Usefulness of Magnetic Resonance Imaging with Dynamic Contrast Enhancement and Fat Suppression in Detecting a Pancreatic Tumor

Koji Murakami, Shigeru Nawano, Noriyuki Moriyama and Yutaka Onuma

Department of Radiology, National Cancer Center Hospital East, Kashiwa, Chiba, Japan

The purpose of this study was to compare the value of dynamic magnetic resonance imaging (MRI) and fat suppression in detecting a pancreatic tumor. The subjects were 19 patients with invasive ductal adenocarcinoma and six patients with islet cell tumor where diagnosis was established pathologically. Breath-hold gradient echo images, breath-hold gradient echo images with fat suppression and breath-hold gradient echo images with dynamic enhancement at 1.5 T were obtained for all patients. The efficacies of these three imaging techniques were compared by calculating the contrast-to-noise ratio, as indicative of conspicuousness between a tumor-affected and a normal pancreas. As for adenocarcinoma, our results indicated that the usefulness in detecting the tumor was high, decreasing in the order dynamic contrast images > fat suppression images > plain images, and that the difference between any two of these three types of image was statistically significant. On the other hand, these imaging techniques showed no statistically significant difference in detecting islet cell tumors. In conclusion, dynamic MRI is the best method for detecting pancreatic adenocarcinoma. As the fat suppression technique has the advantage of being non-invasive, this method is suitable for screening studies of pancreatic adenocarcinoma. However, no advantage was recognized in using the fat suppression technique for detecting an islet cell tumor in comparison with plain MRI.

Key words: magnetic resonance imaging – fat suppression – pancreas – adenocarcinoma – islet cell tumor

INTRODUCTION

Because of artifacts related to respiration and intestinal peristalsis, it is more difficult to obtain good quality abdominal images using magnetic resonance imaging (MRI) than using computed tomography (CT). It has also been reported that MRI is not very useful in the diagnosis of pancreatic disease (1–3). However, following recent advances in fast imaging techniques, it is now possible to obtain MR images while patients hold their breath. This technique has markedly reduced artifacts seen on MR images (4,5). Furthermore, the development of surface coils for MRI, which can be used in close contact with the abdomen, has markedly improved the signal-to-noise ratio (SNR) and thus increased the spatial resolution of MRI.

When CT or MRI is used for the detection of pancreatic disease, the most useful method has been shown to be a dynamic study that involves the rapid intravenous injection of contrast material and plain CT and MRI are less useful because of the poor contrast (6,7). On the other hand, plain CT and MRI still have the advantages of ease of use, low cost and lack of the side effects associated with the use of contrast material. Fat suppression MRI produces higher contrast images of the pancreas, without the use of contrast material. This plain MRI technique is expected to increase the ability to detect pancreatic lesions, as compared with the conventional plain MRI technique (5,8). We have recently compared the usefulness of conventional plain MRI, fat suppression MRI and multi-slice dynamic MRI in obtaining images of pancreatic tumors.

SUBJECTS AND METHODS

The subjects were 19 patients with invasive ductal adenocarcinoma of the pancreas and six patients with islet cell tumor. The average size of the tumor was 3.8 cm maximum diameter for the adenocarcinoma and 2.9 cm for the islet cell tumor. In all cases, a pathological diagnosis was confirmed by surgery or on the basis of biopsy findings. Islet cell tumor was classified as insulinoma in one case, glucagonoma in one case and
non-functional islet cell tumor in the other four cases. Because the fat suppression technique is not expected to improve the visualization of cystic components, cystadenocarcinoma was excluded in this study. MRI was performed with a 1.5 T superconducting magnet (Magnetom H15/SP4000; Siemens, Germany) using a flexible surface coil. Gradient echo imaging in the axial planes [repetition time (ms)/echo time (ms) = 160/6, matrix size = 160 × 256, field of view (FOV) = 250 mm, slice thickness = 6 mm and gapless, flip angle = 70°] was used for all plain MRI, fat suppression MRI and dynamic MRI studies. The number of images was smaller with fat suppression MRI (10 slices in plain and dynamic MRI, three slices in fat suppression MRI) because an off-resonance pulse for suppressing fat signal was added. All images were obtained while the patients held their breath, the time of which was 26.5 s in plain and dynamic MRI and 25.6 s in fat suppression MRI. The patients inhaled oxygen (3 l/min) prior to imaging to facilitate breath holding. For dynamic contrast images, meglumine gadopentetate (Gd-DTPA) (0.1 mmol/kg) was rapidly injected intravenously with a flush of 10 ml of physiological saline. Early phase images were obtained 20–25 s after Gd-DTPA injection and late phase images 5 min after injection. Since early phase in dynamic contrast images are known to be more useful than late phase images, only the early phase images were included in the evaluation.

Regions of interest (ROI) were designated in the tumor and the normal pancreatic parenchyma. The size of the ROI was 5–6 pixels (7.6–9.2 mm²). The ROI in the normal pancreas were settled in the proximal side of the tumor to avoid fibrotic changes due to obstructive pancreatitis. The contrast-to-noise ratio (CNR) for each ROI was calculated on the basis of the signal intensity. For each pulse sequence, the difference in CNR between three types of MR images was analyzed, using a t-test. The CNR was obtained by dividing the difference in signal intensity between the normal regions and the tumors by the background noise:

\[ \text{CNR} = \frac{S(A) - S(B)}{N} \]

where \( S(A) \) = signal intensity of the normal region, \( S(B) \) = signal intensity of the tumor and \( N \) = background noise intensity. A higher CNR indicates less noise and higher contrast, hence imaging techniques with a higher CNR are more useful.

RESULTS

INVASIVE DUCTAL ADENOCARCINOMA OF THE PANCREAS
(PANCREATIC ADENOCARCINOMA)

Fig. 1(a) shows the distribution of CNR for each type of imaging technique obtained in 19 cases of pancreatic carcinoma. The average CNR was 12.6 for early phase in dynamic contrast images [standard deviation (SD) = 6.3], 5.2 for fat suppression images (SD = 3.3) and 3.4 for plain images (SD = 2.0).

The difference between early phase in dynamic contrast images and plain images was 9.2 for the average CNR and 5.9 for the standard deviation of the CNR. When analyzed by a t-test, the CNR was significantly higher for dynamic contrast images than for plain images \((P < 0.001)\). It was also found that the CNR was significantly higher for fat suppression images than for plain image \((P < 0.01)\) and that it was significantly higher for dynamic contrast images than for fat suppression images \((P < 0.001)\). These results indicate that the usefulness in detecting pancreatic adenocarcinoma is high, decreasing in the order dynamic contrast images > fat suppression images > plain images, and that the difference between any two of these three types of images is significant [Fig. 2(a-c)].

ISLET CELL TUMOR

Fig. 1(b) shows the distribution of CNR for each type of imaging technique obtained in six cases of islet cell tumor. The average CNR was 4.6 for dynamic contrast images (SD = 4.0), 3.8 for fat suppression images (SD = 1.5) and 5.6 for plain images (SD = 3.6).

The difference between dynamic contrast images and plain MR images was 1.0 for the average CNR and 5.9 for the standard
deviation of the CNR. When analyzed by a t-test, the CNR did not differ significantly between dynamic contrast images and plain images.

The difference in CNR between fat suppression and plain images (1.8 and 3.2 for the average and standard deviation, respectively) or between dynamic contrast and fat suppression images (1.8 and 3.2 for the average and standard deviation, respectively) was not significant when analyzed using a t-test. Although the number of cases was small (only six), these results demonstrate that the usefulness in detecting islet cell tumor does not differ significantly among these three imaging techniques [Fig. 3(a–c)].

**DISCUSSION**

The use of MRI for the evaluation of abdominal disease has not become as widespread as its use for other areas of the body, because respiration-related artifacts are more conspicuous. However, recent developments in high-speed imaging techniques and surface coils has made it possible to obtain high-quality abdominal images during short breath-holding periods. Although the usefulness of CT in detecting lesions of the pancreas has been established, contrast material is still indispensable for detecting pancreatic tumors. Consequently, CT with contrast material is a relatively expensive and invasive technique. Moreover, CT involves the problem of X-ray exposure.

A great advantage of MRI is high contrast resolution without the use of contrast material and X-rays, but the ability to detect pancreatic lesions has been insufficient with conventional plain MRI (9). Therefore, if a new technique of plain MRI with a high lesion-detecting capacity is established, it will be suitable as a less invasive method than contrast-enhanced CT.

The present study was undertaken to assess the usefulness of fat suppression MRI in detecting pancreatic tumors. With the fat suppression method, the frequency of fat is attenuated specifically and the signals of water are enhanced. This technique suppresses the high signals of peritoneal fat and yields images with a wider dynamic range. On T1-weighted images, obtained with this technique, normal pancreatic parenchyma is depicted as a high-intensity area, contrasting greatly with the pancreatic tumor, which is depicted as a low-intensity area. This is because the pancreatic parenchyma, whose acini contain large amounts of water, is visualized as a relatively high-intensity area by this technique.

Although a few studies have reported the usefulness of fat suppression images in detecting pancreatic tumors (10), few have compared the usefulness of dynamic MRI, fat suppression MRI and plain MRI. Among these studies, Gabata et al. (11) compared the CNR between dynamic and fat suppression MR images, obtained for the diagnosis of pancreatic adenocarcinoma, and reported that the CNR was high, decreasing in the order dynamic MRI > fat suppression MRI > plain MRI, as observed in the present study. Some other reports have also suggested the usefulness of fat suppression MRI as a means of detecting pancreatic adenocarcinoma (5,8,12). It has therefore become
widely accepted that fat suppression MRI is useful in detecting pancreatic adenocarcinoma.

For detailed examination of pancreatic lesions, our study suggested that dynamic MRI was the best among the various MRI techniques because it has the highest CNR, so that there is little need to use fat suppression MRI in addition to dynamic MRI. The fat suppression technique seems to be most suitable as a means of screening outpatients for pancreatic lesions, because the features of this technique are simple and non-invasive without using contrast material.

When used for screening, a single application of fat suppression MRI had a shortcoming owing to its low specificity, because all abnormalities of the pancreas were revealed as a low signal area. A possible measure to improve the low specificity of the fat suppression technique is to combine it with magnetic resonance cholangiopancreatography (MRCP). MRCP can provide images of the pancreatic duct and cysts non-invasively, without using any contrast material. A number of recent reports have indicated the usefulness of this technique in detecting ductal carcinoma and cystic lesions of the pancreas which involve dilation of the pancreatic duct (13,14). A disadvantage of MRCP is that it can depict only the pancreatic duct or cysts and cannot reveal parenchymal changes of the pancreas. On the other hand, fat suppression MRI gives images of the pancreatic parenchyma. Consequently, it can be said that MRCP and fat suppression MRI are complementary techniques and, when combined, they result in an increase in both sensitivity and specificity in detecting pancreatic tumors. The time needed for this combination is only about 20 min. This combined technique is therefore promising as a screening test.

Fewer studies on the use of fat suppression imaging for detecting islet cell tumor have been carried out than on the detection of pancreatic adenocarcinoma. Semelka et al. (15) compared the usefulness of dynamic CT, dynamic MRI and fat suppression MRI in evaluating 10 cases of islet cell tumor. They found that T1-weighted, spin-echo fat suppression images were superior to the other images of gastrinoma in all cases, consisting of insulinoma in three of the four cases and glucagonoma in one of the two cases examined. Dynamic MRI was best in obtaining images of the remaining one case of insulinoma or glucagonoma. They concluded that dynamic MRI was most useful in detecting small tumors. However, our conclusions differ slightly from theirs. In the present study, dynamic MRI was most useful in three of the six cases with islet cell tumor and plain MRI was most useful in the remaining three cases. Fat suppression MRI was not regarded as very useful in any of these six cases. This discrepancy may be explained as follows. In the study by Semelka et al., the images were evaluated subjectively by the radiologists, with emphasis placed on contrast, whereas in our study the images

![Figure 3. A case of a non-functional islet cell tumor in the pancreatic body. (a) The plain MR image shows the tumor clearly (arrow). (b) The MR image with fat suppression shows a similar contrast of the tumor to the plain MR image. (c) The tumor is indistinct on the dynamic MR image. In this case, both MR imaging with fat suppression and dynamic MR imaging were inefficient.](image-url)
were evaluated on the basis of the CNR, an objective parameter reflecting both contrast and noise. The fat suppression technique has a wider dynamic range and depicts lesions in higher contrast to the surrounding normal tissue. This feature favors subjective evaluation. On the other hand, the fat suppression technique involves a relative increase not only in the contrast of lesions but also in noise. Consequently, the CNR for fat suppression images is sometimes lower than that for plain MR images, which is probably the reason why the CNR was relatively low in the present study.

Islet cell tumors are reported to be frequently hypervascular. In the present study, however, this tumor was hypovascular and its contrast was only slightly enhanced in half of the six cases examined. This may be the main reason why our study suggested that dynamic MRI is not so useful in detecting islet cell tumors and fat suppression and plain MRI are more useful than dynamic MRI. In previous studies in which islet cell tumors were found to be hypervascular, the subjects were often patients with functional islet cell tumors with hormonal activity. In the present study, on the other hand, islet cell tumors were often non-functional. This difference may be reflected in the different results for the early phase of dynamic contrast imaging, although no definite conclusion can be drawn at present because the number of subjects was small. This issue needs to be studied in additional cases, because the detection of non-functional islet cell tumors without symptoms will increase with advances in diagnostic imaging.

Acknowledgment

The study was supported in part by a grant-in-aid for Cancer Research from the Ministry of Health and Welfare of Japan.

References