간 자기공명영상의 최신지견

울산대학교 의과대학 서울아산병원 영상의학과

원 형 진

New developments in liver MR imaging

Hyung Jin Won, M.D.

Department of Radiology, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea

국문초록

최근 간 자기공명영상(Magnetic Resonance Imaging, MRI)의 발전에 힘입어, 간 영상에서 MR의 중요성이 커지고 있다. 그 중에서 새로운 간세포 특이적 조영제인 gadoxetate (Gd-EOB-DTPA)는 기존의 비특이적 세포외액조영제의 역동적 영상뿐만 아니라 간세포의 기능적 영상을 함께 얻을 수 있어서 주목 받고 있다. Gadoxetate는 간 국소 병변의 특성화에 추가적인 진단적 가치를 보이며, 간세포암 등의 발견에 있어서도 다중검출 CT (Multidetector CT)보다 우수한 성적이 보고되고 있다. 또 다른 새로운 영상기법으로는 확산강조영상(Diffusion-weighted imaging, DWI)을 들 수 있다. 확산강조영상은 조직내의 물 분자의 확산 특성을 영상화하는 자기공명영상 기법이며, 간 국소 병변의 검출과 감별진단에 도움을 준다. 이 글에서는 gadoxetate와 확산강조영상의 기본원리를 소개하고, 간세포암에 대하여 영상 소견과 진단적 가치를 기술하고자 한다.

색인단어: 간 신생물, 자기공명영상, gadolinium ethoxybenzyl DTPA, 확산강조영상

Keywords: Liver neoplasms, Magnetic Resonance Imaging, gadolinium ethoxybenzyl DTPA, Diffusion Magnetic Resonance imaging
Introduction

Technical advances in magnetic resonance imaging (MRI) of the liver, in terms of hardware, software and contrast agents, have been made in recent years such that it now offers many advantages over computed tomography (CT) and ultrasonography (US) for liver imaging. In this article, among various new developments, new hepatocyte-specific contrast agent gadoxetic acid is presented with emphasis on detection and characterization of the common focal liver lesions including hepatocellular carcinoma (HCC). Furthermore, clinical value of diffusion weighted imaging in the field of liver MRI is discussed.

Gadoxetate-enhanced liver MR imaging

1. Overview of contrast agents for MR imaging

Non-tissue specific, extracellular gadolinium chelates were the first category of MR contrast agents approved for clinical use. Gadolinium chelates have an excellent safety profiles and lesion detection and characterization is based on tumor perfusion properties with dynamic imaging, which are similar to those seen with iodinated contrast agents used in CT. The other two categories of MR contrast agents are targeted to reticuloendothelial systems and hepatocytes, respectively. Superparamagnetic iron oxide particles (SPIO), such as ferumoxide and ferucarbotran is taken up by the reticuloendothelial systems (Kupffer cells in the liver) and produces a decrease in signal intensity on T2-weighted images, while tissue which do not contain RES cells remain unaffected. Hepatocyte-specific contrast media includes the gadolinium- and manganese based agents. The gadolinium-based agents have both hepatocyte and perfusion imaging properties. Gadobenate dimeglumine (Multihance®, Bracco, Milan, Italy; formerly known as Gd-BOPTA) and gadoxetate (Primovist®, Bayer-Schering, Berlin, Germany; formerly known as Gd-EOB-DTPA) are available in this category. The manganese-based agent mangafodipir trisodium (Teslascan®, GE Healthcare, Oslo, Norway; formerly known as Mn-DPDP) is predominantly a T1-shorting agent. With mangafodipir, tumors of non-hepatocyte origin show no enhancement, while hepatocellular lesions show uptake depending on the grade of differentiation.

2. Characteristics of gadoxetate

Gadoxetate (Gadolinium-ethoxybenzyl-diethylene triamine penta-acetic acid, Gd-EOB-DTPA; Primovist®, Bayer Schering Pharma, Berlin, Germany) is a hepatocyte-specific contrast agent that is eliminated in equal quantities by the urinary and biliary systems. Gadoxetate is specifically taken up by hepatocytes and thereby provides increased lesion-liver contrast not achievable with the extracellular gadolinium-based contrast agents. After bolus administration, dynamic T1-weighted GRE pulse sequences are obtained. Whereas only 4% of the injected dose of gadobenate is taken up by hepatocytes, 50% of the injected dose of gadoxetate is taken up by hepatocytes, reaching a plateau after a plateau
after approximately 20 min and lasting for approximately 2 h. Due to the small fraction of gadobenate taken up by the hepatocytes, the delayed phase MR acquisition is started at least 60 min after administration. Both gadobenate and gadoxetate have biliary excretion. Therefore a high degree of enhancement of the biliary tract is seen in the delayed phase images, especially after administration of gadoxetate.

3. Imaging features of focal liver lesions

With gadoxetate-enhanced dynamic imaging, the enhancement pattern of focal nodular hyperplasia (FNH) is very much like the enhancement pattern observed with non-specific gadolinium chelates. On delayed phase T1-weighted images, however, a substantial hepatocellular enhancement is noted within the lesion, while the central scar appears hypointense. Enhancement in the hepatocyte-specific phase after 20 minutes was observed in 90% of FNH in a multicenter trial. Iso- to hyperintensity in the hepatocyte phase after gadolinium injection allows differentiation between FNHs and hepatic adenomas.

The MR appearance of HCC is variable, but it is typically moderately hypointense on T1-weighted images and mildly hypointense on T2-weighted images. The pseudocapsule, if present, may be visible as a thin hypointense rim on T1-weighted images with mild hyperintensity on T2-weighted images. HCCs are in most cases hypervascular and therefore enhance strongly on arterial phase. A typical feature of HCC which helps differentiate dysplastic nodules from HCC is wash-out of contrast agent, which renders HCC hypointense on equilibrium phase images. Some severely dysplastic nodules, however, may also show intense early enhancement and may mimic early HCC. Gadoxetate has limitation in characterization of hepatocellular nodules in cirrhosis, because well-differentiated HCC and dysplastic nodules may show variable degree of contrast agent uptake in hepatobiliary phase.

High-flow hemangiomas might show relatively low signal intensity because of gadoxetate uptake in the surrounding normal liver parenchyma during the equilibrium (3-minute delay) phase. Such findings are called “pseudo washout” and can mimic hypervascular hepatic tumors such as HCC or hypervascular metastasis. However, high-flow hemangioma can be diagnosed by observing bright signal intensity on T2-weighted imaging and isointense or slightly increased signal intensity on subtraction images. Because of the absence of hepatocytes, hemangioma appears hypointense during hepatobiliary phase.

4. Diagnostic performance

Data suggest that the sensitivity of gadoxetate-enhanced MRI is significantly superior to multi-detector row CT for the detection of HCC. But some reports failed to show statistically significant difference. Gadoxetate-enhanced MRI during the hepatobiliary phase can identify small HCC lesions more clearly than dynamic-phase imaging or dynamic CT due to increased liver-lesion contrast after uptake of gadoxetate by functioning hepatocytes.
Diffusion weighted imaging (DWI)

DWI in the liver is a relatively new and increasingly used imaging technique in addition to conventional unenhanced and contrast enhanced MRI.\textsuperscript{17} DWI is an imaging technique which provides tissue contrast by the measurement of diffusion properties of water molecules within tissues. Diffusion is expressed in an apparent diffusion coefficient (ADC), which reflects the diffusion properties unique to each type of tissue.\textsuperscript{18} DWI proved to be helpful in the characterization of focal liver lesions, but should always be used in conjunction with traditional MRI since there is a great overlap between ADC values of benign and malignant lesions.\textsuperscript{19,20} DWI is useful in the detection of small HCC in the cirrhotic liver, with higher sensitivity, specificity and positive predictive value compared to conventional contrast enhanced MR imaging due to better lesion to liver contrast and background suppression of signals arising from vessels and bile ducts.\textsuperscript{21,22} This is also the case for the detection of metastases in the liver.\textsuperscript{23,24} However, it should be noted that DWI images are difficult to interpret since DWI is very sensitive to artifacts. DWI in the follow-up after RFA and TACE shows promising results in the detection of ablation site recurrences, especially in combination with conventional contrast enhanced MR imaging.\textsuperscript{25,26}

Conclusions

The new hepatocyte-specific contrast agent gadoxetate increases the diagnostic confidence of MR imaging for the characterization of focal liver lesions by providing additional functional information. Gadoxetate also seems to be superior in detecting HCC compared with MDCT. Diffusion-weighted imaging of liver is helpful in detection and characterization of focal liver lesions when used in conjunction with conventional contrast enhanced MR imaging.

REFERENCES