Dynamic contrast-enhanced MR imaging and digital subtraction angiography manifestation of hepatic focal nodular hyperplasia

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Background and Objective: Focal nodular hyperplasia (FNH) is a rare benign hepatic tumor and its imaging diagnosis remains difficult. This study sought to analyze dynamic contrast-enhanced MR imaging and digital subtraction angiography (DSA) manifestation of FNH and to improve the diagnostic accuracy of FNH. Methods: The MRI and DSA imaging data of 30 patients with FNH proved by pathology were reviewed. Conventional contrast-enhanced MRI was completed in 11 patients; dynamic contrast-enhanced MRI was completed in 15 patients. DSA was completed in ten patients. Results: On dynamic contrast-enhanced MRI scan, 18 lesions in 15 patients showed obvious enhancement at arterial phase and prolonged enhancement at delayed phase. Central scars were found in 11 lesions and showed enhancement from portal vein phase until delayed phase. The time-signal intensity curves of the 18 lesions ascended rapidly at arterial phase, and descended slowly at portal vein phase and delayed phase. On DSA examination, 13 lesions in the ten patients showed dilated feeding arteries, and radiate feeding arterial branches were seen in eight lesions. Conclusions: Dynamic contrast-enhanced MRI can fully show abnormal signal of the central scar of FNH. The time-signal intensity curve of FNH ascends rapidly and descends slowly. On DSA imaging, the feeding arteries of FNH spread radially. Dynamic contrast-enhanced MRI and DSA could improve the diagnostic accuracy of FNH.

Introduction

Focal nodular hyperplasia (FNH) is a kind of benign hepatocellular tumor-like lesion, surpassed only by hepatic hemangioma in incidence. Recently there has been an increasing trend in its reported incidence. Although there are some characteristic features on imaging studies, diagnoses with some cases are substantially difficult and are usually misdiagnosed as liver cancer or other benign or malignant tumors. Accurate diagnosis from imaging plays a key role in clinically directing the choice of therapeutic options, and can help avoid unnecessary surgical resection. Authors in our study retrospectively reviewed 30 cases of FNH confirmed with surgical pathology in the Second Affiliated Hospital of Sun Yat-sen University between January 1997 and August 2007, centering on analysis and summary of dynamic contrast-enhanced MRI and selective digital subtraction angiography (DSA) presentations to improve the accuracy of imaging diagnosis for FNH.

Materials and Methods

Clinical data. 30 patients with FNH confirmed by surgical pathology were enrolled: 19 males and 11 females, aged between 17 and 64 years old, with a median age of 36.5. Images of liver space-occupying lesions were detected in six patients presenting with upper abdominal discomfort, four patients with other disorders and the remaining 20 patients on routine physical follow-up. Three out of 30 patients had a medical history of hepatitis B with normal liver function. Among the 30 patients, five were misdiagnosed with primary liver cancer, five with hepatic hemangioma and 18 suggesting liver space-occupying lesions without qualitative diagnosis. CT scan was performed in 16 patients and included dynamic contrast-enhanced scan in eight. According to the diagnosis on CT scan, seven cases were FNH, three cases were misdiagnosed with liver cancer, two cases were hemangioma and four cases were without qualitative diagnosis.

Instrumentations and testing procedures. 26 patients underwent MRI scan, including 11 patients with Philips 0.5T (GyroscaT5-II) superconductive MRI imaging system and 25 patients with Philips 1.5T (Intera T15). All 26 patients underwent regular MRI plain and contrast-enhanced scan on the liver region, 15 patients on Philips 1.5T (Intera T15) superconductive MRI imaging system underwent dynamic contrast scan. The scanning sequence consisted regular T₁WI/WATS, T₂WI/TSE, T₂WI/SPIR transverse and T₁WI/WATS coronal scans. Fast multiplanar spoiled gradient-recalled (FMSPGR) sequence was
used for dynamic contrast-enhanced scan with the parameters as follows: TR 9.4 ms, TE 5.3 ms, reverse angle 25°, single collection, slice thickness 6 mm, interval 5 mm, matrix 256 x 256 and FOV 300~380 mm. Contrast media Gd-DPTA (gadolinium-diethylenetriaminpentaaetic acid solution for injection) was administered through cubital vein with MR pressure syringe at the dose of 0.2 mmol/kg and the rate of 2.0~3.0 ml/s immediately followed by flushing with 20 ml normal saline injected at the same rate. Immediately after the injection, breath-holding dynamic contrast-enhanced scan was performed. Double images at arterial phase were successively scanned within 20~35 s, while those at both portal and parenchymal phases were scanned within 60~70 s and 90 s respectively for 6.4 s each and repeated for delayed phase scan after 2~3 min. The time-signal intensity curve was plotted for area of interest.

Ten patients underwent DSA with Philips V3000 DSA system. Their right femoral arteries were punctured with Selginger DSA catheter and a microcathether was inserted for selective angiography of common hepatic artery, and consequent superselective angiography of supply arteries based the locations of lesions to collect images at arterial, venous and parenchymal phases respectively.

**Imaging studies.** MRI scan was performed by MRI specialists, and then MRI images were analyzed by two senior abdominal MRI specialists. DSA was performed by interventional radiologists and then analyzed by two senior interventional radiologists. Number, size, location and feature of lesions were evaluated.

**Results**

A total of 37 lesions were detected in 30 patients with FNH by surgical pathology, among which there were 25 cases with single nodules and five cases with multiple nodules. Thirteen lesions were located in the left lobe and 24 in right lobe. There were nine lesions with the maximum diameter of less than 2 cm, 22 with 2.1~5.0 cm and six with more than 5.1 cm lesions. The lesions were in quasi-circular or elliptic shape and lobular. MRI and DSA findings matched the surgical pathological results in terms of number and size of lesions.

For the 26 patients on MRI plain scan, 24 out of 33 lesions presented as hypointense or slightly hypointense and nine as isointense at T1W; 30 as hyperintense or slightly hyperintense and three as isointense at T2W. On plain scan, astroid or strip-like heterogeneus hypointense was presented in the central satellite scar of 15 lesions (45.4%). For the 11 patients on regular contrast-enhanced scan, all the 15 lesions presented with significant enhancement, including eight lesions (53.3%) as central satellite scar. For 15 patients on dynamic contrast-enhanced scan, all 18 lesions presented with significant enhancement at arterial phase, with more intense at portal and parenchymal phases than at hepatic parenchymal phase, 12 lesions at delayed phase were more intense than at hepatic parenchymal phase, and contrast-enhanced signals of six lesions were comparable to those at hepatic parenchymal phase. For the 18 lesions detected on dynamic contrast-enhanced, 11 lesions (61.1%) presented as central satellite scars, including four lesions with obscure central satellite scars on plain scan but clear on dynamic contrast-enhanced scan. Strip-like hypointense signals in focal central satellite scars began to be enhanced at portal phase until delayed phase. In five lesions, supply arterial branches into the central lesions were detected at arterial phase. Dilated drainage veins were detected in four lesions; incompletely encapsulated structures in four lesions presented as incompletely linear enhancement at delayed phase, which were compressed vessels confirmed pathologically. For 15 patients all the time-signal intensity curves of 18 lesions on dynamic contrast-enhanced scan showed the rapid increase at arterial phase and steady decrease at portal phase until delayed phase in the manner of rapid increase and steady decrease (Fig. 1).

A total of 13 lesions were detected in ten patients by DSA, all of which presented with abundant supply arteries and dilated and obviously tortuose supply arteries at arterial phase. Supply arteries had relatively regular branches and abundant focal blood sinuses with relatively uniform size and distribution; ten lesions were heavily stained at parenchymal and venous phases with clear margin and in lobular shape; four lesions were not uniformly stained. Eight lesions showed supply arterial branches penetrating into lesions in the radial pattern, including the ‘handball’ sign detected in six lesions due to arc compression of supply arterial branches with extension into the central lesions. Six lesions showed dilated drainage veins without any sign of arteriovenous or arterio-portal fistula (Fig. 2).

**Discussion**

The exact causes of FNH are still unclear. Vascular malformation and damages were considered as potential candidates. Currently it is well accepted that FNH was a responsive hyperplasia of liver cells to local vascular abnormalities. Clinically FNH is usually asymptomatic but detected by imaging studies such as ultrasonography in physical examination. Patients usually have normal liver function, negative AFP and insignificant laboratory test results.

Pathologically FNH is classified into classic (about 80%) and non-classic types (about 20%). Classic type presented with three features: (1) liver cells with abnormal nodular structure; (2) central astroid scar or vascular malformation; (3) hyperplastic small bile ducts. The non-classic type presented with either abnormal nodular liver cells or vascular malformation in addition to hyperplastic small bile ducts, but without central astroid scar grossly. Based on the pathological changes, FNH is further classified into three subtypes: (1) telangiectatic, (2) hyperplastic-adenomatous and (3) focal large-cell dysplasia, in which vascular dilation is the relatively common subtype. In the nodular center, there are minute and abundant arteries with multiple dilated vessels similar to hemangioma. Classic type mostly presents with single or multiple visible central astroid scars containing malformed vessels including arteries, capillaries and unspecific vascular pathways and veins other than portal veins. Malformed central arteries provide blood supply peripherally in an acentric manner.

Imaging studies are the main method in the diagnosis of FNH. Ultrasonography can detect hepatic space-occupying lesions, but with less specificity and a less confirmed diagnosis rate—it is difficult to differentiate FNH from liver cancer and hemangioma. CT scan can play an important role in the diagnosis of FNH.
When scars form in the central lesions of classic FNH, CT scan—especially spiral CT scan—can reveal the central satellite scar and aid in the diagnosis of FNH. However, CT scan is also less specific and sensitive when no scars or minute and insignificant scars form in non-classic FNH lesions.\(^5\)

MRI was superior to ultrasonography and CT in revealing the focal internal texture.\(^5\) Manifestations of classic FNH on MRI included slight hypointense or isointense mass at T\(_1\)W with more hypointense mass for central satellite scar; slight hyperintense mass at T\(_2\)W with more hyperintense mass for central mass; regular contrast-enhanced scan revealed significantly enhanced lesions but insignificantly enhanced central satellite scar. A dynamic contrast-enhanced MRI scan could better reflect the features of the focal internal texture and hemodynamic changes. Due to the abundant arterial supply of FNH, the focal parenchyma was uniformly and significantly enhanced at arterial phase, and it was still more significantly enhanced than surrounding liver parenchyma at portal and parenchymal phases due to hyperplasia of both abnormal nodular liver cells and small bile ducts, which led to delay in diffusion of contrast media from vessels into intercellular space compared to that in normal liver tissue. For the 15 patients in our study, 12 out of 18 lesions were more intensely enhanced than the surrounding parenchyma at delayed phase on dynamic contrast-enhanced scan, and the remaining six lesions were comparable to the surrounding parenchyma. On the dynamic contrast-enhanced scan, the time-signal intense curve for 18 lesions showed rapid increase at arterial phase but steady decrease at portal until delayed phase in the manner of rapid increase and steady decrease, differing from the time-signal intense curve of hepatocellular carcinoma, which displayed a rapid increase at arterial phase and a rapid decrease at portal phase until delayed phase in the manner of rapid increase and rapid decrease.\(^6\)

Pathologically, the existence of central satellite scars and radial fiber density are key characteristics of FNH. Central satellite scars consist of fibrous connective tissues in the dotted, striped or asteroid shape. Formation of central satellite scars was associated with the focal size and pathological type, while there was insignificant central satellite scar inside minute lesions. Dynamic contrast-enhancement at arterial phase was readily identified due to significantly enhanced parenchyma but relatively hypointense scar. The scar began to be enhanced at portal phase until delayed phase, while in delayed phase central satellite scar and radial fiber density were delayed in enhancement or more intense than liver parenchyma due to the accumulation of contrast media in fibrous scar with large intercellular space. Meanwhile, delayed enhancement was in favor of identification for scar. MRI plain scan could detect central satellite scars at the approximate rate of 30-50% and up to 78% on a dynamic contrast-enhanced scan.
Out of 18 lesions on the dynamic contrast-enhanced scan, 11 (61.1%) revealed central satellite scar, especially the four lesions with obscure central satellite scar on the plain scan, but clearly detected on dynamic contrast-enhanced scan, indicating that the MRI dynamic contrast-enhanced scan was more sensitive to abnormal signals than the central satellite signal, which was superior to the regular contrast-enhanced scan in revealing the focal internal texture.

DSA patterns of FNH were seldom reported. Pathologically FNH is a hyperplastic disorder with abundant and malformed vessels, showing on DSA with abundant arterial supply, dilated supplying arteries, relatively regular supplying arterial branches and blood sinuses that are uniform in size and distribution. All these changes were detected in all the 13 lesions in our study. Reflux veins were also dilated due to the abundant arterial supply to the lesions. In the study, six lesions presented with dilated drainage veins. In contrast to primary liver cancer and hepatic hemangioma, DSA revealed no sign of arterioportal fistula due to lack of portal vein inside the lesions. Malformed vessels contained in central satellite scar with malformed central arteries providing blood supply in the acentric pattern are the pathological features of FNH. FNH on DSA was characterized by arterial branches penetrating into the lesions and radiating peripherally. In the study, eight lesions presented with supplying arterial branches penetrating into the lesions and radiating peripherally. Moreover, FNH was a benign hepatic space-occupying disorder with significant space-occupying effects for large lesions leading the shift of compressed vessels. In the study, six lesions presented with the 'handball' sign due to arc compression of supply arterial branches with extension into the central lesions.

Pathological polymorphism of FNH presented as polymorphism on imaging studies. However, an MRI dynamic contrast-enhanced scan can better reveal the histopathological features and hemodynamic changes of FNH because the time-signal intense curve on dynamic enhanced scan, which shows rapid increase and steady decrease, significantly differs from that for liver cancer. FNH on DSA was characterized by arterial branches penetrating into the lesions and radiating peripherally. MRI dynamic contrast-enhanced scan and DSA would improve the accuracy for diagnosis of FNH.

References