



The efficacy of diffusion weighted imaging for detection of acute pancreatitis and comparison of subgroups according to Balthazar classification

PANCREAS

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ABSTRACT

Background/Aims: The aim of this study was to measure the apparent diffusion coefficient (ADC) values detected by diffusion-weighted imaging (DWI) in acute pancreatitis and compare them with computerized tomography (CT) findings in acute pancreatitis subgrouped by the Balthazar classification.

Materials and Methods: The study population included 50 patients diagnosed with clinical pancreatitis who were evaluated with both multidetector CT and magnetic resonance imaging (MRI) within 24 h of clinical presentation. We calculated pancreatic ADC values obtained from DWI ($b=0$ and $b=1000 \text{ mm}^2/\text{sn}$). These values were compared with their normal counterparts ($n=24$). The patients with acute pancreatitis were subgrouped according to the Balthazar classification. The mean ADC values were calculated in each subgroup, and they were compared with control ADC values.

Results: The mean pancreatic ADC values in acute pancreatitis ($1.19 \times 10^{-3} \text{ mm}^2/\text{sn} \pm 0.32$) was significantly lower than in the normal group ($1.78 \times 10^{-3} \text{ mm}^2/\text{sn} \pm 0.29$) ($p < 0.001$). In the subgroup analysis, ADC values in each group were significantly lower than in the control group ($p < 0.001$). In addition, as severity of pancreatitis increased according to the Balthazar classification, lower ADC values were noted.

Conclusion: DWI with MRI and ADC values are helpful in the diagnosis of all subgroups of acute pancreatitis. Due to the lack of CT findings in grade A patients, DWI may be helpful in the diagnosis in this group as well.

Keywords: Pancreas, pancreatitis, MRI, MDCT

INTRODUCTION

Acute pancreatitis (AP) is one of the most commonly observed pancreatic disorders. It is described as an acute nonbacterial inflammatory condition of the pancreas, and is caused by early activation of the digestive enzymes found in the acinar cells of pancreatic tissue. Although the clinical presentation varies widely between individuals, it is usually a self-limiting disease. However, almost 15-20% of cases may progress to involve local or distant extrapancreatic tissues and cause severe attacks associated with significant morbidity and mortality (1).

Owing to its varied clinical presentation, treatment of AP is highly dependent on the severity of the disease.

Therefore, grading of AP is mandatory to manage the disease appropriately. In clinical practice, there are many laboratory findings and scoring systems to predict the course of the disease (2). Both laboratory and radiologic studies are more important for stratifying the severity of AP than physical examination findings. Among radiologic studies, the Balthazar classification, which is based on computerized tomography (CT) findings of the disease, is commonly used to investigate and support the diagnosis and to predict prognosis (3). However, in this classification method, all AP grades have associated CT findings except for subgroup A (grade A); therefore, the diagnosis of grade A is established by clinical findings and laboratory results.

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Magnetic resonance imaging (MRI) has been shown to accurately diagnose AP, especially with advances in the technology for abdominal imaging. A recently applied method, diffusion-weighted imaging (DWI), is an MRI technique used to reveal molecular diffusion, which is the Brownian motion of the spins in biologic tissue. The apparent diffusion coefficient (ADC) is a quantitative parameter calculated from diffusion-weighted MRI (DW-MRI) and results from the combination of the effects of capillary perfusion and water diffusion in the extracellular extravascular space (4). DW-MRI holds great potential for abdominal imaging, in particular for detecting and characterizing focal lesions and evaluating diffuse parenchymal diseases for which current techniques are often inadequate. Recent studies have already shown the potential value of this method in the evaluation of various parenchymal diseases.

In the present study, we aimed to measure pancreatic ADC values detected by DW-MRI in AP. In addition, we compared the ADC values of the subgroups of the Balthazar classification. We also investigated the ability of ADC values to detect the severity of AP in all subgroups of the Balthazar classification including the Grade A classification.

MATERIALS AND METHODS

A total of 50 patients with the diagnosis of clinical pancreatitis were retrospectively included in the study after obtaining approval from the local ethics committee and informed consent from the patients. The presence of a history of pancreatic disorders including neoplasia, cysts, prior hepatic and gastrointestinal disease, pancreatic atrophy, and chronic pancreatitis were the exclusion criteria for the study. The clinical diagnosis of all the patients was established on the basis of the patient's clinical symptoms, physical findings, and elevated pancreatic enzymes. In this study, patients who had a biliary etiology indicative of pancreatitis underwent an MRI examination. Initially, the patients with AP were evaluated with a multidetector CT, and all of them were subgrouped into 1 of the 5 groups of the Balthazar classification (Figure 1). Then, all patients were examined using DW-MRI to assess the ADC value of their pancreas (Figure 2). The ADC values of the patients in each subgroup were compared with each other as well as with their normal counterparts. Both CT and MR imaging of the participants were performed within 24 h of their presentation. The control group for this study consisted of patients who had undergone abdominal MRI owing to suspicious adrenal and renal masses but who had no known pancreatic disorders.

In our study, CT examinations were performed with a 16-multi detector CT (MD-CT) scanner (Toshiba Activion, Tokyo, Japan). Contrast-enhanced CT examinations were used in the portal venous phase to demonstrate the inflammation in pancreatic tissue. CT was used for diagnosis and staging of AP.

Within 24 hours of CT examination, an MRI examination was performed using a 4-channel 1.5 Tesla MRI scanner (Achieva;

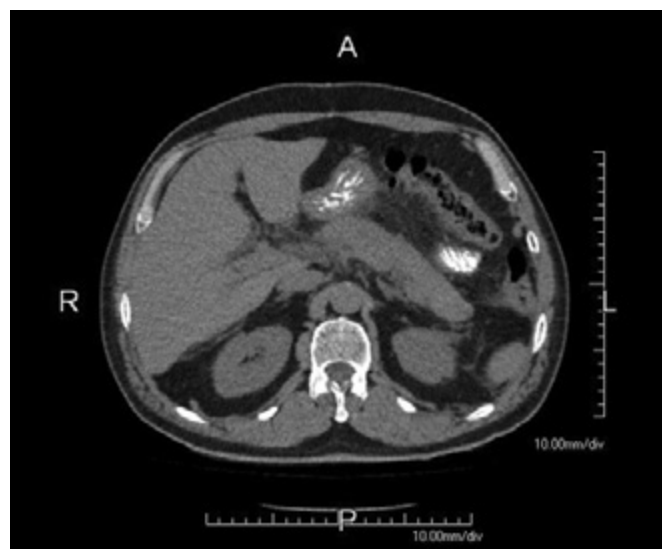


Figure 1. Grade C acute pancreatitis; MD-CT shows diffuse pancreatic enlargement and peripancreatic minimal inflammatory changes

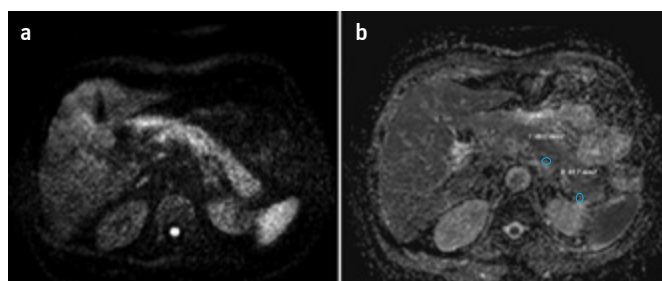


Figure 2. a, b. On DW-MRI; Diffuse restriction throughout the pancreas (a) and on ADC map low signal indicating the restricted diffusion (b).

Philips Medical Systems, Best, Netherlands) equipped with a high-performance phased array sensitivity coding (SENSE) body coil in the supine position. In addition to a routine abdominal MRI protocol, ADC values were calculated on each patient's DWI series.

Statistical Package for the Social Sciences 17.0 program (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Comparison of the ADC values between subgroups was statistically analyzed by Kruskal-Wallis and Mann-Whitney U nonparametric tests. A value of $p < 0.05$ was considered statistically significant at a 95% confidence level.

RESULTS

In total, 50 patients were enrolled in this study. There were 32 men and 18 women, and the mean patient age was 53.2 ± 8.4 years (range, 32-67 years). All patients with AP were subgrouped into grades A to E based on the Balthazar classification. There were 13, 11, 9, 8, 9 patients in subgroups A to E, respectively (Table 1). The control group consisted of 24 patients with suspected renal and adrenal masses.

The ADC values for patients with AP were lower than that of the controls (Table 1) ($p < 0.001$). When we compared the differences in ADC between subgroups of AP, the lowest ADC values

Table 1. Comparison of ADC values of the subgroups on the basis of Balthazar classification

	Patients (n=50)	Control (n=24)	p values
Grade A	1.45x10 ⁻³ mm ² /sn±0.24	1.78x10 ⁻³ mm ² /sn±0.29	<0.001
Grade B	1.36x10 ⁻³ mm ² /sn±0.21	1.78x10 ⁻³ mm ² /sn±0.29	<0.001
Grade C	1.24x10 ⁻³ mm ² /sn±0.26	1.78x10 ⁻³ mm ² /sn±0.29	<0.001
Grade D	1.04x10 ⁻³ mm ² /sn±0.14	1.78x10 ⁻³ mm ² /sn±0.29	<0.001
Grade E	0.89x10 ⁻³ mm ² /sn±0.18	1.78x10 ⁻³ mm ² /sn±0.29	<0.001

ADC: apparent diffusion coefficient

were found in grade E patients. The differences between ADC values of the Balthazar subgroups was statistically significant ($p<0.01$). ADC measurement in this study showed that there was a decline in ADC values as the severity of the disease increased (Table 1).

DISCUSSION

Acute pancreatitis is an emergent gastrointestinal disorder, which is observed in 1-8% of patients admitted to the emergency room complaining of abdominal pain (5). Its clinical presentation is heterogeneous, and the clinical course varies significantly between individuals. Although approximately 20% of patients experience a severe attack, most patients with pancreatitis have a mild disease course that is self-limiting and resolves spontaneously (6).

Early diagnosis, accurate staging, and immediate treatment may improve the outcome of AP (7). However, there is no single method to establish the diagnosis of AP or grade disease severity. Patient symptoms, physical findings, laboratory, and radiologic findings are used in clinical practice to grade the disease. Clinical signs such as epigastric pain are nonspecific and can be absent in up to 10% of patients with pancreatitis (8). Although serum lipase and amylase levels have commonly been used to diagnosis pancreatitis, they are normal in up to 20% of cases (5,7). Therefore, clinical and laboratory findings are not sufficient to establish an accurate diagnosis in clinical practice, but radiologic examinations are helpful for making the diagnosis and determining the severity of AP.

Among the radiologic studies, contrast-enhanced CT is the most commonly used radiologic tool to stage the disease and determine associated complications (9). It also provides a sensitive structural evaluation of the pancreas as well as identifying pancreatic and extrapancreatic inflammation, which is highly associated with a severe clinical course. In the literature, the diagnostic ability of contrast enhanced CT for the detection of parenchymal changes related to AP is as high as 90% (9,10). Balthazar et al. (3) developed a system for grading disease severity to predict clinical outcome based on CT findings. Elements of this grading system, which categorizes the disease into stages A through E, include the degree of pancreatic enlargement and inflammation, presence and number of fluid

collections, and degree of necrosis. In our study, all of the patients with AP were initially evaluated with contrast-enhanced CT to grade the severity of the disease according to the Balthazar classification. They were then treated accordingly.

Today, MRI has an expanded role in the radiologic investigation of abdominal pathologies. It can successfully reflect the functional as well as the morphological status of the parenchymatous organs (11). DWI is a new MRI technique that gives us information about the diffusion of water protons in vivo. Molecular diffusion is a physical process, which is related to the Brownian motion of water molecules within the tissues (11-13). However, it cannot be explained by this motion alone, and additional factors have been considered such as perfusion in the capillary network. DW-MRI yields ADC as a quantitative parameter, which reflects the microenvironment of diffusing water molecules (14-17). DW-MRI was initially used in the diagnosis of brain tumors and ischemia. Technological development in MRI led to DWI for the detection of pathology in various other organs, including the liver, kidney, and pancreas (18-20). Since the pancreas is an endocrine organ, it has a good vascular supply. Therefore, it is expected that the pancreas would have good diffusion characteristics that may provide useful insight into the functional status of different pancreatic diseases. Therefore, in the present study we measured ADC values to evaluate the impact of diffusion changes in AP.

In the literature, a limited number of studies have demonstrated successful application of DW-MRI in pancreatic diseases, especially in acute and chronic pancreatitis (21,22). Some authors have shown DW-MRI has a high sensitivity and specificity (100% and 73%, respectively) for differentiating chronic pancreatitis from a normal pancreas (23). In another study, Taniguchi et al. (24) reported lower ADC values in patients with autoimmune pancreatitis compared to patients with chronic pancreatitis and a normal pancreas. Some authors have reported the successful application of DW-MRI in AP (22,25), and, in our study, we found a similar efficacy of DW-MRI in the detection of AP. ADC values in all subgroups of the Balthazar classification were lower than their normal counterparts. In addition, ADC values differed between the Balthazar subgroups. Lower ADC values were noted in the more severe subgroups of pancreatitis. Different ADC values of the subgroups in this study also showed that DW-MRI can differentiate AP based on disease severity.

There is limited data comparing CT and MRI in the literature. Although contrast enhanced multislice CT (MD-CT) has traditionally been accepted as the method of choice for imaging AP in clinical practice, recent studies have reported a higher accuracy rate with MRI in AP. Authors have reported the superior sensitivity and specificity of MRI compared to MD-CT in severe cases of AP. In their study, authors accepted the Ranson's score as the gold standard, and they found that MRI detected severe AP with an 83% sensitivity and 91% specificity, whereas the sensitivity for MD-CT was 78% and its specificity was 86% (26). Likewise, Sa-

toshi et al. (25) also stated that DWI was a beneficial imaging modality for evaluating AP, and they claimed that DW-MRI has the potential to replace MD-CT as the primary diagnostic tool for AP. Our study was not designed to compare the efficacy between MD-CT and DW-MRI in patients with AP, and in the present study, both MD-CT and DW-MRI were effective in determining the severity of the disease. Lower ADC values were observed in the cases that were most severe according to the Balthazar classification. In addition, patients classified as grade A usually do not have radiologic findings on MD-CT; however, this study showed that both DW-MRI and a decrease in ADC value have the potential to indicate inflammatory changes in pancreatic tissues, even in Balthazar grade A patients.

Another important advantage of MRI for the diagnosis of AP is its ability to visualize the inflammatory changes associated with AP without the use of contrast materials. MD-CT can determine pancreatic and extrapancreatic inflammation, but contrast enhancement must be used (27). However, enhancement material has been reported to aggravate AP, and it can also lead to worsening renal failure related to AP (28).

Although our data confirms the ability to use ADC to assess pancreatic functional alterations, this study has some limitations. First, the study was designed as a retrospective analysis; therefore, a direct comparison between DW-MRI and MD-CT could not be performed. Secondly, each subgroup contained only a small number of patients, which may have led to biostatistical bias. Furthermore, because of the difference in imaging timing between MD-CT and DW-MRI, the severity of inflammation could have progressed, which may have caused technical bias. Despite these limitations, our results show how DW-MRI can be used to evaluate cases of AP, which has been the focus of a limited number of studies in the literature.

In conclusion, acutely inflamed pancreatic tissue has restricted diffusion that can be differentiated from normal tissue on DWI by an increased signal on DWI and decreased calculated ADC values. However, the diagnosis and staging of AP is mainly based on MD-CT, DW-MRI, and ADC values are beneficial radiologic tools. We think that DW-MRI can be especially beneficial in mild forms of AP because it reveals pancreatic and extrapancreatic changes. However, future clinical studies should be designed to compare the diagnostic accuracy of DWI with MD-CT and to investigate the role of ADC values as a prognostic indicator in AP.

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K.M.; Data Collection&/or Processing - E.Y., S.T., K.T., A.Ö., Ö.C., Ö.T., K.M.; Analysis&/or Interpretation - E.Y., S.T., K.T., A.Ö.; Literature Search - E.Y., S.T., A.Ö.; Writing - E.Y., S.T., K.T., A.Ö.; Critical Reviews - M.S., K.T.

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