MRI characteristics for the differential diagnosis of benign and malignant small solitary hypovascular hepatic nodules

Haizhen Qian*, Shihong Li*, Ming Ji and Guangwu Lin

**Purpose** To compare the MRI findings of benign and malignant solitary hypovascular hepatic nodules and identify the differentiating features.

**Materials and methods** A total of 135 patients with solitary hypovascular hepatic lesions up to 3 cm (mass forming intrahepatic cholangiocarcinoma, \( n = 29 \); metastases, \( n = 26 \); inflammatory pseudotumors and solitary necrotic nodule, \( n = 48 \); and hemangioma, \( n = 32 \)) were assessed. MRI findings were analyzed, and lesions were scored for peripheral and intratumoral appearance and enhancement patterns.

**Results** Univariate and multivariate analyses showed that the most common findings for benign lesions were subcapsular, sharp margin, homogeneous, marked high signal on T2WI, mild hyperintensity on T2WI, increasing intensity of peripheral globular enhancement, and persistent central septum-like linear enhancement on delayed phase \( (P < 0.05) \). An area under the curve of 0.955 was obtained for differentiating malignant from benign nodules using the combined imaging features of ill-defined margins, heterogeneity, decreasing intensity of peripheral rim-like enhancement, and central increasing intensity of patchy enhancement. Interobserver agreement was good, ranging from 0.72 to 1.00.

**Conclusion** MRI may be a useful noninvasive method for determining whether hypovascular hepatic nodules are malignant or benign. Eur J Gastroenterol Hepatol 28:749–756

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**Introduction**

The liver is both a principal site of primary malignancies and a major target of metastatic disease from almost any primary malignant neoplasm [1]. In addition, the incidence of benign hepatic lesions is high in the adult population [2–4]. With remarkable advances in diagnostic imaging of the liver, small hepatic hypovascular lesions are increasingly being detected. These include malignant lesions, such as intrahepatic cholangiocellular carcinoma (ICC) and hepatic metastases (HM), as well as benign lesions, such as atypical hepatic hemangiomas (HG), inflammatory pseudotumors (IPT), and solitary necrotic nodules (SNN) of the liver. It is important to differentiate these lesions because the carcinoma and metastases are considered potentially fatal diseases that require prompt surgical or therapeutic attention, whereas benign lesions do not often require any intervention [5–8]. Therefore, the ability to accurately differentiate between benign and malignant hypovascular hepatic lesions is increasingly a clinically important issue.

On the basis of our experience, hepatic hypovascular tumors are not uncommon. These four entities need to be distinguished, especially hemangioma and metastasis. Motosugi et al. [9] reported that bright signals on T2WI could be detected in both hemangiomas and hepatic metastases in 94–98% and 13–25% of cases, respectively.

In earlier studies, characteristics of large lesions (>3 cm) and multiple lesions were reported [4,10–14]. However, to the best of our knowledge, the MRI features of small solitary hypovascular hepatic nodules (HHN) (≤ 3 cm) have not been reported so far. This retrospective study aimed to describe the MRI findings of hypovascular hepatic lesions as well as the diagnostic performance of MRI in differentiating malignant from benign hepatic lesions.

**Materials and methods**

**Patients**

This retrospective study was approved by the institutional review board and informed consent was waived. Between January 2005 and January 2014, 145 consecutive patients with 145 solitary hypovascular hepatic lesions (≤ 3 cm) were admitted to two medical centers. Patients with cirrhosis and cysts without associated enhancement were excluded from the study.

Study inclusion criteria were as follows: (a) patients with precontrast and contrast agent enhancement at multiple phases (e.g. no contrast enhancement, arterial phase, portal venous phase, delayed venous phase), (b) solitary

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hepatic lesions, (c) maximum diameter of any hepatic nodules up to 3 cm, and (d) hypovascular nodules, defined as nodules with large areas of hypointensity on the arterial and portal venous phases of dynamic enhancement, which was the same as or less than that of adjacent liver.

Imaging criteria used for the diagnosis of atypical hemangioma were as follows: (a) nodules without radiofrequency ablation, chemoembolization, or other similar; (b) lesions first detected or 20% larger than the previous images using the same technique; and (c) follow-up imaging with any other primary malignant tumors (mean follow-up period of 8.65 ± 3.18 months, range 3–12 months).

Overall, 135 patients were included in the final study population (57 women and 78 men; age range 21–91 years; mean age 56 ± 13 years). The hepatic lesions included IPT and SNN (n = 48), atypical HG (n = 32), ICC (n = 29), and HM (n = 26). Symptoms and laboratory test results are summarized in Table 1. All IPT and SNN (n = 48) were confirmed by surgical resection (n = 28) or percutaneous biopsy (n = 20). Thirty-two atypical HG were confirmed by percutaneous biopsy (n = 8) or surgical resection (n = 4) and follow-up imaging (n = 20). Twenty-nine ICC were confirmed by surgical resection (n = 26) and percutaneous biopsy (n = 3). All HM were confirmed by surgical resection (n = 7) or percutaneous biopsy (n = 8) and imaging follow-up (n = 11). The longest follow-up duration was 5 years.

MRI examination

MRI was performed using a 3 T scanner (Magnetom Trio; Siemens, Erlangen, Germany) with an eight-channel body phased-array coil. Baseline MRI images were acquired by percutaneous biopsy (n = 30), and HM (n = 26). Symptoms and laboratory test results are summarized in Table 1. All IPT and SNN (n = 48) were confirmed by surgical resection (n = 28) or percutaneous biopsy (n = 20). Thirty-two atypical HG were confirmed by percutaneous biopsy (n = 8) or surgical resection (n = 4) and follow-up imaging (n = 20). Twenty-nine ICC were confirmed by surgical resection (n = 26) and percutaneous biopsy (n = 3). All HM were confirmed by surgical resection (n = 7) or percutaneous biopsy (n = 8) and imaging follow-up (n = 11). The longest follow-up duration was 5 years.

| Characteristic               | Malignant nodule (59) | Benign nodule (80) |
|------------------------------|-----------------------|--------------------|
| Age (years)                 | 68 (43–91)            | 42 (48–87)         |
| Sex (male/female)           | 18/11                 | 19/7               |
| Tumor marker (μl)           | N/AFP 1/356.0         | 0/-                |
| N/CEA 0/-                   | 7.75–15.0             | 0/–                |
| N/CA19-9 0/-                | 1/89.3                | 0/–                |
| Main symptoms               | Abdominal discomfort  | 18                  |
| Weight loss                 | 2                     | 0                  |
| Asymptomatic                | 0                     | 40                 |
| Follow-up imaging           | 26                    | –                  |
| History                     | Sclerosing cholangitis| 2                   |
| Autoimmune hepatitis        | 1                     | 0                  |
| Colorectal cancer           | 20                    | 0                  |
| Gastric cancer              | 4                     | 0                  |
| Pancreatic cancer           | 2                     | 0                  |

AFP, α-fetoprotein; CA19-9, carbohydrate antigen 19-9; CEA, carcinoembryonic antigen; HG, atypical hepatic hemangiomas; HM, hepatic metastases; ICC, intra-hepatic cholangiocellular carcinoma; SNN, solitary necrotic nodules.

aData are means, with range in parentheses.
bFollow-up imaging after malignant tumor surgery.

with the following parameters: breath-hold T1-weighted gradient-echo images; repetition time (TR), 220 ms; echo time (TE), 5.1 ms; flip angle (FA), 66°; matrix, 320 × 256; number of signals acquired, one; section thickness, 6 mm; intersectional gap, 1.0 mm; and acquisition time, 28 s. Navigator-triggered, fat-suppressed, and T2-weighted turbo spin echo images were acquired using the following parameters: TR, 4781 ms; TE, 81 ms; FA, 140°; matrix, 256 × 256; number of signals acquired, one; section thickness, 7 mm; intersectional gap, 1.0 mm; and acquisition time ∼90 s. T2-weighted half-Fourier acquisition single-shot turbo spin echo sequence (TR/TE, 4500/78 ms; FA 150°; matrix, 256 × 256; 6 mm slice thickness); and a breath-hold T1-weighted fast low angle shot sequence (TR, 172 ms; TE, 2.50 (in-phase)/1.22 ms (out-phase)); FA 65°; matrix, 208 × 256; average of 1 and 2 acquisitions; 5 mm slice thickness). Dynamic imaging with a three-dimensional volumetric interpolated breath-hold examination sequence was obtained before (precontrast) and 20 s (arterial phase), 50 s (portal venous phases), and 3–5 min (delayed phases) after an intravenous administration of a gadolinium (Gd)-based contrast medium Gd–diethytriaminepentaacetic acid (Primovist; Bayer Schering Pharma, Leverkusen, Germany) at a dose of 0.1 mmol/kg and 3.0 ml/s using a contrast enhancement autoinjector, followed by a 20 ml saline flush. Some delayed images were acquired at 10 min. All images were acquired in the transverse plane with a field of view of 370 mm to cover the entire liver. The average interval between MRI and surgery was 10 days (range 1–30 days).

Image interpretation

Two radiologists with 10 years of clinical experience in abdominal MRI, blinded to the pathologic and clinical findings, independently analyzed all images, described the characteristics, and then rated the likelihood of a malignant mass in each patient using a five-point scale as follows: 1, definitely benign; 2, probably benign; 3, indeterminate; 4, probably malignant; and 5, definitely malignant. Combined unenhanced and contrast-enhanced MRI images were randomly assigned to each observer. Each observer interpreted the MRI images independently and separately. All MRI images were evaluated on the picture archiving and communication system monitors. All analyses were carried out by the location, margin (defined or ill-defined edge), signal intensity on T2WI, nodule homogeneity, capsular retraction, enhancement patterns and features, and vessel encasement. The enhancement patterns included globular or rim-like enhancement at the lesions’ edge, and patchy, septum-like linear or nodular enhancement in the center. The above-mentioned signs are evaluated for determining the nodules benign or malignant. The long diameter of each mass was also measured.

Statistical analysis

Either the χ²-test or the Fisher exact test was used to compare MRI findings. The statistically significant variables of the qualitative imaging features obtained from univariate analysis were used to carry out multivariate logistic regression analysis to determine the most predictable findings. These findings were used to differentiate...
malignant from benign nodules. Diagnostic performance for differentiating malignant from benign lesions was then assessed using the area under the receiver operating characteristic curve (Az). A difference with a P less than 0.05 was considered statistically significant for all tests. The κ statistic was used to evaluate interobserver agreement. A κ value less than 0.20 was considered to be poor, 0.21–0.4 as fair, 0.41–0.60 as moderate, 0.61–0.80 as good, and 0.81–1.00 as excellent. SPSS, version 17.0 software (IBM SPSS, Inc., Chicago, Illinois, USA) was used for statistical analysis.

Results

The mean diameter of the lesions examined was 1.8±0.7 cm (range 0.5–3.0 cm). The main imaging features are summarized in Tables 2–4. Univariate analysis indicated that there were significant differences between the malignant group and the benign group in terms of location, margin, T2-weighted signal intensity, nodule homogeneity, and type and degree of peripheral and intratumoral enhancement (P<0.05). Multivariate analysis showed that the statistically common findings for malignant hypovascular nodules were ill-defined borders (n=42, 76%, P<0.05); heterogeneity (n=29, 52%, P<0.05); rim-like enhancement at the periphery (n=51, 93%, P<0.05) with decreasing intensity on the delayed phase (n=47, 86%, P<0.05); and patchy enhancement centrally (n=24, 44%, P<0.05) with increasing intensity on delayed phase (n=27, 49%, P<0.05). The most common MRI finding for ICC (n=27) was peripheral enhancement in the arterial dominant phase with centrifetal enhancement on delayed phases. Twenty-three ICC showed patchy enhancement on delayed phases and three showed patchy enhancement in the center with peripheral defects (Fig. 2e). Twenty of 26 hepatic metastases were because of colorectal carcinoma. The most common MRI finding for HM (n=23) was peripheral rim enhancement (Fig. 3d–f).

Statistically, the most common findings for benign nodules were subcapsular (n=39, 49%, P<0.05), defined borders (n=62, 78%, P<0.05), marked high-signal intensity on T2WI (n=49, 61%, P<0.05), mild hyper-intensity on T2WI (n=22, 28%, P<0.05), HG (n=53, 66%, P<0.05), peripheral nodular enhancement (n=30, 38%, P<0.05) and increasing intensity (n=40, 51%, P<0.05) on delayed phase, and central septum-like linear enhancement (n=27, 34%, P<0.05) and persistence in the delayed phase (n=77, 96%, P<0.05). Large area of atypical HG was a persistent low signal intensity on the three routine phases, but the enhancing area was slightly enlarged like an enhancing dot even at 10 min of delay (n=24; Fig. 4d–f). Twenty-seven cases of IPT and SNN showed thin and rim-like enhancement at the periphery (Fig. 5c–e).

As Fig. 1 shows, the Az values for MRI diagnostic performance in differentiating malignant from benign nodules was 0.955, sensitivity was 96.4%, and specificity was 83.8%.

Table 2. Unenhanced MRI findings for malignant and benign hepatic hypovascular nodules

| MRI findings                  | Malignant nodule (55) | Benign nodule (80) | χ²-value | P     |
|-------------------------------|-----------------------|--------------------|----------|-------|
|                               | ICC (29)              | HM (26)            | SNN (48) | HG (32) |
| Location                      |                       |                    |          |        |
| Subcapsular                   | 9 (16)                | 2 (4)              | 22 (28)  | 17 (21) | 11.55  | <0.001  |
| Deep parts of lobe            | 20 (36)               | 24 (44)            | 26 (33)  | 15 (19) |        |         |
| Margin                        |                       |                    |          |        |
| Sharp                         | 13 (24)               | 0                  | 30 (38)  | 32 (40) | 38.30  | <0.001  |
| Indistinct                    | 16 (29)               | 26 (47)            | 18 (23)  | 0      |        |         |
| Si on T2WI                    |                       |                    |          |        |
| Regional markedly high        | 5 (9)                 | 9 (16)             | 17 (21)  | 32 (40) | 16.78  | <0.001  |
| Mild hyperintensity           | 0                     | 0                  | 22 (28)  | 0      | −      | <0.001  |
| Homogeneity                   |                       |                    |          |        |
| Homogeneous                   | 9 (16)                | 17 (31)            | 21 (26)  | 32 (40) | 4.84   | 0.03    |
| Heterogeneous                 | 20 (36)               | 9 (16)             | 27 (34)  | 0      | −      |         |
| Capsule retraction            | 0                     | 4 (7)              | 3 (4)    | 1 (1) | −      | 0.72    |

Note: Data are presented as the number of patients, with percentages in parentheses. Percentages are calculated for each group. A difference with P<0.05 was considered statistically significant for the χ²-test and the Fisher exact test used to compare each of the MRI findings between benign and malignant groups.

HG, atypical hepatic hemangiomas; HM, hepatic metastases; ICC, intrahepatic cholangiocellular carcinoma; Si, signal intensity; SNN, solitary necrotic nodules.
Table 3. Dynamic contrast-enhanced MRI findings for malignant and benign hepatic hypovascular nodules

| MRI findings | Malignant nodule (55) | Benign nodule (80) | $\chi^2$ | $P$ |
|--------------|-----------------------|-------------------|--------|-----|
| PE Globular enhancement | 2 (4) | 2 (4) | 6 (8) | 24 (30) | 14.24 | <0.001 |
| Rim-like enhancement | 27 (49) | 24 (44) | 42 (53) | 8 (10) | 43.19 | <0.001 |
| CE | | | | |
| Cloud-like enhancement | 23 (42) | 1 (2) | 1 (1) | 0 | |
| Septum-like linear enhancement | 4 (7) | 1 (2) | 27 (34) | 0 | |
| Nodular enhancement | 0 | 0 | 0 | 3 (4) | |
| No enhancement | 2 (4) | 24 (44) | 20 (25) | 29 (36) | |
| DP-SI | | | | |
| Increasing | 2 (4) | 3 (5) | 38 (48) | 2 (3) | 97.13 | <0.001 |
| Decreasing | 24 (44) | 23 (42) | 2 (3) | 0 | |
| No change | 3 (5) | 0 | 8 (10) | 30 (38) | |
| DC-SI | | | | |
| Increasing | 27 (49) | 0 | 3 (4) | 0 | 36.19 | <0.001 |
| Decreasing | 2 (4) | 26 (47) | 45 (56) | 32 (40) | |
| No change | 2 (4) | 0 | 2 (3) | 0 | |

Note: Data are presented as the number of patients, with percentage in parentheses. Percentages are calculated for each group. A difference with a $P < 0.05$ was considered to be statistically significant for the $\chi^2$-test and the Fisher exact test used to compare the MRI findings between benign and malignant groups.

CE, central enhancement patterns; DC-SI, central signal intensity changes in delayed phases; DP-SI, peripheral signal intensity changes in delayed phases; HG, atypical hepatic hemangiomas; HM, hepatic metastases; ICC, intrahepatic cholangiocellular carcinoma; PE, peripheral enhancement patterns; SNN, solitary necrotic nodules.

Table 4. Results of multivariate logistic regression analysis

| | $B$ | SE | Wald | d.f. | Significance | Exp ($B$) | 95% CI for Exp ($B$) |
|--------------|-----|-----|------|------|-------------|----------|---------------------|
| $CE$ | | | | | | 95% CI for Exp ($B$) | Lower | Upper |
| Cloud-like enhancement | 4.114 | 1.042 | 15.573 | 1 | 0.000 | 61.161 | 7.928 | 471.806 |
| Septum-like enhancement | -1.628 | 0.525 | 9.608 | 1 | 0.002 | 0.196 | 0.070 | 0.550 |
| Nodular enhancement | -20.866 | 23 205.422 | 0.000 | 1 | 0.999 | 0.000 | 0.000 | 0.000 |
| No enhancement | -0.567 | 0.354 | 2.560 | 1 | 0.110 | 0.567 | 0.283 | 1.136 |
| DP-SI | | | | | | <0.000 | 0.036 | 0.277 |
| Increasing | -2.303 | 0.520 | 19.637 | 1 | 0.000 | 0.100 | 0.000 | 0.000 |
| Decreasing | 5.434 | 0.812 | 44.806 | 1 | 0.000 | 229.125 | 46.669 | 1124.912 |
| No change | -2.753 | 0.635 | 18.815 | 1 | 0.000 | 0.064 | 0.018 | 0.221 |

CE, central enhancement pattern; CI, confidence interval; DP-SI, peripheral signal intensity changes in delayed phase.

Fig. 2. Peripheral nodule cholangiocarcinoma in a 68-year-old man (a–f). (a, b) MRI images of the nodule in segment V. The nodule is about 17 mm in diameter; by transverse T1WI, the nodule is hypointense relative to the liver parenchyma; by transverse T2WI, the nodule is slightly hyperintense relative to the liver parenchyma. (c–e) The arterial, portal phase, and delayed phase show that the nodule has rim enhancement surrounding a hypoenhancing centre. (f) Histological examination was diagnostic of cholangiocarcinoma (hematoxylin–eosin-stained section, original magnification, ×100).
HHN can be classified into benign and malignant etiologies, including ICC, HM, HG, IPT, SNN, etc. [1–4,9, 10,16–20]. Malignant nodules usually appear with advanced age, immune liver disease, history of malignancy, etc. However, these clinical features may be insufficient indicators for differentiation. Therefore, MRI examination, because of its superior soft-tissue contrast, may play an important role in the diagnosis and differential diagnosis of solitary HHN.

Currently, ICC accounts for ~15–20% of all primary liver cancers and is the second most common primary...
hepatic tumor worldwide [17,18]. Histologically, ICC are adenocarcinomas emerging from the epithelial lining of the small intrahepatic bile ducts [19,20]. When visualized by MRI, because of the similarity of ICC to some benign lesions, it may lead to delayed cholangiocarcinoma diagnosis. The most common enhancement feature of ICC was a peripheral rim enhancement pattern during the arterial phase, followed by progressive and concentric filling with contrast material and patchy enhancement on delayed phases. This pattern was observed in 23 cases, corresponding well with the results of Kim et al. [21].

The cancers from the gastrointestinal tract often metastasize to the liver by the portal vein. HM develop during the course of the disease in up to 50% of colorectal cancer patients [3,22]. For surveillance of liver metastases, MRI plays a major role because of its superior diagnostic sensitivity and specificity when evaluating liver lesions [23, 24]. Yoon and Tanabe [25] and Choi et al. [26] reported that metastasis to the liver is the sole site of metastatic disease in 25–40% of colorectal cancer patients. In our study, 24 HM nodules showed peripheral enhancement such as HHN, which is in agreement with the report of Zech et al. [27].

Yun et al. [16] reported that 88% of HG smaller than 2 cm showed peripheral nodular enhancement with persistent hypodensity (even at 10 min) using two-phase spiral CT. Tiny enhancing dots in two-phase spiral CT corresponded well to the initial enhancing globsules in dynamic MRI. Although the nodules were up to 3 cm, 75% of the nodules in this study showed the same enhancement pattern as described previously [16]. In addition, central nodular enhancement, progressive range, and intensity of enhancement on delayed phase were observed in three HG, probably because of replacement of parts of the central sinusoids by fibrous tissue.

IPT and SNN can also present as HHN. Twenty-seven IPT and SNN in our study appeared to be heterogeneous, with mixed or patchy high signals on T2WI, which resulted from liquefaction or fibrosis in the nodule [11]. In our study, mild hyperintensity appeared only in IPT and SNN. Diverse enhancement patterns for IPT and SNN following the administration of Gd–diethyltriaminepentaacetic acid have been reported. Most reported IPT and SNN have been hypovascular, with limited or no appreciable enhancement at the arterial phase. Peripheral enhancement with a central nonenhancing core is a commonly reported morphological enhancement pattern [28,29]. Other morphological enhancement features may include nodular enhancement of the central core, thick irregular septations, and ‘stalactite’ marginal enhancement [30]. In this study, peripheral rim-like enhancement with central septum-like enhancement was observed in 27 cases, which was the most common enhancement pattern. In 20 cases, no enhancement of the central core was observed.

In our study, subcapsular nodules were more commonly observed in the benign group with HG, 17 cases, whereas IPT and SNN were observed in 22 cases. These observations are consistent with previous reports [31,32]. By contrast, smaller ICCs were located in the more central parts of the liver, whereas HM had no particular location preference.

As typically expected for HG, all 32 HGs showed markedly high signals on T2WI, whereas regional high T2WI signals appeared in nine HMs. Small solitary metastases were often misdiagnosed as HG. Motosugi et al. [9] reported that a bright signal on T2WI (94–98% in HG, and 13–25% in metastasis) and ring-like
enhancement (4% in HG and 58–60% in metastasis) were the independent findings suggesting HG and metastasis, respectively.

According to our data, 24 HG showed peripheral nodular enhancement. Yun et al. [16] reported that persistently hypotauenating small HG visualized by two-phase spiral CT should be considered tumors with large vascular spaces. In this study, 42 IPT and SNN showed peripheral enhancement, 38 cases of which had increasing enhancement in the delayed phase. Venkataraman et al. [33] used microscopy to show that this change in MRI appearance was because of expansion of the portal tracts caused by fibrosis and ablusive phlebitis of the large-sized and medium-sized veins caused by granulation tissue. These findings were visualized as perportal soft-tissue infiltration.

Kitajima et al. [34] found that HM contained central necrosis, an enhanced area of active tumor cells and a zone of peritumoral edema and congestion. These results explain the fact that HM nodules are often ill defined, with rim-like enhancement and decreased intensity of peripheral enhancement. In our study, a similar enhancement pattern appeared in 23 HM and 24 ICC. Several previous reports have described infiltration of the edges of lesions by tumor cells, resulting in the ICC enhancement pattern [6,8,13].

Zen et al. [31] reported that venous encasement in the nodule was frequently observed in SNN. Kim et al. [35] reported that 53% of ICC also showed venous encasement. We also found that two cases in the ICC group showed portal vein encasement. This encasement was likely because of infiltration of the tumor into hepatic vessels.

However, there are some limitations in our study. First, because it was a retrospective study, some inherent selection bias was present. Second, a precise correlation between imaging findings and histological composition was not made because of the lack of pathologic rereview and lack of surgical specimens from all patients. Third, surgical correlations were not available for all of our study patients. Many cases of benign nodules required no further invasive investigations or surgery. However, in these cases, we had a firm clinical diagnosis and imaging follow-up.

In conclusion, nodular lesions with imaging findings of subcapsularity, sharp margins, homogeneity, marked high signal intensity on T2WI, mild hyperintensity on T2WI, increasing intensity of peripheral globular enhancement, and persistence of central septum-like linear enhancement on delayed phase should be considered benign. The most common findings for malignant nodules were ill-defined margins, heterogeneity, decreasing intensity of peripheral rim-like enhancement, and centrally increasing intensity of patchy enhancement.

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Authors contributions: Shihong Li contributed equally to this work as the co-first author with Haizhen Qian. Haizhen Qian, data collection and processing, manuscript writing; Shihong Li, data collection and statistical analysis, manuscript writing; Ming Ji, data collection; Guangwu Lin, supervisor, project development, manuscript revision and submission.

Conflicts of interest

There are no conflicts of interest.

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