

## Hyperintense Cirrhotic Nodules on MRI

Susan A. Koslow,<sup>1</sup> Peter L. Davis,<sup>1</sup> Georgine B. DeMarino,\* Robert L. Peel,<sup>2</sup> Richard L. Baron,<sup>1</sup> and David H. Van Thiel<sup>3</sup>

Departments of <sup>1</sup> Radiology, <sup>2</sup> Pathology, and <sup>3</sup> Surgery, Presbyterian-University Hospital, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

**Abstract.** Descriptions of regenerating nodules of cirrhosis indicate that they are often isointense to liver parenchyma on magnetic resonance imaging (MRI). Regenerating nodules of cirrhosis can occasionally appear hypointense on all MRI sequences due to iron deposition within the nodules. We reviewed 21 cases of pathologically proven mixed or macronodular cirrhosis using MRI. In five patients, nodules appeared as hyperintense to liver parenchyma on short TR/TE images and were isointense on long TR/TE or GRASS images. In another five cases, nodules appeared hypointense on either long TR/TE or GRASS images, and corresponding hypointense nodules were observed on short TR/TE images in one of these patients. Our findings suggest that regenerating nodules of cirrhosis may have a more variable appearance on short TR/TE images.

**Key Words:** Liver, cirrhosis—Liver, disease—Liver, MR studies—Magnetic resonance.

Imaging of the cirrhotic liver is often performed to identify hepatocellular carcinoma, which is found with an increased incidence in cirrhosis. As the cirrhotic liver has a heterogeneous architecture created by repeated episodes of scarring and regeneration, identifying hepatocellular carcinoma in its nodular, as well as its infiltrating form, can be difficult. On magnetic resonance imaging (MRI), regenerating nodules are often isointense. No suspicion of tumor is created by this isointense appearance. Regenerat-

ing nodules of cirrhosis are occasionally detected by MRI as hypointense nodules on short TR/TE, long TR/TE, and FLASH images [1–3]. These regenerating nodules can be differentiated from tumor, such as hepatocellular carcinoma, which is hypo- or hyperintense on short TR/TE and iso- to hyperintense on long TR/TE or FLASH [4]. We have observed another appearance of nodularity in the cirrhotic liver, which may represent regenerating nodules, which appear hyperintense on short TR/TE while not being identified on long TR/TE or GRASS. We reviewed the MRI appearance of these nodules with a retrospective study of preoperative images in 21 patients that had pathologically proven macronodular or mixed micro-macronodular cirrhosis.

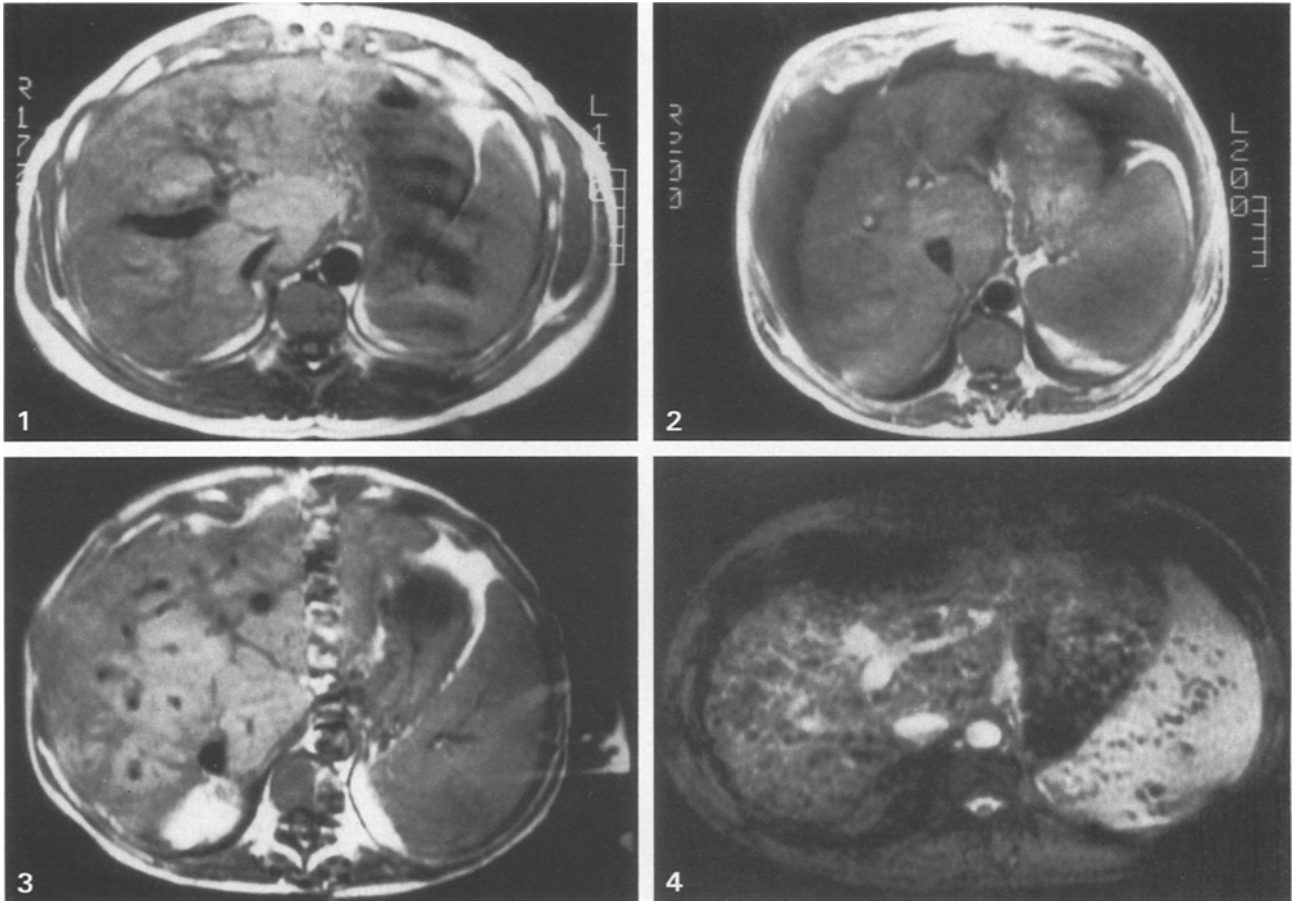
### Methods and Materials

A computer search of the pathology records over a 1-year period identified 132 patients who subsequently underwent total hepatectomy for liver transplantation and had a pathological diagnosis of macronodular or mixed cirrhosis without tumor. Preoperative MRI had been performed in 21 of these patients to document the status of the portal venous circulation. MRI sequences were obtained in the axial plane, with a 1.5-Tesla Signa System (General Electric Co., Milwaukee, WI, USA). The MRI studies were performed a mean of 7.3 weeks (range between 2 days and 37 weeks) prior to the liver resection. Slice thicknesses were 10 mm with interposed 2-mm gaps using a 128 × 128 matrix. Short TR/TE spin-echo pulse sequences were performed in all 21 cases. In addition, five cases were imaged using GRASS, 13 were imaged with long TR/TE, and three were imaged with both GRASS and long TR/TE sequences. The short TR/TE sequences were performed with respiratory compensation and spatial presaturation to decrease motion artifact. Similarly, the long TR spin-echo sequences were performed with respiratory compensation, spatial presaturation, and cardiac gating. GRASS studies were performed preferentially in patients with large amounts of ascites. Since motion artifact related to ascites rendered some long TR/TE images uninterpretable, the GRASS sequences were acquired during a single breath to reduce this artifact.

The protocol for pathological examination at our institution,

\* Present address: St. Clair Memorial Hospital, Pittsburgh, PA 15241

Address offprint requests to: Susan A. Koslow, M.D., Department of Radiology, Presbyterian-University Hospital, DeSoto at O'Hara Streets, Pittsburgh, PA 15213, USA



**Fig. 1.** MRI (TE 20, TR 400). Many small hepatic nodules are hyperintense to the surrounding parenchyma. The caudate lobe is also relatively bright.

**Fig. 2.** MRI (TE 20, TR 400). Tiny nodules are present within the liver and are hyperintense when compared to adjacent hepatic parenchyma.

**Fig. 3.** MRI (TE 25, TE 500). Multiple large, high-signal hepatic nodules are identified. These large nodules contain central vascular structures.

**Fig. 4.** On MRI GRASS imaging sequence TE 25, TR 100, and angle of 10°, many small, low-intensity nodules are present throughout the liver. Several small splenic nodules are also identified.

which performs approximately 600 liver transplantations annually, includes a gross examination with 1-cm sections of the entire liver. Multiple sections for histological examination are obtained throughout the liver at random, and through any large or dominant nodule. All reviewed histological sections of the 21 selected cases confirmed the diagnosis of macronodular or mixed micro-macronodular cirrhosis. Gross and microscopic evaluation revealed no evidence of dominant nodules, atypia, or neoplastic

lesions. Macronodular cirrhosis was defined as having nodules equal to or greater than 3 mm in diameter [5]. The mean diameter of the largest nodule in each liver at pathologic evaluation was 8.5 mm (range between 4 and 25 mm). As this study was retrospective, radiologic-pathologic correlation of specific nodules was not able to be performed.

## Results

On short TR/TE MRI sequences, discrete nodules hyperintense to adjacent parenchyma were demonstrated in five of the 21 livers (Figs. 1 and 2). In four of these patients, the nodules measured approximately 5 mm; however, in one patient several large nodules (up to 2.5 cm) with central vascular structures were present (Fig. 3). Each of these five cases had additional long TR/TE or GRASS images. In one patient, long TR/TE images demonstrated a homogeneous liver without discrete nodularity. In the other four patients, long TR/TE (in one patient) and GRASS (in three patients) images were obtained and showed heterogeneous liver parenchyma typical of cirrhosis but without discrete lesions.

Long TR/TE liver images were obtained in 16

patients. Diffuse low-signal nodules approximately 5 mm in diameter were present in three patients, and two discrete hypointense nodules were identified in a fourth patient. Corresponding low-intensity nodules were present on short TR/TE images in only one of these four patients. None of these four patients with hypointense nodules on long TR/TE images had ascites. In five cases, we could not assess the hepatic texture for nodularity because of the "slosh" motion artifact due to the ascites.

GRASS images were obtained in eight cases. One case demonstrated 5-mm low-intensity nodules diffusely, with similar nodules observed in the spleen (Fig. 4). This liver appeared heterogeneous but without focal lesions on the long TR/TE images. No corresponding nodularity was present on short TR/TE images in the one case of discrete nodules observed on GRASS images.

## Discussion

Regenerating nodules are often not identified on MRI, indicating that they are usually isointense to liver parenchyma on all imaging sequences [1–3]. When detected, regenerating nodules have been reported as small, low-intensity nodules seen in the minority of patients on short TR/TE and slightly more often on long TR/TE or FLASH images [1–3]. The etiology for this appearance is suspected to be iron deposition [3]. Our study confirms the finding of low-intensity nodules on short TR, long TR, or GRASS images in some cirrhotic patients with regenerating nodules. The hypothesis of iron deposition is supported by one case of low-signal nodules observed on GRASS images within the spleen, as well as the liver. Low-signal nodules in the spleen have previously been described as siderotic nodules [6].

The hypointense appearance of regenerating nodules due to iron deposition occurs only occasionally. Certainly not all regenerating nodules contain iron [3]. Nodules that are not seen on MRI presumably do not have enough paramagnetic material to appear dark. Such nodules may be isointense [1–3]. We report five patients with high-intensity hepatic

nodules on short TR/TE images. The nodules in these five patients were isointense to hepatic parenchyma on long TR/TE or GRASS images. The etiology for these bright nodules is uncertain, but no tumor was noted at macroscopic or microscopic pathologic examination. In addition, no dominant mass was identified macroscopically to suggest premalignant adenomatous hyperplastic nodules [4, 7]. As the benign regenerating nodule was the only entity identified both macroscopically and microscopically, it remains the current diagnosis for the hyperintense lesions found on short TR/TE.

In summary, bright lesions on short TR/TE images without corresponding nodules on long TR or GRASS images can be found in the cirrhotic liver. Such lesions may represent benign regenerating nodules, and not necessarily adenomatous hyperplastic nodules or hepatocellular carcinoma containing fat.

*Acknowledgment.* We thank Kathy Fraser for typing, and Meg Sachse for editing this manuscript.

## References

1. Itai Y, Ohnishi S, Ohtomo K, et al. Regenerating nodules of liver cirrhosis: MR imaging. *Radiology* 1987;165:419–423
2. Ohtomo K, Itai Y, Ohtomo Y, Shiga J, Jio M. Regenerating nodules in hepatic cirrhosis: MR imaging with pathologic correlation. *AJR* 1990;154:505–507
3. Morakami T, Kuroda C, Marukawa T, et al. Regenerating nodules in hepatic cirrhosis: MR findings with pathologic correlation. *AJR* 1990;155:1227–1231
4. Osamu M, Kadoya M, Kameyama T, et al. Adenomatous hyperplastic nodules in the cirrhotic liver: differentiation from hepatocellular carcinoma with MR imaging. *Radiology* 1989;173:123–126
5. Robbins SL, Cotran RS, Kumar V. The liver and biliary tract. In: *Pathologic basis of disease*, 3rd ed. Philadelphia: WB Saunders, 1984:915–959
6. Minami M, Itai Y, Ohtomo K, et al. Siderotic nodules in the spleen: MR imaging of portal hypertension. *Radiology* 1989;172:681–684
7. Furuya K, Nakamura M, Yamamoto Y, Toge K, Otsuka H. Macroregenerative nodule of the liver: a clinicopathologic study of 345 autopsy cases of chronic liver disease. *Cancer* 1988;61:99–105

*Received: February 7, 1991; accepted: March 10, 1991*