ARAŞTIRMA MAKALESİ / *RESEARCH ARTICLE*

Abdominopelvic Pain: A Prospective Study of 137 Patients

Abdominopelvik Ağrı: 137 Olgunun Prospektif Çalışması

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ABSTRACT

Aim: *This prospective study aims to evaluate the role of diffusion-weighted magnetic resonance (DW-MR) imaging in patients presenting with acute abdominopelvic pain, who are decided a follow-up with conservative treatment after admission in the emergency department.*

Material and Method: *A total of 137 consecutive patients with various causes of acute abdominopelvic pain were followed-up with DW-MR imaging to monitor the response to medical treatment after a primary diagnosis made by combination of DW-MR imaging and computed tomography (CT).*

Results: *The demography of study population was as follows: mean age, 49.8; range, 19–84 years: 72 females, 65 males. For each follow-up DW-MR imaging review, the decision was made by three radiologists in consensus. All data regarding follow-up DW-MR imaging, clinical symptoms and laboratory results were documented. A total of 283 DW-MR scans were performed; 273 DW-MR scans were compatible with the clinical status, while 10 were disconcordant with the clinical status. 11 patients needed a CT scan and 16 patients underwent surgery.*

Conclusion: *DW-MR imaging is a non-invasive and efficient technique that may be used with confidence to monitor patients with non-operated acute abdominopelvic pain during follow-up.*

Key words: *acute abdominopelvic pain; computed tomography; diffusion-weighted magnetic resonance imaging; emergency department*

ÖZET

Amaç: *Bu prospektif çalışmada, difüzyon ağırlıklı manyetik rezonans (DAG-MR) görüntülemenin akut abdominopelvik ağrı ile acil servise baş vuran ve konservatif tedavi ile takip kararı verilen olgulardaki rolünün araştırılması amaçlanmaktadır.*

Materyal ve Metot: *Toplam 137 olguda DAG-MR ve bilgisayarlı tomografi (BT) kombinasyonu ile ilk tanı konulduktan sonra, takipte tedavi yanıtı DAG-MR ile değerlendirildi.*

Bulgular: *Çalışma popülasyonu; ortalama yaş 49,8, yaş aralığı 19–84, 72 kadın ve 65 erkek şeklinde idi. Takipte toplamda 283 DAG-MR tetkiki yapıldı. Bunlardan 273 tanesi klinik bulgular ile uyumluyken, 10 tanesi uyumsuzdu. 11 olguda BT ihtiyacı olurken, 16 tanesi opere edildi.*

Sonuç: *DAG-MR görüntüleme invazif olmayan, etkili bir yöntem olup akut abdominopelvik ağrılı olguların takibinde güvenli bir şekilde kullanılabilir.*

Anahtar kelimeler: *akut abdominopelvik ağrı; bilgisayarlı tomografi; difüzyon ağırlıklı manyetik rezonans görüntüleme; acil servis*

Introduction

Computed tomography (CT) has been used both as the primary diagnostic imaging method and follow-up imaging method for acute abdominopelvic pain. However, with increased demand of CT scans, concern has been put on limitations, especially those about radiation induced potential risk of malignancy, contrast induced allergic reactions, and contrast induced nephrotoxicity[1].

Ultrasonography (USG) is imaging method, generally as a first-line tool, in the most acute clinical managements, especially in children and pregnant women. On the other hand, it has some limitations in solving complex disease processes[2,3].

Magnetic resonance (MR) imaging has become an alternative imaging method for acute abdominopelvic pain in emergency departments. There are many reviews regarding the utility of MR imaging for assessment of acute abdominopelvic pain. The advantages of MR imaging include, being free of ionizing radiation and not using iodinated contrast agent[4–6].

Diffusion-weighted MR (DW-MR) imaging has been increasingly used for such emergencies. Diffusion relies on the priciple of different degrees of mobility of molecules, primarily water molecules, among different

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Geliş Tarihi: 21.05.2016 • Kabul Tarihi: 23.01.2017

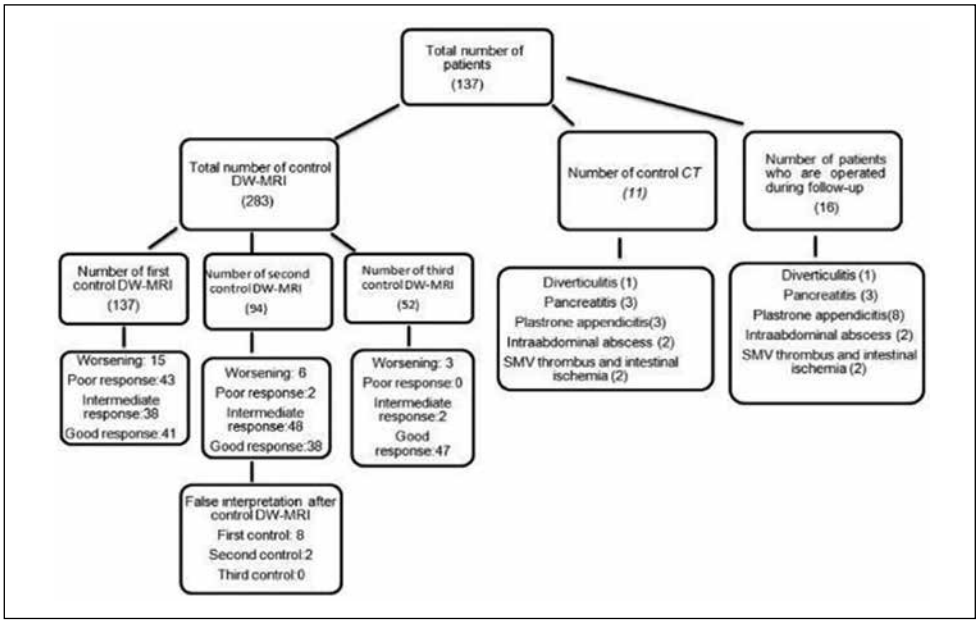

Figure 1. *Patient flow diagram (DW-MRI: diffusion weighted imaging, CT: computed tomography, SMV: superior mesenteric vein).*

tissues at cellular level. It is inversely related to cellularity, cell membrane integrity, and lipophilicity. Tumors, abscesses, fibrosis, and cytotoxic edema lead to restricted diffusion[7–9].

To our knowledge, this is the first study that analyses the utility of DW-MR imaging monitoring the non-operated patients with various causes of acute abdominopelvic pain to assess the response to medical treatment. We hypothesize that the use of DW-MR imaging for follow-up of non-operated patients with acute abdominopelvic pain can reduce unnecessary CT scans that might be needed in the follow-up, and thus reducing radiation dose. We also think that DW-MR is an efficient method of imaging for monitoring the response to medical treatment.

Material and Method

Patient Selection and Inclusion Criteria

Between October 2014 and May 2015, a total of 137 consecutive non-operated patients presenting with various causes of acute abdominopelvic pain were followed-up with DW-MR imaging to monitor the response to medical treatment after a primary diagnosis was made with the combination of DW-MR imaging and computed tomography (CT) in the emergency department. Acute abdominopelvic pain was characterized as a sudden pain starting within a few days with typical clinical and laboratory findings such as pain on palpation, rebound, and rise of the acute phase reactants with elevation of white blood cell count. In our study, we included clinically stable patients who were started medical therapy rather than emergency surgery by the desicion of attending surgeon in charge. Children under the age of 16, pregnant women, patients who underwent surgery after the initial diagnosis, extremely unstable patients, and those who were not suited for MR imaging (e.g. claustrophobia, pacemaker, rejected consent, etc.) were excluded from the study. All the patients were clinically stable and decided to be followed up conservatively. The study sample were as follows: mean age, 49.8; range, 19–84 years; 72 females (52.5%), 65 males (47.4%). The patient flow diagram is shown at Figure 1.

In the follow-up, all patients underwent DW-MR, varying from 1 to 3 times, and 11 of them (8%) needed a CT scan. Follow-up of these patients was discontinued after a two-months of non-symptomatic period. Approval from the hospital ethics committee and informed consents from all patients were obtained.

Imaging Protocols

DW-MR examinations were made on a 1.5-T MR imaging unit (Magnetom® Aera; Siemens, Erlangen, Germany). DW-MR imaging was performed on all patients after the first 10-days of medical treatment period.

The DW-MR protocol consisted of an axial diffusion-weighted single-shot echoplanar sequence with fat suppression, without breath holding (TR (time to repeat), 7500; TE (time to echo) 62–80 ms; matrix, 192x192; slice thickness, 5 mm; gap, 6 mm; FOV, 400 mm; PAT factor 2; b values: 0, 500, and 1000 s/mm^2; scanning time, 3 min). An additional DW-MR was performed on the patients who needed a control scanning after a 10-day period. The time for a control DW-MR scan ranged between 10 to 30 days. Patients who developed complications had an additional contrast enhanced CT scan. CT was performed with a 16-slice multidetector-row scanner (Toshiba Alexion™/Advance, Toshiba Medical Systems Corporation Nashu, Japan).

Image and Statistical Analysis

All examinations were reviewed prospectively in consensus by three radiologists with at least 5 years of experience in abdominal imaging interpretation. The readers were aware of the initial diagnosis and consecutive clinical-laboratory findings.

The DW-MR images were evaluated in an independent workstation (Syngo. via, Siemens). Three b values (0, 500, and 1000) were used, and on images with the highest b value, a bright signal was considered to be positive for regions of interest. Three different apparent diffusion coefficient (ADC) values were calculated using region of interest (ROI) placed centrally, and the mean was measured.

Follow-up DW-MR images were interpreted according to disease progress, and scored as those that have worsening, poor or little response, intermediate response, and those with good response. The parameters used for scoring were, the size and ADC values for the specific disease. Patients who developed complications had an additional contrast enhanced CT scan. CT was performed with a 16-slice multidetector-row scanner (Toshiba Alexion™/Advance, Toshiba Medical Systems Corporation Nashu, Japan) pathology on DW-MR scans. An increase of size with or without ADC decrement was accepted as worsening, a rate less than 10% decrease in size with little or no ADC increment was accepted as poor response, a decrease of size between 10–50% with ADC increment was accepted as intermediate response, and decrease of size more than 50% with ADC increment was accepted as good response. DW-MR was repeated after 10-day period when the response was either poor or little. A CT scan was performed when patients had clinical and laboratory worsening.

C-reactive protein (CRP) level, white blood cell (WBC) count, amylase level, urine analysis, fever, and abdominal pain were the major parameters used for assessment of the clinical status, depending on the pathology.

Results

The results are shown at Table 1. The mean follow-up time was 5.6±2.4 months (range: 2.1–10.8). After a 10-day period, all patients underwent DW-MR imaging. 94 patients needed a second DW-MR (68%), and 52 patients (37.9%) needed a third DW-MR, after a 10-day period. A total of 283 DW-MR scans were performed. The evaluation of treatment response with each DW-MR imaging were as follows: 1. worsening in 24 (8.4%), 2. poor or little response in 45 (15.9%), 3. intermediate response 88 (31%), and 4. good response in 126 (44.5%). 255 (90%) DW-MR scans revealed improvement compatible with the clinical status.[18] DW-MR scans (6.3%) showed worsening in concordance with clinical status. 6 (2.1%) and 4 (1.4%) DW-MR scans had worsening and improvement, respectively disconcordant with the clinical status. All patients who underwent a CT scan, had either poor-little or intermediate response on DW-MR imaging. A CT scan was performed on a total of 11 patients (8%). A total of 16 patients (11.6%) underwent surgery.

Discussion

A quick decision making on the basis of clinical and laboratory evaluation in acute abdominopelvic pain is essential to avoid unnecessary interventions as well as a delay of diagnosis of serious emergencies[10]. It has been reported that imaging in acute abdominopelvic pain increases the accuracy of the clinical diagnosis, influences decision making about management, and increases the diagnostic certainty in patients with acute abdominopelvic pain[11]. USG and CT are the most widely used imaging tools for acute abdominopelvic pain, both at presentation and in follow-up period.

Sonographer dependency, obesity, abdominal gas, and inefficiency to solve complicated disease processes are the disadvantages of USG. On the other hand, USG is a simple and cheap imaging method that is particularly useful in children and pregnant women[12,13].

Increased demand of CT scans in emergency departments has led concern on limitations, especially those about radiation induced potential risk of malignancy,

Table 1. *Diagnoses and imaging results of the patients*

Diagnosis	Number and frequency	DW 1.	DW 2.	DW 3.	Control CT	Surgery
Cholecystitis	26 (18.9%)	26 (1 W, 4 P, 7 Int, 14 G, 1 F)	12 (0 W, 0 P, 5 Int, 7 G, 1 F)	5 (0 W, 0 P, 0 Int, 5G, 0 F)	-	-
Pyelonephritis	20 (14.5%)	20 (0 W, 2 P, 6 Int, 12 G, 0 F)	8 (0 W, 0 P, 2 Int, 6 G, 0 F)	2 (0 W, 0 P, 0 Int, 2 G, 0 F)	-	-
Diverticulitis	19 (13.8%)	19 (2 W, 2 P, 8 Int, 7 G, 1 F)	12 (1 W, 0 P, 3 Int, 8 G, 0 F)	4 (1 W, 0 P, 0 Int, 3 G, 0 F)	1	1
Pancreatitis	15 (10.9%)	15 (4 W, 9 P, 0 Int, 2 G, 1 F)	12 (2 W, 0 P, 10 Int, 0 G, 1 F)	12 (2 W, 0 P, 0 Int, 10 G, 0 F)	3	3
Plastron appendicitis	15 (10.9%)	15 (2 W, 6 P, 7 Int, 0 G, 2 F)	15 (1 W, 1 P, 6 Int, 7 G, 0 F)	7 (0 W, 0 P, 2 Int, 5 G, 0 F)	3	8
Infammatory bowel disease	12 (8.7%)	12 (1 W, 9 P, 2 Int, 0 G, 1 F)	12 (0 W, 0 P, 10 Int, 2 G, 0 F)	10 (0 W, 0 P, 0 Int, 10 G, 0 F)	-	-
Intraabdominal abscess	10 (7.3%)	10 (2 W, 6 P, 0 Int, 2 G, 0 F)	8 (2 W, 0 P, 6 Int, 0 G, 0 F)	6 (0 W, 0 P, 0 Int, 6 G, 0 F)	2	2
SMV thrombus and intestinal ischemia	8 (5.8%)	8 (3 W, 3 P, 2 Int, 0 G, 2 F)	7 (0 W, 1 P, 4 Int, 2 G, 0 F)	4 (0 W, 0 P, 0 Int, 4 G, 0 F)	2	2
Mesenteric panniculitis	7 (5.1%)	7 (0 W, 1 P, 4 Int, 2 G, 0 F)	5 (0 W, 0 P, 1 Int, 4 G, 0 F)	1 (0 W, 0 P, 0 Int, 1 G, 0 F)	-	-
Epiploic appendagitis	5 (3.6%)	5 (0 W, 1 P, 2 Int, 2 G, 0 F)	3 (0 W, 0 P, 1 Int, 2 G, 0 F)	1 (0 W, 0 P, 0 Int, 1 G, 0 F)	-	-

DW: MR Findings, W: worsening, P: poor response, Int: intermediate response, G: good response, F: False interpretation

contrast induced allergic reactions, and contrast induced nephrotoxicity[1,14]. There are many studies in the literature pointing the importance regarding the attempts to reduce radiation dose in CT scans[15–18]. It seems logical that CT scans performed in the follow-up for monitoring some of the patients with non-operated acute abdominal pain, will increase the radiation exposure. This is the major concern pointed in our study.

Recent advances in MR imaging has led to increased number of use in emergency departments for acute abdominopelvic pain. Free of ionizing radiation and no need of iodinated contrast agent are the advantages of MR imaging[3,4,6,15,19,20]. DW-MR imaging in the abdomen is now widely used. DW-MR relies on the principle of different degrees of mobility of molecules, primarily water molecules, among different tissues at cellular level. Diffusion is inversely related to cellularity, cell membrane integrity, and lipophilicity. Restricted diffusion is observed in tissues with high cellularity (e.g. tumors, abscesses, fibrosis, and cytotoxic edema). The images are obtained in short intervals without the need of contrast agent. With generation of ADC maps, quantitative analysis can be made with different b values. At least 2 b values are needed for DW imaging analysis, and itis well known that the greater number of b values improves the accuracy of calculated ADC[6,19,21–24]. We used 0, 500, and 1000 as the standart b values in our study.

Our study population consisted of patients who were admitted to the emergency department, with a specific diagnosis as a cause of abdominopelvic pain made by both DW-MR and CT imaging. It was decided that these patients would be followed-up without the need of an operation at presentation. We aimed to follow-up these non-operated patients with DW-MR to monitor the response to medical treatment. All reviews were made with consensus by three radiologists. 11 of 137 patients (8%), who developed unavoidable clinical and laboratory worsening needed a CT scan. A total of 294 scans (283 DW-MR and 11 CT scans) were performed in the overall follow-up periods. Knowing the fact that only 11 CT scans (5.6% of total scans) were inevitable, it is obvious that we precluded most of the CT scans, thus reducing ionizing radiation.

In our study, in patients with superior mesenteric vein (SMV) thrombosis, DW-MR revealed both the thrombus and the ischemic changes of bowel, hence allowing to monitor the thrombus as well as the ischemia during thrombolytic and antibiotic medications (Figure 2). Our patients with plastron appendicitis were screened with DW-MR for optimum timing of operation (Figure 3). It was also found to be a good predictor for monitoring treatment response for pancreatitis (Figure 4).

This study has several limitations. Low spatial resolution of DW-MR imaging, short time interval for follow-up, and lack of use of another imaging modality for comparison were the major limitations of our study. We also haven not included other MR sequences that may provide morphological information which could have better idenified the lesion borders, especially with the use of IV contrast. However, the inclusion of other MR sequences would go against our aim in this study as we tried to implement the quickest MR method without the use of IV

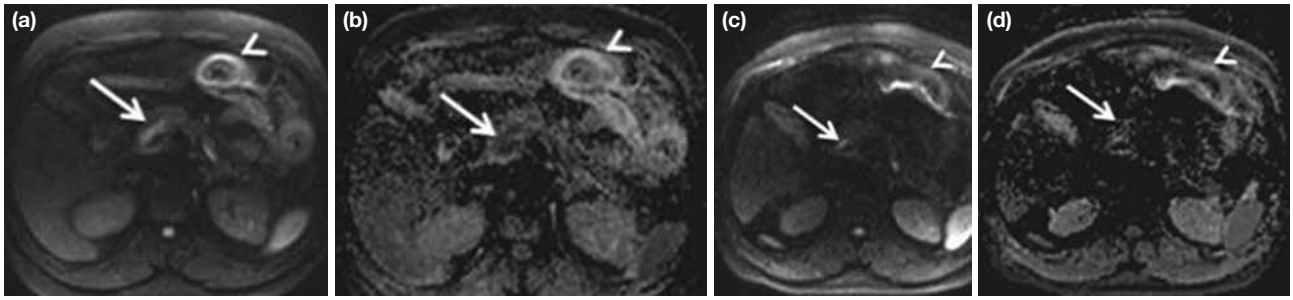

Figure 2. a–d. *A 43-year-old man presenting with abdominal pain, nausea and vomiting. The small bowel ischemia and acute portal vein-superior mesenteric vein thrombus (arrow) shows high signal intensity on axial diffusion-weighted MR image and corresponding low signal intensity on ADC map at presentation* ***(a, b)****. On follow-up axial diffusion-weighted MR images after medical treatment, lysis of portal vein-superior vein thrombus and healing of bowel wall (arrow head) is seen* ***(c, d)****.*

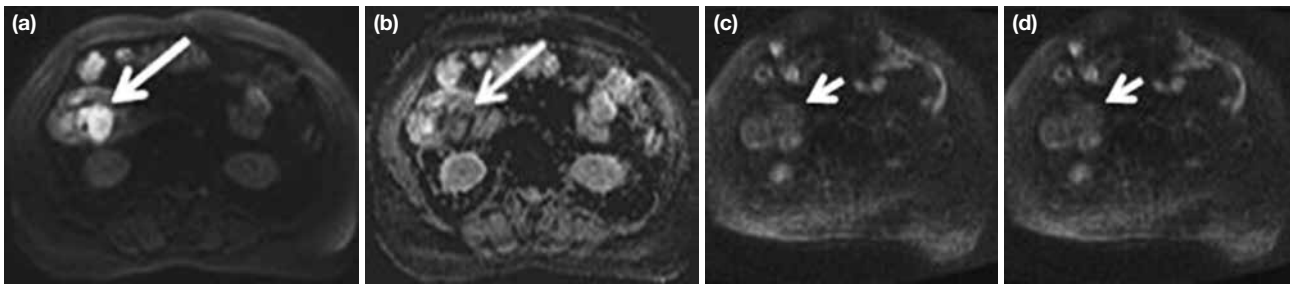

Figure 3. a–d. *A 72-year-old woman presenting with right-sided abdominal pain and leukocytosis (white blood cell count, 16.600/μL [reference value, <10.000/μL]). Initial diffusionweighted MR image and ADC map show pericecal abcess formation (long arrow) due to perforated appendicitis (Plastron appendicitis) that has markedly high signal intensity on diffusion image with corresponding low signal intensity on ADC map* ***(a, b)****. On control diffusion-weighted MR images after medical treatment the abscess has disappeared (short arrow)* ***(c, d)****.*

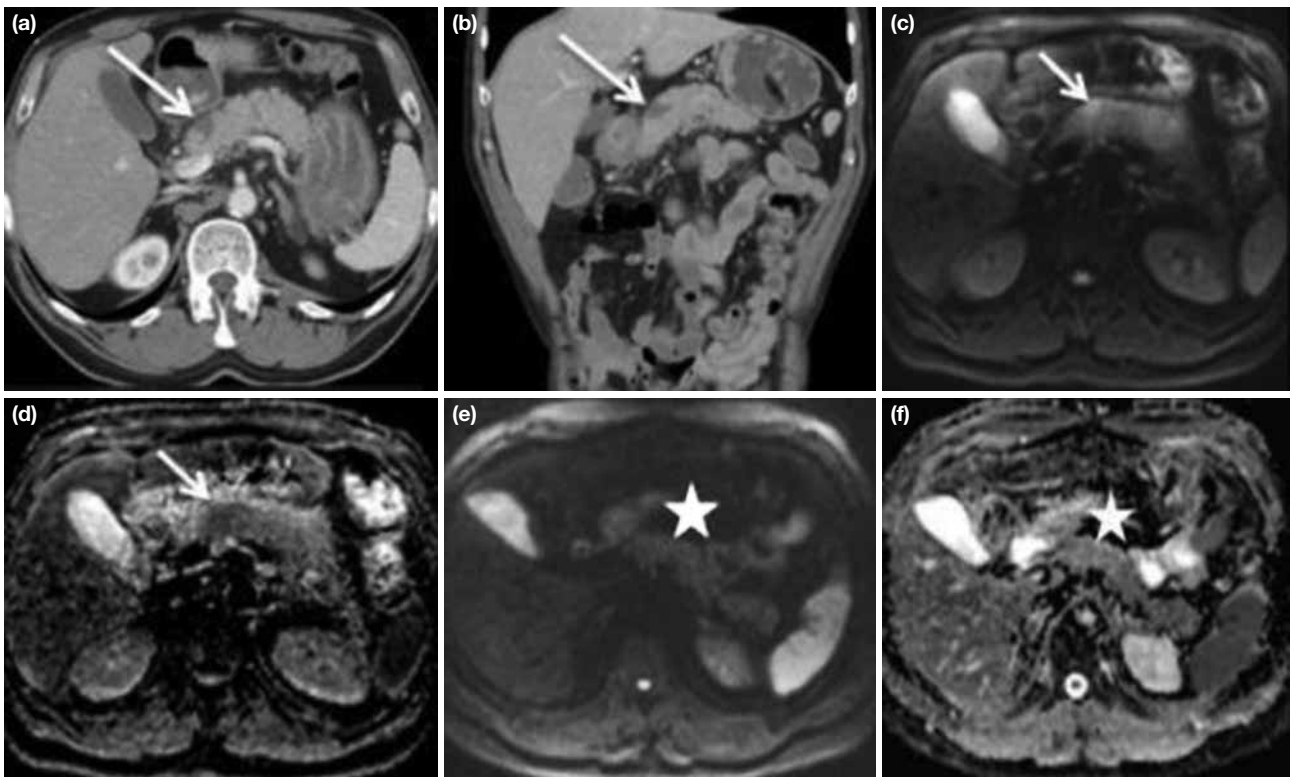

Figure 4. a–f. *Focal pancreatitis in a 55-year-old man. Contrast enhnaced CT shows a focal hipodense area (long arrow) at the body of pancreas compatible with focal pancreatitis* ***(a, b)****. Axial diffusion weighted MR image (b=1000 sec/mm2) shows the focal pancreatitis (short arrow) as a hyperintense area with corresponding hypointensity on axial ADC map (restricted diffusion)* ***(c, d)****. After medical treatment, follow-up diffusion weighted MR images show disappearance of diffuse enlargement of pancreas and focal pancreatitis (star)* ***(e, f)****.*

contrast media. We did not perform statistical analysis of changes in DW-MR and laboratory findings during follow-up period. This issue may be studied in the future with larger patient groups.

On the other hand, repeated MR scanning during follow-up may not be cost effective and practical as in many institutions the MR machine may not be available for 7/24 hours and MR imaging is much more expensive than USG and CT.

In conclusion, we suggest that DW-MR is an efficient and reliable imaging predictor for management and monitoring of medical treatment for various causes of acute abdominal pain. DW-MR does not have ionizing radiation and there is no need of contrast agent. It is clear that DW-MR can prevent unnecessary CT scans, and thus helps to reduce ionizing radiation and complications related to contrast agents.

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