffusion coefficient (ADC) value as an alternative imaging modality to scintigraphy in noninvasive diagnosis of post-traumatic splenosis in patients otherwise healthy.

Material and methods

Between May 2012 and December 2014, we retrospectively evaluated 26 post-traumatic splenectomy patients (19 men and 7 women; mean age 29.4 years; range 19-49 years) who had abdominal mass(es) suspicious for splenosis on control ultrasonography. The institutional ethics committee approved this retrospective study. Written informed consent was obtained from all patients. MRI including DWI with a 1.5 Tesla MR system (Avanto, Siemens, Erlangen, Germany) and scintigraphy were performed for diagnosis. For DWI, we used the breath hold single-shot fast-spin echo planar imaging (EPI) with parallel imaging sequence. No patient had a history of liver disease, malignancy or hematological disease in the group of suspected splenosis. Tc-99m sulfur colloid scintigraphy was performed in 13 patients (11 men and 2 women; mean age 26.5 years) of this group. MRI including DWI was the only diagnostic modality in the other 13 patients. In control group for measurement of ADC value on DWI, 30 patients (20 men and 10 women; mean age 33.1 years) underwent abdominal MRI for investigating urinary tract dilatation due to calculus (17), hypertrophied column of Bertin (4), and cholelithiasis (9) were enrolled for measurement of the mean ADC value of normal spleen.

The images were independently analyzed by two radiologists (9 and 13 years experienced in abdominal radiology) who performed ADC measurements on the workstation (Leonardo, Siemens AG Healthcare Sector, Erlangen, Germany). Number, size, shape, and location of the mass(es) were recorded in the group of suspected splenosis. In patients with multiple masses, ADC measurement was made from the biggest one. A single region of interest (measuring 0.46-0.47 mm²) was placed on the mass and spleen. The ADC measurements

were taken from spleen parenchyma at least 1 cm away from the capsule and not crossing major vascular structures as far as possible. Images with b value of 1000 s/mm² were preferred due to perfusion contamination of low b values. The mean ADC value of the masses was compared with the mean ADC value of normal spleen. Then, the Results of DWI were compared with the Results of scintigraphy in the 13 patients.

Because of our study is a first step method-comparison study that measures the diagnostic accuracy, we firstly performed the gold standart test (scintigraphy) and then used our technique (DWI) in the first 13 patients. The radiologists were blind to the Results of the gold standart test in order to avoid possible influence. All the Results between two tests showed intercompatibility, so we did not performed a statistical test. The Intraclass Correlation Coefficient (ICC) was used to measure of the reliability of measurements between two radiologists.

Results

The number of masses was three or more in 13 (50%) patients, two in 9 (34.6%) patients, and one in 4 (15.4%) patients. A total of 84 masses were detected. The size of mass(es) changed between 10 mm and 57 mm. The shape of mass(es) were observed as follows; ovoid in 16 (61.5%), round in 5 (19.2%), conglomerated in 5 (19.2%). The mass(es) were predominantly located in the left upper quadrant (73.6%). According to frequency, the other locations were; left renal (9.7%), right renal (6.9%), right upper quadrant (5.5%), left paracolic (4.1%), and omentum majus (2.7%). The mean ADC value of masses was $0.790 \pm 0.087 \times 10^{-3} \text{mm}^2/\text{s}$. In control group, the mean ADC value of spleen was $0.807 \pm 0.084 \times 10^{-3} \text{mm}^2/\text{s}$ (Fig. 1a,b). All of the masses appeared hyperintense on DWI and hypointense on ADC map, and the mean ADC value of masses showed similarity with the ADC value of normal spleen. The 13 patients had positive Results for splenosis on Tc-99m sulfur colloid scintigraphy (Fig. 2), and the mean ADC value of these group were also compatible with splenosis too (Fig. 3a,b). So, the followings in the study group with history of post-traumatic splenectomy allowed the diagnosis of splenosis to be assigned. First; the masses were predominantly located in the left upper quadrant and ovoid, round or conglomerated in shapes. Second; DWI characteristics with the mean ADC value were identical to normal spleen. An excellent agreement was established between two radiologists by intraclass correlation coefficient (ICC) (Single measures ICC: 0.929, Averages measures ICC: 0.963).

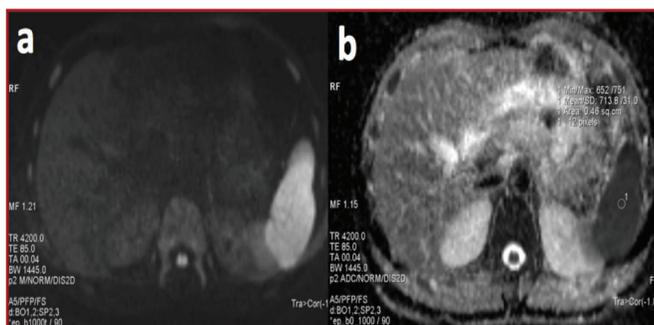


Figure 1a,b: Diffusion weighted imaging (DWI) (a), and apparent diffusion coefficient (ADC) map (b) images of the spleen in a 25-year-old man with urolithiasis. The spleen shows profound restricted diffusion with hyperintense appearance on DWI and hypointense appearance on ADC map. The mean ADC value of the spleen is $0.713 \times 10^{-3} \text{mm}^2/\text{s}$.

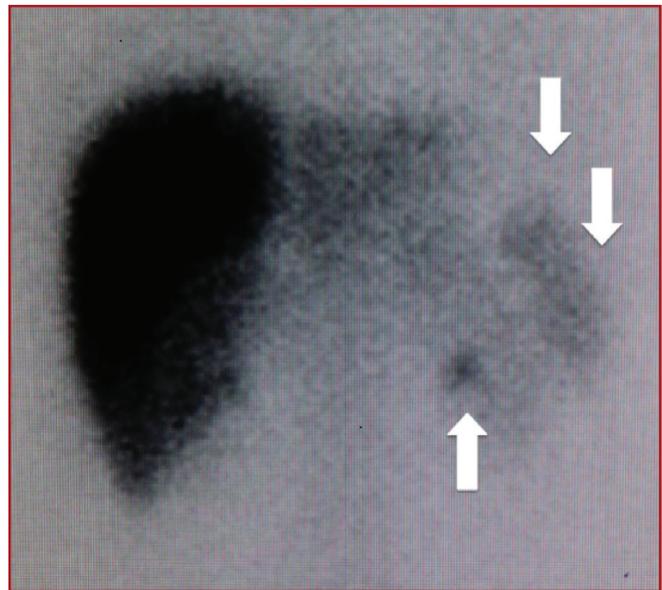


Figure 2: Tc-99m sulfur colloid scintigraphy in a 21-year-old man who had a history of post-traumatic splenectomy. Spleen is not visible due to splenectomy. Multiple conglomerated lesions of uptake in the left upper quadrant are seen (arrows).

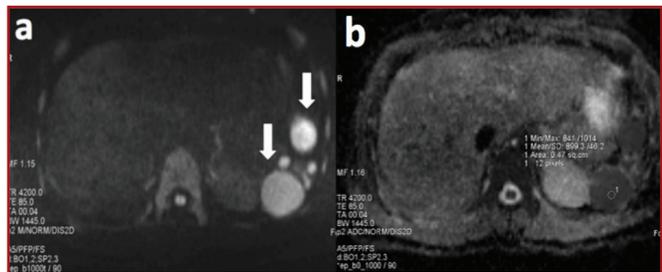


Figure 3a,b: Diffusion weighted imaging (DWI) (a), and apparent diffusion coefficient (ADC) map (b) images of the same patient in Figure 2. Two big (arrows) and numerous smaller splenic implants all show restricted diffusion with hyperintense appearance on DWI and hypointense appearance on ADC map. The mean ADC value of the biggest one is $0.899 \times 10^{-3} \text{mm}^2/\text{s}$.

Discussion

Splenosis is defined as heterotopic autotransplantation of splenic tissue that was first used in term in 1939 (1,2). It usually occurs secondary to traumatic rupture of the spleen or splenectomy. The splenic vein embolism or hematogenous spread of splenic pulp are considered as the other mechanisms of transplantation that may explain the cases of intrahepatic and intracranial splenosis (3,4). In splenosis, the splenic implant has no hilum with an entering artery and exiting vein, but has a poorly formed capsule. Since the blood supply is provided with surrounding vessels, splenic implants do not generally grow to large size. Histologically, poorly formed white pulp with normal appearing red pulp and lacking trabecular structures are considered (5,6). The occurrence of splenosis in patients after traumatic splenectomy has a wide range of 16% to 67% (7). The average time of occurrence of abdominal splenosis after trauma is 10 years, with a range of 5 months to 32 years (2,8). Splenic implants are often numerous, variable in shape, and located throughout the peritoneal cavity or even in extraperitoneal locations. In study group, the most preferred location was the left upper quadrant. The size of splenic implants varies from millimeters to several centimeters. Splenosis is usually considered asymptomatic and found incidentally on imaging studies. It may rarely cause abdominal pain, intestinal obstruction and recurrent Felty syndrome (9). Splenic implants

may resemble adenopathy, hepatic lesions (4,10,11), peritoneal carcinomatosis, renal neoplasms (12), lymphoma (13) or endometriosis.

Ultrasonography shows a well-demarcated hypoechoic to isoechoic mass with a thin rim of hyperechoic wall (14). It has nonspecific arterial and venous color Doppler imaging findings. On non-contrast CT, splenic implants manifest as a variably shaped, homogeneous hypodense soft tissue mass. On contrast-enhanced CT, they are hyperdense in the arterial phase, isodense in the portal venous phase, and hypodense in the equilibrium phase (15). On MRI, splenic implants appear homogeneously hypointense to the liver on T1-weighted images, and hyperintense to the liver on T2-weighted images (16). The signal changes and enhancement patterns are usually identical to those of the spleen. But, diagnosis may be problematic in small implants, because the characteristic heterogeneous enhancement pattern may not be visible in arterial phase. In the cases of intrahepatic splenosis, a rim of low signal intensity on T1- and T2-weighted images has been described as a characteristic finding. The rim composes of fat or fibrous capsule (4,10,17). MRI with intravenous administration of superparamagnetic iron oxide, have also been used in the past for diagnosis of splenosis (18). Scintigraphy is the most common used modality for definitive noninvasive diagnosis of splenosis. Tc-99m heat-damaged erythrocytes or In-111 labeled platelets are more sensitive than Tc-99m sulfur colloid. Because they have better signal-to-back ratio, and specificity for splenic tissue (10,19-21).

To date, scintigraphy is considered the most sensitive and specific imaging modality for noninvasive diagnosis of splenosis. Beside this, our study shows that DWI with conventional MRI may be used to confirm the diagnosis of splenosis. In contrast to the scintigraphy, MRI has higher spatial resolution without need of any radiation exposure. DWI is a form of MRI based on T2-weighted imaging. It measures the Brownian molecular motion of water within a voxel of tissue, yields the ADC as a quantitative measure. Bipolar gradients is applied around the 180° refocusing pulse of a T2-weighted sequence. The phase shift created by the first diffusion gradient in static water molecules is subsequently rephased by the second diffusion gradient. Thus, in static tissue, no significant change in measured signal intensity is detected. On the other hand, moving water molecules are not rephased by the second gradient due to motion, and Results in signal loss. As a result, motion of water molecules Results as a reduction in measured signal intensity. The sensitivity of DWI to water motion is determined by the b value (s/mm²). It reflects the influence of the diffusion gradients, and may be changed by different gradient amplitude, gradient duration and time interval between the paired gradients (22,23). Increasing the b value reduces the effect of perfusion. On visual assessment, tissue with restricted diffusion appears hyperintense on DWI and hypointense on ADC map. On quantitative analysis of DWI, ADC map that is a quantitative measure of tissue diffusivity is expressed in $\times 10^{-3} \text{mm}^2/\text{s}$. DWI is a fast and noninvasive imaging technique which does not require contrast agent (24). But, artifacts due to respiration, pulsatility and metallic hardware may effect the image quality. Respiratory motion compensation techniques may be performed to reduce motion artifacts. The spleen have the greatest degree of nonpathological restricted diffusion of all solid intraabdominal organs (23). The mean ADC values of spleen on DWI had a spectrum from $0.634 \times 10^{-3} \text{mm}^2/\text{s}$

to $0.973 \times 10^{-3} \text{mm}^2/\text{s}$ in the literature (25-28). Our Results in control group were consistent with the literature, and the mean ADC value of suspected splenic implants showed similarity with the mean ADC value of normal spleen. Sometimes, it may be challenging to differentiate the benign incidental mesenteric lymph nodes from splenosis on CT and MRI. Since the mean ADC value of the lymph nodes due to benign conditions such as gastric ulceration or during the resolution period of an acute pancreatitis is $2.38 \pm 0.29 \times 10^{-3} \text{mm}^2/\text{s}$ and higher than the splenic values; it is very easy to determine if the mass is splenic tissue or a lymph node with DWI (29).

We had some limitations when interpreting the Results of this study. First, the main part of this study is of retrospective character and we do not have follow up imaging. Second, because of our study is a first step method-comparison study that measures the diagnostic accuracy, we firstly performed the gold standart test and then used our technique in the first 13 patients. We did not performed the gold standart test to the patients that had only DWI (the last 13 patients). In the second step of the study, we want to add other patients with possible false positive and false negative Results such as liver disease, malignancy and hematological disease. Third, our study group consists of patients with only intraperitoneal splenosis, and studies about extraperitoneal splenosis may be needed.

The occurrence rate of splenosis in patients after traumatic splenectomy may be high as 67%. Noninvasive diagnosis of splenosis may prevent unnecessary surgery. Addition to conventional MRI, measurement of the mean ADC value in suspected post-traumatic splenosis patients otherwise healthy may be an indicator in the determination of splenosis as an alternative imaging modality to scintigraphy.

Conflict of interest: The authors declare that there is no conflict of interest.

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