Pancreatic Masses: Does Diffusion Weighted MR Imaging Add to Contrast Enhanced CT in their Diagnosis and Staging?

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Abstract

Background: Pancreatic cancer is one of the most lethal human cancers that requires early diagnosis. Ultrasound, CT and MRI are different imaging modalities used for diagnosis of pancreatic masses. DW imaging can add to the diagnosis of pancreatic masses.

Objective: The purpose of the study is to compare between DW MRI (as a relatively recent modality) and CECT (as the standard protocol) regarding detection of pancreatic masses and proper staging. This would allow early detection of pancreatic cancer (for better therapeutic outcome) and accurate staging (for proper management) as a potential benefit.

Patients and Methods: 36 patients with clinical suspicion of having pancreatic pathology. Ages ranged between 38 to 86 years (mean age 55.2); 26 males & 10 females. CECT examinations were performed using 64 channels MSCT scanner (Toshiba). The MR examination was done using Philips 1.5 Tesla MRI (Intera). Diffusion imaging: using single-shot spin-echo planar imaging with \( b=0,500,1000 \text{mm/s}^2 \) and ADC maps were created.

Results: The sensitivity and specificity of DWI and CECT in detection of pancreatic masses reached 100% considering bulky pancreatic head as a positive result. Extension beyond the pancreas and nodal involvement were equally detected in both.

Liver metastasis was detected in sixteen cases (44.4%) by DWI, and only ten cases (27.8%) by CECT.

Conclusion: DWI can detect pancreatic masses with high accuracy. Moreover it can detect small liver metastasis in cases of pancreatic carcinoma with higher accuracy than the contrast enhanced CT. Therefore it can alter the staging of pancreatic masses.

Key Words: Pancreatic cancer – MRI imaging – CECT.

Introduction

PANCREATIC cancer is one of the most lethal human cancers and still represents a major unsolved health problem. The pancreatic cancer ranks 13th in incidence and the 8th as a cause of cancer death worldwide [1].

Surgical resection is the treatment of choice for patients with pancreatic cancer. It is currently the only potentially curative therapy. Unfortunately, most patients present with advanced disease at the time of diagnosis [2].

Currently CT scan is the preferred imaging modality used for the diagnosis and staging of pancreatic cancer. In addition to the evaluation of the primary tumor localization and size, CT is used to assess major vessels adjacent to the pancreas for neoplastic invasion or thrombosis, as well as distant or hepatic metastases, enlarged regional peripancreatic lymph nodes, invasion of retroperitoneal structures and intraperitoneal dissemination [3].

Ultrasonography, multidetector computed tomography (MDCT) and magnetic resonance imaging (MRI) are not satisfactory modalities for detection of pancreatic cancer at an early stage. New methods are required for early diagnosis [4].

Diffusion-weighted imaging in the abdomen and pelvis has been increasingly used since the 1990s with the development of stronger diffusion gradients, faster imaging sequences, and improvements in technology and magnetic resonance (MR) imaging instrumentation [5].

Diffusion-weighted magnetic resonance (MR) imaging allows the detection of focal solid and cystic lesions in the abdomen and pelvis and, is most effectively used in conjunction with other imaging sequences to avoid pitfalls [6].

In malignant lesions, the hypercellularity and larger volume cells lead to restriction of the free movement of water particles. This results in a
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Decrease in the ADC value and hyperintense signals on DWI [6].

Aim of the work:

The purpose of the study is to compare between diffusion weighted MRI (as a relatively recent modality) and contrast enhanced CT (as the standard protocol) regarding detection of pancreatic masses and proper staging to allow early detection of pancreatic cancer (for better therapeutic outcome) and accurate staging (for proper management).

Patients and Methods

This study was a prospective study performed between January 2015 and January 2016. The study included 36 patients. 26 males (72.2%) and 10 females (27.8%) with age ranged from 37 to 70 years, with mean age 53.5 years. They were referred to the radiology Department of Kasr El Aini hospital from the general surgery Department with clinical suspicion of having pancreatic pathology. 25 patients with obstructive jaundice, 15 patient with weight loss and 32 patient with epigastric pain radiating to the back.

The ethical committee of our institution approved the study. All patients signed consent of approval. The patients were subjected to thorough history, full examination, abdominal contrast enhanced CT and diffusion weighted MR imaging. These patients underwent diagnostic percutaneous or endoscopic biopsy (28 cases), pancreatic surgery (10 cases) or follow-up in inflammatory cases.

Inclusion criteria:
- Obstructive jaundice.
- Epigastric pain, vomiting and Weight loss.

Exclusion criteria:
- High serum creatinin >2mg/dl.
- Patient with allergy to contrast media.
- Patients with cardiac pacemakers, cochlear implants, aneurysmal clips.

CT examination:

Equipment used:
- 64 channels MSCT scanner (Toshiba).

Patient Preparation:
- Oral Administration of 1.5 liter of the oral contrast (positive or negative) over 2 hours.
- Renal function tests.
- History for sensitivity to contrast media should be revised.

Image acquisition:

Scanogram:
- The patient was positioned supine comfortably on the CT couch with no movement in order to ensure that the planned scan region matched the region actually scanned.

Scanned region:
- From above the diaphragmatic copula to below the liver shadow.
- Injection of 80ml of the contrast material in the antecubital vein.
- The start of scanning was 60 seconds following the start of the contrast material injection.

MRI examination:

Equipment used:
- High field system (1.5 Tesla) magnet units (Philips intera) using a TORSO 16 channel coil.

Patient preparation:
- Patients were instructed to fast for 4 hours before the MRI examination in order to optimize visualization of the pancreaticobiliary tree.
- History for cochlear implants, cardiac pacemaker or aneurysmal clips should be revised.

MR protocol used:

Diffusion-weighted MR imaging was performed at our institution with single-shot spin-echo echo-planar imaging with a spectral presaturation attenuated inversion-recovery (SPAIR) fat-suppressed pulse sequence.

The parameters were as follows:
- Repetition time/echo time, 5000/80 msec; matrix, 156 x 192; section thickness, 6mm; gap, 1.8mm; field of view was adjusted to cover the whole liver and pancreas; free breathing; and b values of 0 and 500 and 1000 sec/mm².

Imaging evaluation:

The images obtained by the CT examinations and MR diffusion weighted imaging were evaluated for presence of a pancreatic mass, its size, peripancreatic infiltration, vascular invasion, nodal spread as well as distant liver metastases.

ADC calculation:

The mean ADC of each lesion detected was measured by drawing a region of interest over the lesion. The ROI was traced within the boundaries of the lesion using an electronic cursor. It was
manually placed such that it was smaller in size than the actual lesion and didn't include adjacent normal tissue.

**Statistical methods:**

Data were coded and entered using the statistical package SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 22. Data was summarized using mean, standard deviation, median, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data.

Comparison between ADC values in pancreatic lesions and normal pancreas was done using unpaired T test. For comparing categorical data, Chi square ($\chi^2$) test was performed. Exact test was used instead when the expected frequency is less than 5. ROC curve was constructed with area under curve analysis performed to detect best cutoff value of ADC for detection of pancreatic adenocarcinoma. $p$-value less than 0.05 was considered as statistically significant.

**Results**

There were 36 cases; 32 pancreatic adenocarcinoma, 2 lymphoma, and 2 inflammatory cases.

All of the studied cases were having pathologically proven pancreatic masses that were all detected by DWI MRI while thirty four (94.4%) were detected by CT as definite masses and two cases (5.6%) was described as bulky pancreatic heads and consequently the size of that pancreatic lesion couldn't be determined in the CT.

So the sensitivity and specificity of DWI and CECT in detection of pancreatic masses reached 100% considering that bulky pancreatic head is a positive result.

Thirty four out of the thirty six pancreatic masses were having size more than 2cm.

Twenty six cases (72.2%) of pancreatic masses showed extension beyond the pancreas. They were equally detected in CT and DWI.

Contrast enhanced CT revealed vascular encasement in eighteen cases (50%). DWI revealed vascular encasement in ten cases (27.7%), negative in twelve cases (33.3%) and was non conclusive in fourteen cases (38.8%).

Twenty four cases of pancreatic masses showed nodal involvement. They were equally detected in CT and DWI.

Liver metastasis was detected in sixteen cases (44.4%). They were all detected by DWI while contrast enhanced CT detected only ten cases (27.8%).

The mean ADC value of the pancreatic lesions was $1.09 \pm 0.23 \times 10^{-3}$ mm$^2$/sec. ADC values ranged between $0.78 \times 10^{-3}$ mm$^2$/sec and $1.72 \times 10^{-3}$ mm$^2$/sec. The mean ADC value of the normal pancreatic areas was $1.43 \pm 0.26 \times 10^{-3}$ mm$^2$/sec. ADC values ranged between $1.06 \times 10^{-3}$ mm$^2$/sec and $2.06 \times 10^{-3}$ mm$^2$/sec (Table 1).

The mean ADC value of pancreatic adenocarcinoma was $1.069 \pm 0.20 \times 10^{-3}$ mm$^2$/sec. ADC values ranged between $0.89 \times 10^{-3}$ mm$^2$/sec and $1.46 \times 10^{-3}$ mm$^2$/sec (Fig. 1). ADC value of lymphoma was $1.3 \times 10^{-3}$ mm$^2$/sec. ADC value of the inflammatory lesion was $0.83 \times 10^{-3}$ mm$^2$/sec (Table 2).

ADC values below $1.278 \times 10^{-3}$ mm$^2$/sec are considered for pancreatic adenocarcinoma with sensitivity of 88.9% and specificity of 71.4%. ADC values between $0.706 \& 1.016 \times 10^{-3}$ mm$^2$/sec are for pancreatic adenocarcinoma with 95% confidence (Table 3).

### Table (1): ADC values of pancreatic lesion and that of normal pancreas.

<table>
<thead>
<tr>
<th>ADC (lesion) ($x10^{-3}$ mm$^2$/sec)</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.09</td>
<td>1.05</td>
<td>0.78</td>
<td>1.72</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Table (2): ADC values of different pancreatic lesions.

<table>
<thead>
<tr>
<th>Pathology (MRI)</th>
<th>ADC (x10^{-3} mm^2/sec)</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenocarcinoma</td>
<td>1.069</td>
<td>0.2</td>
<td></td>
<td>1.042</td>
<td>.89</td>
<td>1.46</td>
</tr>
<tr>
<td>Chronic pancreatitis</td>
<td>.83</td>
<td></td>
<td>.83</td>
<td>.83</td>
<td>.83</td>
<td>.83</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>1.30</td>
<td></td>
<td></td>
<td>1.30</td>
<td>1.30</td>
<td>1.30</td>
</tr>
</tbody>
</table>

Table (3): Cut off ADC values of pancreatic adenocarcinoma.

<table>
<thead>
<tr>
<th>Area under curve</th>
<th>p-value</th>
<th>95% Confidence Interval</th>
<th>Cutoff value (x10^{-3} mm^2/sec)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound (x10^{-3} mm^2/sec)</td>
<td>Upper Bound (x10^{-3} mm^2/sec)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.861</td>
<td>.706</td>
<td>1.016</td>
<td>1.2785</td>
<td>88.9</td>
</tr>
</tbody>
</table>

Discussion

In our study both DWI and contrast enhanced CT detected all cases of pancreatic masses with sensitivity and specificity reached 100%. Only two cases had pancreatic mass of size less than 2cm denoting that symptoms appear late when the mass attains large size. Contrast enhanced CT described two pancreatic mass cases as bulky pancreatic head & the mass couldn't be clearly defined and needed other modality to confirm the presence of an actual pancreatic mass as in case 1 (Fig. 2).

Also there was no major difference with results of [7] in which DWI had a sensitivity and specificity of 96% and 98.6% for the detection of pancreatic adenocarcinoma. Only two cases of pancreatic adenocarcinoma were interpreted as undetermined with mild to moderate signal.

As regards peri pancreatic extension and nodal metastases, there was no difference in the results of both CT and DW MRI as in case 1 and case 2 (Figs. 2,3).

Concerning vascular encasement CT detected 18 cases with vascular encasement out of 36 cases. Six cases with no vascular encasement showed liver metastases. The aforementioned 24 cases were considered non resectable.

While CECT was conclusive in detection of vascular encasement and aided in decision making, diffusion weighted MRI was non conclusive in 14 cases.

Liver metastases were detected in 16 cases using DW MRI. On the other hand, liver metastases were detected only in 10 cases and were missed in 6 cases using CECT as in case 1 and case 3 (Figs. 2,4).

Despite of having non statistically significant difference between DW MRI and CECT concerning detection of liver metastases, those results agreed with [8,9] that the main limitation of helical CT in preoperative staging is a difficulty in revealing unsuspected tiny liver metastases.

Based on the results of [10] that there is no significant difference in the detection rate of liver metastases for contrast enhanced MRI compared to DWI as a stand alone sequence. The results of this study agreed with [8] in the superiority of contrast enhanced MRI over CECT in detection of small liver metastases.

They also showed that the ADC value of malignant pancreatic tumors were lower than that of the normal pancreas with mean values of 1.069±0.2x10^{-3} mm^2/sec and 1.43±0.26x10^{-3} mm^2/sec respectively as stated in Table (1). Such values were consistent with those of [11].

However, the ADC values of our results showed a difference compared with those of [12,13].

Their results were as follows:

- Huang et al., [11]: Mean ADC values for pancreatic carcinoma was (1.06±0.15) while normal pancreas mean ADC values were (1.47±0.18).
- Matsuki et al., [12]: Mean ADC values for pancreatic carcinoma was 1.43 ± 0.20 while normal pancreas mean ADC values was 1.90±0.05.
- Nikolaos et al., [13]: Mean ADC values for malignant pancreatic tumors was 1.40±0.30 while normal pancreas mean ADC values were 1.61.
(±0.25), 1.68 (±0.22) and 1.55 (±0.21) x 10⁻³ mm²/s for pancreatic head, body and tail respectively.

The absolute ADC values of the lesions were not similar among different studies, probably due to differences in the applied techniques including the used b values. However, they reported that mean ADC values of malignant pancreatic tumors were lower than that of normal pancreas as described before.

Although the statistical analysis in our study defined a cut off ADC value of about 1.278 x 10⁻³ mm²/sec below which the pancreatic lesion is considered pancreatic adenocarcinoma with sensitivity of 88.9% and specificity of 71.4% and ADC values between 0.706 & 1.016 x 10⁻³ mm²/sec are considered for pancreatic adenocarcinoma with 95% confidence. These results may be deceiving due to limited number of other pancreatic pathologies in our study.

Concerning the use of ADC number in differentiation between pancreatic adenocarcinoma and mass forming pancreatitis: There was only two cases of chronic pancreatitis in this study, as shown in case 4 (Fig. 5).

![Fig. (2): A female 42 years old with obstructive jaundice diagnosed as pancreatic adenocarcinoma. Axial CECT images show: (a) bulky pancreatic head with dilated CBD and no definite pancreatic head mass. No peripancreatic extension. Enlarged coeliac lymph node (curved arrow) No vascular invasion (arrow). (b) dilated intrahepatic biliary radicles and no liver metastases. T1N1M0, Stage IIb. (c,d) Axial ADC images &DWI (b1000) images show pancreatic head mass with restricted diffusion (arrow) and ADC value of 1.087 x10⁻³ mm²/sec. (e,f) Axial diffusion weighted (b1000) and ADC images show small liver metastasis (dashed circle) with restricted diffusion. It couldn't be appreciated in the CECT study altering the staging to T4N1M1, Stage IV.](image-url)
Fig. (3): A male 62 years old with obstructive jaundice diagnosed as pancreatic adenocarcinoma. (a) Axial CECT image shows hypodense pancreatic mass < 2cm in the uncinate process (arrow) with unclear surrounding fat planes. No pathologically enlarged lymph nodes, vascular invasion or liver metastases. Biliary stent is noted. T3N0M0, Stage IIb. (b) Axial DWI (b500) shows no vascular invasion (arrow). No liver metastases. (c,d) Axial DWI (b500) and ADC images show pancreatic mass in the uncinate process with restricted diffusion (arrow) and ADC value of 1.25 x10⁻³ mm²/sec. No pathologically enlarged lymph nodes. T3N0M0, Stage IIb.

Fig. (4): A male 57 years old presented with obstructive jaundice diagnosed as pancreatic adenocarcinoma. Axial CECT images show: (a) large pancreatic head hypodense mass (> 2cm) with a biliary stent and peripancreatic lymph nodes enlargement (arrow). (b) The pancreatic mass encasing & attenuating the superior mesenteric vessels (arrow). No liver metastases. T4N1M0 Stage III. (c, d) Axial ADC images and DWI (b500) images show large pancreatic head mass with restricted diffusion and ADC value of 1.46 x10⁻³ mm²/sec. (e) Diffusion weighted (b500) images show small hepatic metastasis (dashed circle) with restricted diffusion. It couldn’t be appreciated in the CECT study. T4N1M1, Stage IV.
However, in 2015 [14] acknowledged an overlap of ADC values between mass-forming pancreatitis and ductal adenocarcinoma that mirrors an overlap in histologic patterns thus presenting a major limitation of DW MRI in its inability to distinguish between them.

There were some limitations in this study. First, the study included very limited non malignant cases so no reliable specificity or negative predictive value can be calculated. Second the presence of respiratory motion-related artifacts was unavoidable in uncooperative patients with an irregular respiratory rhythm. These artifacts might cause errors to ADC value measurement.

References


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