Clinical Radiology xxx (2018) 1–6

Contents lists available at ScienceDirect

Clinical Radiology

journal homepage: www.clinicalradiologyonline.net

Visual criterion for evaluating hepatobiliary phase image acquisition of gadolinium-ethoxybenzyl-diethylenetriaminepentaacetic acid-enhanced MRI

Y. Takatsu [a,c,*], M. Nakamura [b], S. Kobayashi [c], T. Miyati [c]

[a] Department of Radiological Technology, Tokushima Bunri University, 1314-1 Shido, Sanuki-city, Kagawa, 769-2193, Japan
[b] Department of Radiology, Otsu City Hospital, 2-9-9, Motomiya, Otsu-shi, Shiga, 520-0804, Japan
[c] Division of Health Sciences, Graduate School of Medical Sciences, Kanazawa University, 5-11-80 Kodatsuno, Kanazawa, 920-0942, Japan

ARTICLE INFORMATION

Article history:
Received 28 November 2017
Accepted 3 April 2018

AIM: To evaluate the hepatobiliary phase (HBP) of liver magnetic resonance imaging (MRI) using gadolinium-ethoxybenzyl-diethylenetriamine penta-acetic acid, and report a visual criterion based on the portal vein (PV), which can be used as a substitute for the quantitative liver–spleen contrast ratio (Q-LSC).

MATERIALS AND METHODS: In HBP images of 167 patients, a visual criterion was established based on the sufficient contrast between the liver parenchyma (LP) and PV. The Q-LSC was calculated for patients to assess whether the cut-off value of 1.5 was exceeded. The correlation between the signal intensities in the PV and tumours were determined and comparisons were made. The contrast between LP and the tumour was visually assessed with scores ranging from 1 to 3 defined as poor, fair, and good, respectively. The correlation between Q-LSC and quantitative liver–PV contrast ratio (Q-LPC) was also assessed.

RESULTS: The Q-LSC was <1.5 in all patients who did not meet the visual criterion. There was a strong correlation between the signal intensities in the PV and tumours ($r=0.72$), and no significant differences ($p=0.99$) were found between the signal intensities in PV and tumours by Wilcoxon's signed-rank test. Significant differences of all the combinations were found using Steel–Dwass multiple comparisons in the visual assessments of contrasts between LP and tumour. The correlation between Q-LSC and Q-LPC was strong ($r=0.82$).

CONCLUSIONS: The visual criterion based on the PV was suitable for the assessment of HBP images as a substitute for Q-LSC.

Introduction

Magnetic resonance imaging (MRI) of the liver involves the administration of gadolinium-ethoxybenzyl-diethylenetriaminepentaacetic acid (Gd-EOB-DTPA), a contrast medium that is selectively taken up by hepatocytes and distributed in the hepatic cells over time.[1] The degree of uptake of the contrast medium between the pre- and post-contrast phases depends on liver function[2–6] and the presence of uptake transporters.[7,8] Depending on the presence of transporters, a hepatic tumour is clearly visible as the signal intensity of the liver parenchyma increases.

* Guarantor and correspondent: Y Takatsu, Department of Radiological Technology, Tokushima Bunri University, 1314-1 Shido, Sanuki-city, Kagawa, 769-2193, Japan. Tel.: +81 87 899 7293; fax: +81 87 894 4201.
E-mail address: pcblue2@yahoo.co.jp (Y. Takatsu).

https://doi.org/10.1016/j.crad.2018.04.001
0009-9260/

According to previous reports, the degree of Gd-EOB-DTPA uptake in the liver depends on several factors.[9] A 10-minute delay for the hepatobiliary phase (HBP) after Gd-EOB-DTPA injection is sufficient for patients without a history of chronic liver disease.[10,11] Moreover, a 15- minute delay is sufficient for patients with mild liver dysfunction classified as Child–Pugh A; however, a delay longer than 5 minute for patients with moderate or severe liver dysfunction classified as Child–Pugh class B or C is meaningless.[12]

In another report, the hepatic parenchymal enhancement in patients with parenchymal liver disease on a 30-minute delayed image after EOB injection was greater than that on a 20-minute delayed image.[3] According to this report, it was surmised that if the delay time was extended, the parenchymal enhancement would be more sufficient than that on the 15- to 20-minute delay images of extended liver dysfunction cases, such as Child–Pugh B or C.

The degree of Gd-EOB-DTPA contrast enhancement during the HBP can be determined using the quantitative liver–spleen contrast ratio (Q-LSC).[5,13] A Q-LSC greater than the cut-off value of 1.5 has a higher sensitivity for the detection of hepatic lesions[13]; therefore, this score has been used as a cut-off value for evaluating HBP images. The Q-LSC is used when assessing the degree of Gd-EOB-DTPA uptake or deciding the length of the time until scan of HBP; however, measurements using the Q-LSC for setting a region of interest (ROI) can be cumbersome. Moreover, there may be individual differences while setting the ROI, and areas outside the ROI cannot be evaluated. Therefore, the Q-LSC may be difficult to use during an MRI study. Furthermore, the Q-LSC cannot be used for patients who have undergone a splenectomy and cannot be precisely calculated in patients with Gamna–Gandy bodies. In such patients, a ratio based on the portal vein instead of the spleen could be useful.[14] A previous study showed a strong correlation between the quantitative liver–portal vein contrast ratio (Q-LPC) and Q-LSC.[14] Therefore, focusing on the portal vein could be feasible for visual assessment; however, the cut-off value of the Q-LPC was not assessed. Moreover, the contrast of visual assessment between the liver and portal vein could be easier to visualise and semi-quantitatively understand than that of the ROI setting between the liver and spleen. Therefore, a suitable visual criterion that includes the contrast between the liver parenchyma and portal vein could be useful for performing visual assessments. The main purpose of HBP imaging using Gd-EOB-DTPA is to detect a tumour by creating a contrast between the liver uptake and tumour; however, Gd-EOB-DTPA in blood vessels washes out with time. Thus, data describing the association between signal loss in the portal vein and tumour are required along with the comparison data between the visual assessment of the tumour and Q-LSC; however, to the authors' knowledge, no such study has been reported to date. Similar to Q-LSC as an objective assessment, the visual criterion as a subjective assessment was evaluated on whether it corresponded with the required sensitivity for the detection of hepatic lesions. The value of these definitions differed between objective and subjective assessments; however, if the visual criterion corresponded with the Q-LSC, it could be used as a substitute for the Q-LSC. Therefore, to perform an easy evaluation of HBP images without ROI setting in the present study, a visual criterion was established and evaluated as a subjective assessment based on the portal vein that can be used as a substitute for the Q-LSC.

Materials and methods

Patients and clinical assessment

This retrospective study was approved by the ethics committee of Otsu City Hospital. Between April 2015 and September 2015, 198 consecutive patients (122 men and 76 women; mean age±standard deviation, 67.5±11.7 years) underwent liver MRI with Gd-EOB-DTPA. Of these patients, 31 were excluded according to the following exclusion criteria: presence of a diffuse tumour (n=8), splenectomy (n=3), hepatectomy (n=9), Gamna–Gandy bodies in the spleen (n=2), and movement artefacts (n=9). No patient had uptake lesions in the HBP.

The remaining patients (n=167) were included in this study. Of these patients, 29 had no chronic liver disease or pathology. The remaining patients had the following liver diseases: hepatitis B (n=27) or C (n=37), of whom 18 had liver cirrhosis; primary biliary cirrhosis (n=12); alcoholic chronic hepatitis (n=6); and chronic liver disease without hepatitis virus infection or alcohol abuse (n=74). The Child–Pugh classifications of their hepatic function were as follows: Child–Pugh class A, 31 patients; Child–Pugh class B, 134 patients; Child–Pugh class C, no patients; and Child–Pugh undetermined due to lack of laboratory data, two patients. Of the included patients, 74 had more than one tumour: hepatocellular carcinoma (n=34, including 10 patients with two lesions, five patients with three lesions, two patients with four lesions, and one patient with more than five lesions), metastasis (n=11, including four patients with two lesions and five patients with more than five lesions), and haemangioma (n=29, including three patients with two lesions, two patients with three lesions, one with four lesions, and two with more than five lesions). Forty-six patients had more than one tumour >10 mm in size: hepatocellular carcinoma (n=22, including three patients with two lesions), metastasis (n=10, including one patient with two lesions), and haemangioma (n=14, including four patients with two lesions). The total number of tumours was 54. The presence of tumours was confirmed using imaging analysis and diagnostic reports. Only haemangioma met all the following diagnostic criteria: characteristic contrasting pattern of dynamic images, remarkable high intensity of the T2-weighted image, high echoic image, and unremarkable size change at follow-up.

MRI

MRI was performed using a 3-T MRI unit (Ingenia, anterior coil; Philips Medical Systems, Best, the Netherlands) with fat-saturated three-dimensional

Please cite this article in press as: Takatsu Y, et al., Visual criterion for evaluating hepatobiliary phase image acquisition of gadolinium-ethoxybenzyl-diethylenetriaminepentaacetic acid-enhanced MRI, Clinical Radiology (2018), https://doi.org/10.1016/j.crad.2018.04.001