Feasibility of the DWI and ADC value in differential diagnosis of pancreatic cystic lesions

Poster No.: C-0779
Congress: ECR 2015
Type: Scientific Exhibit
Authors: M. Osawa, K. Takeshita, S. Furui, T. Kanda, J. Kotoku, H. Oba, K. Toyoda; Tokyo/JP
Keywords: Abdomen, Pancreas, MR physics, MR, MR-Diffusion/Perfusion, CT, Efficacy studies, Imaging sequences, Cancer, Cysts, Pathology
DOI: 10.1594/ecr2015/C-0779

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Aims and objectives

- Diffusion-weighted imaging (DWI) has been reported to be useful for detecting several malignancies including breast cancer, hepatocellular carcinoma, pancreatic cancer, renal cancer, prostatic cancer, and ovarian cancer [1-7].

- Several reports have described the use of DWI for the differential diagnosis of malignant and non-malignant pancreatic cystic lesions (PCLs). However, its application is still controversial [8-12].

- The present study aimed to evaluate the utility of signal intensity on DWI and apparent diffusion coefficient (ADC) values of PCLs in the differential diagnosis of malignant and non-malignant lesions.
Methods and materials

Patients and PCLs

The institutional review board approved this study, waiving the requirement to obtain written informed consent. We studied retrospectively the preoperative MR images of 41 patients with 43 PCLs, who underwent surgical resections of the lesions between May 2009 and September 2013.

The 41 patients included 22 males and 19 females. The mean age was 64.8 years (range, 30 - 82 years).

The 43 PCLs were classified as malignant PCLs (n=14) and non-malignant PCLs (n=29) according to the pathological diagnoses (Table 1). Atypia and borderline malignant lesions were classified as non-malignant PCLs.

MR Imaging techniques

All MRI was performed with a 1.5 tesla MRI scanner (Magnetom Avanto, Siemens Healthcare, Erlangen, Germany) with a phased-array coil.

**Axial unenhanced T2-weighted images** (T2WI) were obtained with the following parameters: repetition time (TR) msec/echo time (TE) msec, 1560/107; flip angle, 140 degrees; slice thickness, 6 mm without gap; number of signals acquired, 1; and matrix size, 320#320.

**Axial unenhanced T1-weighted images** (T1WI) (Breath-hold in phase and out-of-phase) were obtained with the following parameters: TR/TE msec, 193/2.38; flip angle, 75 degrees; section thickness, 6 mm without gap; number of signals acquired, 1; and matrix size, 192#163.

**DWI** (Breath-hold) were obtained with the following parameters: TR/TE msec, 1300/75; slice thickness, 6 mm without gap; number of signals acquired, 1; and matrix size, 128#96. **ADC maps** were automatically created using two b values (0 and 800 s/mm^2). **Fat-saturated T1-weighted 3D dynamic contrast-enhanced imaging** (TR/TE msec, 4.0/1.5; slice thickness 3 mm; flip angle, 15 degrees; matrix size, 256#205) was performed after administration of 0.1 mmol/kg of Gadoteridol (ProHance; Eisai Co. Ltd., Tokyo, Japan) per kg of body weight at an injection rate of 1 ml/s, followed by a 20 ml saline flushing with a power injector. Arterial, portal, and delayed phase images were obtained serially 15 seconds, 50 seconds, 90 seconds, and 180 seconds after contrast injection.
For each sequence, a field of view of 32-38cm was used, depending on the size of the liver and pancreas.

**Image Analysis**

The following morphological features of PCLs were evaluated: location of the lesion in the pancreas (head, body, or tail), characteristics of cyst (solitary: one cyst, multiple: more than 2 cysts), the maximum diameter of cyst on T2WI, the maximum diameter of main pancreatic duct (MPD) on T2WI, presence or absence of solid portion showing contrast enhancement, and the signal intensity of PCLs on DWI. The signal intensity was visually assessed and classified as follows: hypointensity when the lesion signal intensity was mostly lower than that of the surrounding pancreas; isointensity when the lesion signal intensity was mostly similar to that of the pancreas; and hyperintensity when the lesion signal intensity was mostly higher than that of the pancreas. In addition, measurement of the ADC values was conducted on ADC maps with operator defined region-of-interest (ROI) measurements. The ROIs were placed covering the whole PCLs, and the minimum ADC values was recorded (Fig.1).

Two radiologists (M.O. and K.T., with 5 and 27 years of experience) evaluated the above factors by consensus.

**Statistical Analysis**

Welch two sample t-test was used to determine the statistical differences between malignant and non-malignant PCLs in age, size of cyst, diameter of MPD, and ADC values.

Fisher's exact test was performed to evaluate the statistical difference between malignant and non-malignant PCLs in sex, location (head, body, or tail), solitary or multiple, and presence of solid portion.

Chi-squared test was performed to evaluate the statistical difference between malignant and non-malignant PCLs in DWI findings.

The tree structure approach#Conditional inference trees, Hothorn et al. 2006# was also used to analyze the relationship between ADC values and the pathological diagnoses (malignant or non-malignant). The optimum cutoff ADC value for differentiation of malignant and non-malignant PCLs was estimated.

The sensitivity, specificity, and accuracy in differential diagnosis of non-malignant and non-malignant PCLs were evaluated for the factors that were statistically significant.
Statistical analyses were performed using the R software environment for statistical computing (version 3.0.1; http://www.r-project.org/). A $p$ value of less than 0.05 was considered statistically significant.
Table 1: Pathological diagnoses after surgical resections for 43 pancreatic cystic lesions (PCLs) comprising 14 malignant and 29 non-malignant PCLs.

<table>
<thead>
<tr>
<th>Pathological Diagnoses</th>
<th>Malignant</th>
<th>Non Malignant</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPMN (n=26)</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Pancreatic carcinoma (n=4)</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Mucinous cystic neoplasm (n=4)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Serous cystic neoplasm (n=3)</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Solid pseudo-papillary neoplasm (n=2)</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>(Epidermoid cyst, Neuroendocrine tumor, Pseudo-cyst, Hematoma) (n=4)</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>14</td>
<td>29</td>
</tr>
</tbody>
</table>
Fig. 1: A 78-year-old male patient with invasive ductal carcinoma derived from IPMN. The PCL (yellow arrow) was seen in the body of the pancreas on T2WI. The lesion (yellow arrow) showed hyperintensity on DWI compared with the surrounding pancreatic parenchyma. The minimum ADC value over the ROI (red dot circle) covering the whole PCL was measured as $1.06 \times 10^{-3}$mm$^2$/s.

© Radiology, Teikyo University School of medicine - Tokyo/JP
Results

Table 1 showed the pathological diagnoses of the 43 lesions with 14 malignant PCLs, 29 non-malignant PCLs (2 patients had 2 lesions).

Table 2 showed the results of the statistical analyses comparing malignant and non-malignant PCLs. Signal intensity on DWI, minimum ADC values and presence rates of solid portion were significantly different (P<0.01) between malignant and non-malignant PCLs. Typical cases of malignant and non-malignant PCLs were shown in figure 2 and 3, respectively.

Table 3 showed the signal intensity on DWI and ADC values of 43 PCLs.

The optimum cutoff ADC value was estimated to be $1.76 \times 10^{-3}\text{mm}^2/\text{sec}$ by the tree structure approach. Analysis of the 43 PCLs at the optimum cutoff ADC value classified the malignant and non-malignant lesions as significant ($p = 0.003$).

As for signal intensity on DWI, only 1 (5%) of 16 isointensity and 5 hypointensity lesions was malignant, while 13 (59%) of 22 hyperintensity lesions were malignant.

Five non-malignant lesions presented hyperintensity on DWI and ADC values below $1.76\times10^{-3}\text{mm}^2/\text{sec}$. They were solid pseudo-papillary tumor ($n = 1$), epidermoid cyst ($n = 1$), neuroendocrine tumor ($n = 1$), pseudo-cyst ($n = 1$), and hematoma ($n = 1$). Fig.4 and 5 showed 2 of these PCLs.

Table 4 showed the sensitivity, specificity, and accuracy of hyperintensity on DWI, low ADC value ($< 1.76 \times 10^{-3}\text{mm}^2/\text{s}$) and presence of solid portion in differential diagnosis of malignant and non-malignant PCLs. The diagnosability of both hyperintensity on DWI and low ADC value ($< 1.76 \times 10^{-3}\text{mm}^2/\text{s}$) was better than or equivalent to that of the presence of solid portion.
<table>
<thead>
<tr>
<th>Pathological Diagnoses</th>
<th>Malignant</th>
<th>Non Malignant</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPMN (n=26)</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Pancreatic carcinoma (n=4)</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Mucinous cystic neoplasm (n=4)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Serous cystic neoplasm (n=3)</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Solid pseudo-papillary neoplasm (n=2)</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Others (Epidermoid cyst, Neuroendocrine tumor, Pseudo-cyst, Hematoma) (n=4)</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14</strong></td>
<td><strong>29</strong></td>
</tr>
</tbody>
</table>

**Table 1:** Pathological diagnoses after surgical resections for 43 pancreatic cystic lesions (PCLs) comprising 14 malignant and 29 non-malignant PCLs.

© Radiology, Teikyo University School of medicine - Tokyo/JP
Table 2: Results of statistical analyses comparing malignant and non-malignant pancreatic cystic lesions (PCLs). The presence rates of solid portion, DWI findings and minimum ADC values were significantly different (P<0.01) between malignant and non-malignant PCLs. *Welch two sample t-test,**Fisher’s exact test,***Chi-squared test

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Malignant (n=14)</th>
<th>Non-Malignant (n=29)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age (range)</td>
<td>69.6(41-82)</td>
<td>62.2(30-82)</td>
<td>NS*</td>
</tr>
<tr>
<td>Sex (Male, Female)</td>
<td>8,6</td>
<td>16,13</td>
<td>NS**</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>9(64%)</td>
<td>15(52%)</td>
<td>NS**</td>
</tr>
<tr>
<td>Body</td>
<td>2(14%)</td>
<td>11(38%)</td>
<td>NS**</td>
</tr>
<tr>
<td>Tail</td>
<td>4(29%)</td>
<td>7(24%)</td>
<td>NS**</td>
</tr>
<tr>
<td>Characteristics of cyst</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solitary</td>
<td>8(57%)</td>
<td>11(38%)</td>
<td>NS**</td>
</tr>
<tr>
<td>Multiple</td>
<td>6(43%)</td>
<td>18(62%)</td>
<td>NS**</td>
</tr>
<tr>
<td>Size of cyst (mm)</td>
<td>38.4(15-110)</td>
<td>30.7(10-80)</td>
<td>NS*</td>
</tr>
<tr>
<td>Diameter of MPD (mm)</td>
<td>4.5(1.0-9.5)</td>
<td>3.3(1.0-9.5)</td>
<td>NS*</td>
</tr>
<tr>
<td>Solid portion</td>
<td>11(79%)</td>
<td>8(28%)</td>
<td>p&lt; .01**</td>
</tr>
<tr>
<td>DWI findings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypointensity</td>
<td>0</td>
<td>5(17%)</td>
<td></td>
</tr>
<tr>
<td>Isointensity</td>
<td>1(7.1%)</td>
<td>15(52%)</td>
<td>p&lt; .01***</td>
</tr>
<tr>
<td>Hyperintensity</td>
<td>13(93%)</td>
<td>9(31%)</td>
<td></td>
</tr>
<tr>
<td>Minimum ADC value (mm²/s)</td>
<td>1.35(1.01-2.20)</td>
<td>2.27(0.65-3.78)</td>
<td>p&lt; .01*</td>
</tr>
</tbody>
</table>
**Fig. 2:** A 41-year-old female patient with a mucinous cystadenocarcinoma. The lesion (white arrow) was seen in the body and tail of the pancreas on T2WI. The majority of the lesion (white arrow) showed hyperintensity on DWI compared with the non-tumorous pancreatic parenchyma (asterisk). The minimum ADC value of over the ROI (red dot circle) was measured as $1.32 \times 10^{-3}$mm$^2$/s. The low ADC value reflected the diffusion restricted area at the right side of the lesion (yellow arrow). The area corresponded well to the solid portion (red arrow) which showed contrast enhancement on gadolinium-enhanced T1WI.

© Radiology, Teikyo University School of medicine - Tokyo/JP
Fig. 3: A 68-year-old female patient with non-malignant IPMN (branch type). The lesion (yellow arrow) was seen in the tail of the pancreas on T2WI. The lesion (yellow arrow) showed isointensity on DWI compared with the non-tumorous pancreatic parenchyma (white arrow). The minimum ADC value over the ROI (red dot circle) was measured as $3.08 \times 10^{-3}\text{mm}^2/\text{s}$.
Table 3: The vertical axis was for the signal intensity on DWI, and the horizontal for the ADC values. Forty-three PCLs were plotted on it. Malignant PCLs were colored in red, and non-malignant in yellow. All but one of the 16 isointensity and 5 hypointensity lesions on DWI were non-malignant, while 13 of 22 hyperintensity lesions were malignant. Analysis of the 43 PCLs at the optimum cutoff ADC value of $1.76 \times 10^{-3}$mm$^2$/s classified the malignant and non-malignant lesions as significant ($p = 0.003$).
**Fig. 4:** An 82-year-old female patient with a solid pseudo-papillary neoplasm. The PCL was present in the body of the pancreas on T2WI (white arrow). The lesion (white arrow) showed hyperintensity on DWI. The minimum ADC value over the ROI (red dot circle) was measured as $0.81 \times 10^{-3}$ mm$^2$/s below $1.76 \times 10^{-3}$ mm$^2$/sec. Part of the lesion (yellow arrow) showed hyperintensity on T1WI, suggesting the presence of intra-tumoral bleeding.

© Radiology, Teikyo University School of medicine - Tokyo/JP
**Fig. 5:** A 41-year-old female patient with heterotopic spleen with epidermoid cyst. The lesion (white circle) was seen in the tail of the pancreas on T2WI. The majority of the lesion showed hyperintensity on DWI. The minimum ADC value over the ROI (red dot circle) was measured as 0.65 × 10⁻³ mm²/s and was below the cut off value of 1.76 × 10⁻³ mm²/sec. On pathological examination of the resected specimen, the hyperintensity area of the lesion on DWI corresponded to the pancreatic parenchyma, while the hypointensity area corresponded to an epidermoid cyst with high viscosity fluid. Similar findings have been reported in epidermoid cysts in heterotopic spleen[14,15].

© Radiology, Teikyo University School of medicine - Tokyo/JP
Table 4: The sensitivity, specificity, and accuracy of hyperintensity on DWI, low ADC value (< $1.76 \times 10^{-3}$ mm$^2$/s) and presence of solid portion in the differential diagnosis of malignant and non-malignant PCLs. The diagnosability of both hyperintensity on DWI and low ADC value (< $1.76 \times 10^{-3}$ mm$^2$/s) was better than or equivalent to that of the presence of solid portion.

© Radiology, Teikyo University School of medicine - Tokyo/JP
Conclusion

- Signal intensity on DWI and ADC values were useful in the differential diagnosis of malignant and non-malignant PCLs.

- In the differential diagnosis, diagnosability of both hyperintensity on DWI and low ADC value ($< 1.76 \times 10^{-3} \text{mm}^2/\text{s}$) was better than or equivalent to that of presence of solid portion.

- The 5 non-malignant PCLs showed hyperintensity on DWI and low ADC values ($< 1.76 \times 10^{-3} \text{mm}^2/\text{s}$). They were solid pseudo-papillary neoplasm, epidermoid cyst, neuroendocrine tumor, pseudo-cyst and hematoma. These lesions had specific conditions (e.g. bleeding, cellular debris, high viscosity) that produce both hyperintensity on DWI and low ADC values due to diffusion restriction.
Personal information

- Marie OSAWA MD, Department of Radiology, Teikyo University School of Medicine, Tokyo, Japan; funimaru@funimarun@funimarun@yahoo.co.jp
- Koji TAKESHITA MD, PhD, Division of Radiology, Tokyo Yamate Medical Center, Tokyo, Japan
- Tomonori KANDA MD, PhD, Department of Radiology, Teikyo University School of Medicine, Tokyo, Japan
- Jun'ichi KOTOKU PhD, Department of Radiological Technology Faculty of Medical Technology, Teikyo University, Tokyo, Japan
- Asako YAMAMOTO MD, PhD, Department of Radiology, Teikyo University School of Medicine, Tokyo, Japan
- Megumi MATSUDA MD, Department of Radiology, Teikyo University School of Medicine, Tokyo, Japan
- Hiroshi OBA MD, PhD, Department of Radiology, Teikyo University School of Medicine, Tokyo, Japan
- Keiko TOYODA MD, PhD, Department of Radiology, Teikyo University School of Medicine, Tokyo, Japan
- Shigeru FURUI MD, PhD, Prof, Department of Radiology, Teikyo University School of Medicine, Tokyo, Japan
References


