# "DWI-MR AND ADC VALUE IN CHARACTERIZATION OF DIFFERENT PANCREATIC MASSES"

***Esam M Hemat & Ahmed A. Ismail***
Radiology department, faculty of medicine, Zagazig University

**Corresponding Author:**
**Esam Mohamed Hemat**

**e-mail adress:**
esamhemat@yahoo.com

**Mobile no : 01006359293**

## ABSTRACT

*Purpose:* Our work was aiming to assess DWI and ADC values in characterization of different pancreatic masses.

*Patients & methods;* This cross sectional study carried out on 20 patients (9 males & 11 females), with a mean age of 48 years (ranged from 35 years to 67 years), from December 2013 till October 2015. All the patients were referred from general surgery, internal medicine, oncology departments and outpatient clinics of Zagazig University hospitals to radiology department for conventional MRI, DWI & ADC mapping. All patients gave a written consent before scanning.

.*Results:* The mean ADC value of benign pancreatic masses was $2.49x10^{-3}$ $mm^2$/sec (at b= 1000 $mm^2$/sec) and $3.006\ x10^{-3}$ $mm^2$/sec.(at b= 500 $mm^2$/sec). The malignant pancreatic masses mean ADC value was 1.24x10-3 $mm^2$/sec (b= 1000 $mm^2$/sec) and was $1.34x10^{-3}$ $mm^2$/sec (b= 500 $mm^2$/sec). So, there is a significant difference between benign and malignant pancreatic masses and the mean ADC values of benign and malignant lesions done by using b=1000 are statistically higher than done by b=500. Sensitivity, specificity, PPV and NPV were 92.8%, 83.33%, 92.8%, 83.33% respectively at b value 500 $mm^2$/sec. However, sensitivity, specificity, PPV, NPV were 100%, 83.33%, 93.33%, 100%, respectively at b value 1000 $mm^2$/sec.

By using ADC cutoff value of $1.5x10^{-3}$ $mm^2$/sec in differentiating benign and malignant pancreatic masses, the *p* value was < 0.001 at b value 1000 $mm^2$/sec.

*Conclusion:* DWI has the advantage that it can be obtained without breath-holding, using respiratory triggered technique and it is simple and non-invasive. So, we recommend adding of DWI and ADC value in conjunction to conventional MRI as a useful modality in assessment and characterization of pancreatic masses, specially at b value 1000 s/$mm^2$ to get a highest sensitivity and specificity.

**Key words:** Pancreatic carcinoma; pseudocysts; MRI; DWI and ADC values.

## INTRODUCTION

Cancer pancreas is one of the most lethal human cancers and continues to be a major unresolved health problem at the start of the twenty one century [1]. Pancreatic ductal adenocarcinoma, which accounts for approximately 90% of all pancreatic neoplasms, is the fourth-leading cause of cancer-related deaths in the United States, with more than 37 000 patients dying of pancreatic cancer every year. Unfortunately, the prognosis is almost universally poor, with an overall 5-year survival rate of approximately 5% and a median survival of less than 6 months [2]. Incidence increases with age, and most patients are diagnosed with pancreatic adenocarcinoma after age 50 (median age at diagnosis is 71 years).

Pancreatic cystic lesions include various non-neoplastic and neoplastic cysts. Pancreatic pseudocysts represents about 85-90% of all cystic lesions of the pancreas [3]. Due to the possible malignant change of the pancreatic mucinous cystic neoplasms , careful and accurate diagnosis is mandatory to choose the optimal treatment for each patient [4].

Diffusion-weighted magnetic resonance imaging (DWI) is increasingly used in detecting and characterizing pancreatic lesions. DWI provides an additional information in evaluating patients with cystic or solid pancreatic neoplasms [5].

DWI could provide comparable performance to conventional MRI for the detection of neuroendocrine tumors and is particularly superior in detecting small (0.5–1 cm) and non-hypervascular lesions[6].

The principles of using DWI as a diagnostic modality in neoplastic masses is

based on the fact that, malignant lesions hypercellularity diminishes the extracellular space leading to restriction of free movements of water particles resulting in low ADC value and high intensity on DW images [7]. However, benign lesions are characterized by extracellular space expansion and hypocellularity, that facilitates water molecules diffusion, displaying it as high ADC value and DWI low intensity [7].

The aim of the study was to evaluate the role of DWI and measurement of ADC values in assessment and characterization of different pancreatic masses.

## PATIENTS & METHODS

### Patients

This cross sectional was compliant with our institution committee ethics and a written consent from all patients was taken. This study was carried out on a total of twenty patients (nine males & eleven females), with a mean age of 48 years (ages ranged from 35 years to 67 years), at radiology department of Zagazig University hospitals, from December 2013 till October 2015. All patients were referred from general surgery, internal medicine and oncology departments and outpatient clinics of Zagazig University hospitals.

***All patients were subjected to:***

**1) Full clinical assessment** by the referring physicians; laboratory investigations including Ca 19-9 and CEA.

**2) Radiological assessment:**

**# Conventional MRI:**

- All the cases examined by MRI using 1.5 Tesla superconducting MR imager (Philips- achieva), Netherland. All cases were examined in a supine position with a circulatory polarized body with small field of view and thin sections. Patients were instructed to hold breath to reduce respiratory artifacts during examination.
- T1WI and T2WI with fat suppression were obtained. After IV injection of contrast media either Omniscan or Magnivist [Gadolinium Diethelene Triamine Penta Acetic Acid ("Gd-DTPA'')] 0.1 mmol/kg., post-contrast fat suppression T1WI spin echo sequence was obtained in axial, coronal and sagittal planes. Examination was done by the following parameters: TR/TE of 500-600/8-9 ms for T1WI and TR/TE of 3000/ 100 ms for T2WI, with a field of view (FOV) of 22x25 cm , Slice thickness of 2-4 mm with 1-2 mm interval, and matrix of 256x256 for axial images.

**# Diffusion-weighted MRI & ADC mapping:**

All cases evaluated by DWI in axial planes with ADC map. A multi-section single shot echo-planar DWI sequence was done. Imaging parameters of DWI were as follows: repetition time (TR)/echo time (TE) = 3395/100 ms; slice thickness/ gap, 2-4 mm/1 mm; matrix 256 × 256; field of view (FOV), 23 × 25.5 cm; number of excitations (NEX) = 1. DWI acquired with a diffusion-weighted factor, using *b value* of 500 and 1,000 $mm^2$/sec. DWI can be obtained without breath-holding, using respiratory triggered technique. The average scan time was 35 sec.

**Post-processing:** DWI data were transferred to the workstation and ADC values were generated for all images.

**# Image Analysis:**

Signal characteristics on DWI and ADC maps were described as a hyperintense for bright and as a hypointense for those with low signal intensity compared to normal pancreatic tissue.

To calculate the ADC values, two or more regions of interest were placed in the lesions and their mean value was used to increase the reliability of the calculation. Care was taken to avoid the edges of the lesions to exclude the effect of partial volume averaging.

### Statistic analysis

Statistical analysis was done by SPSS programs (Statistical Package for the Social Science) version 18. Student *t*-test used to compare between benign and malignant lesions. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were performed to compare the signal characteristics of DWI images and ADC maps of benign and malignant pancreatic masses. The mean standard deviation (±SD) for ADC value measurements was done.

*P value >0.05* was non-significant.

*P value <0.05* was significant.

*P value <0.01* was highly significant.

## RESULTS

This study was carried out at radiology department of Zagazig University hospitals, from December 2013 to October 2015. Twenty patients (nine males & eleven females) were included, with a mean age of 48 years ( ranged from 35 years to 67 years) (table1).

Histopathologically, the patients were classified into two main groups: Group-I; benign lesions (6 cases) including 3 cases pancreatic pseudocysts (one of them was infected), one case pancreatic simple cyst(figure1), one case pancreatic abscess and one case focal pancreatitis & Group-II; malignant lesions (14 cases) including 12 cases pancreatic adenocarcinoma (figures 2,3,4), one case lymphoma and one case metastasis (table2).

Conventional MRI findings of all patients were summarized in table3.

In benign group (6 cases), there is one case false +ve and 5 cases true -ve at b value 500 & 1000. However, in malignant group (14 cases), there is 13 cases true +ve and one case false –ve at b value 500 & 14 cases true +v and no cases false –ve at b value 1000.

**Table (1):** Demographic data of the studied cases.

| | | Studied Group |
|---|---|---|
| | | N (20) |
| AGE | mean ± (SD) | 35-67 (48) |
| Sex | Male | 9 (45 %) |
| | Female | 11 (55 %) |

**Table (2):** Histopathological types of the studied patients.

| Lesions | No of patients | Lesions | No of patients |
|---|---|---|---|
| ***Group I* : benign** | 6 | ***Group II* : malignant** | 14 |
| Pancreatic pseudocyst | 3 | Adenocarcinoma | 12 |
| Pancreatic abscess | 1 | Lymphoma | 1 |
| Simple cyst | 1 | Metastasis | 1 |
| Focal pancreatitis | 1 | - | - |

**Tables (3):** All patients MRI findings.

| Lesions | No | T-1WI | T-2WI | Post-contrast |
|---|---|---|---|---|
| Pseudocyst | 3 (one infected) | All cases were hypointense (infected one is heterogenous) | All cases were hyperintense (infected one is heterogenous) | - |
| Abscess | 1 | Hypointense | Hyperintense | - |
| Simple cyst | 1 | Hypointense | Hyperintense | - |
| Focal pancreatitis | 1 | Isointense | Isointense | Homogenous enhancement pattern |
| Adenocarcinoma | 12 | All cases were hypointense | 9 hyperintense<br>2 isointense<br>1 hypointense | Poor early enhancement |
| Lymphoma | 1 | Hypointense | Hyperintense | Enhanced rim |
| Metastasis | 1 | Hypointense | Hyperintense | Homogenous enhancement |

The mean ADC value of benign pancreatic masses was 2.49x$10^{-3}$ $mm^2$/sec (at b= 1000 $mm^2$/sec) and 3.006 x$10^{-3}$ $mm^2$/sec (at b= 500 $mm^2$/sec) (table 4).

**Table (4):** ADC value of all patient at b 500, 1000 $mm^2$/sec.

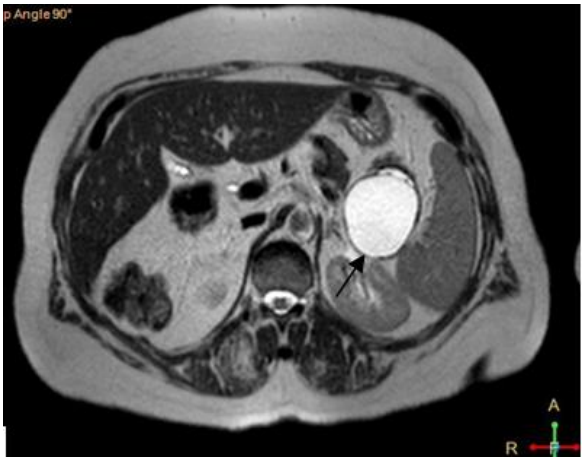
| Lesions | No | Mean ADC value x $10^{-3}$ $mm^2$/sec ( b = 500 $mm^2$/sec) | Mean ADC value x $10^{-3}$ $mm^2$/sec ( b = 1000 $mm^2$/sec) |
|---|---|---|---|
| Pancreatic pseudocyst | 3 | 2.94 (2.32-3.56) | 2.41 (2.12- 2.7) |
| Pancreatic abscess | 1 | 2.71 | 2.24 |
| Simple cyst | 1 | 3.51 | 3.01 |
| Focal pancreatitis | 1 | 1.49 | 1.39 |
| Adenocarcinoma | 12 | 1.32 (1.21-1.51) | 1.27 (1.01-1.44) |
| Lymphoma | 1 | 1.42 | 0.98 |
| Metastasis | 1 | 1,32 | 1.25 |

There was a significant difference between ADC values of benign and malignant pancreatic masses and the mean ADC values done at b=1000 was statistically higher than that done at b=500 (table 5).

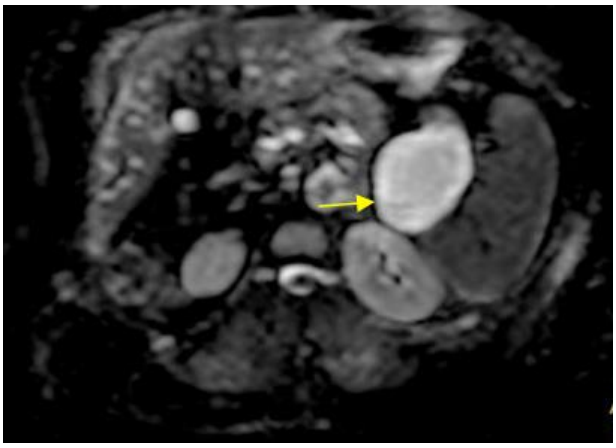
**Table (5):** ADC value, t-test and p-value of pancreatic lesions.

| | Benign (6) | Malignant (14) | t-test | p- value |
|---|---|---|---|---|
| Mean ADC value x$10^{-3}$ $mm^2$/sec (b=500 $mm^2$/sec) | 3.006 ( 2.31-3.56) | 1.34 ( 1.15- 1.52) | -4,5 | 0.001*** |
| Mean ADC value x$10^{-3}$ $mm^2$/sec (b=1000 $mm^2$/sec) | 2.49 ( 2.12-3.01) | 1.24 (1.01-1.49) | -2.09 | 0.002** |

(A)



(b)



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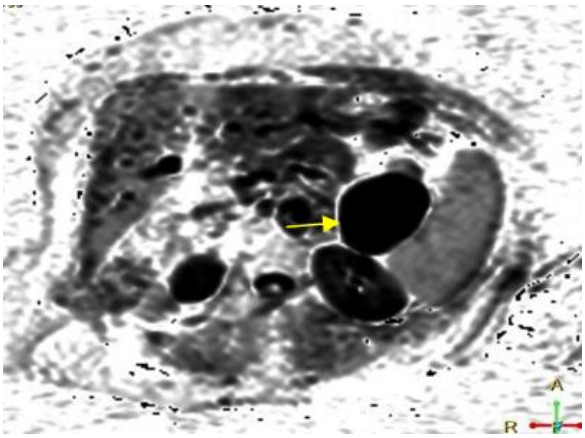
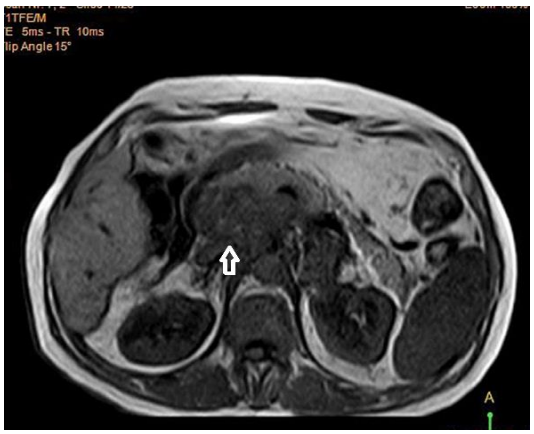


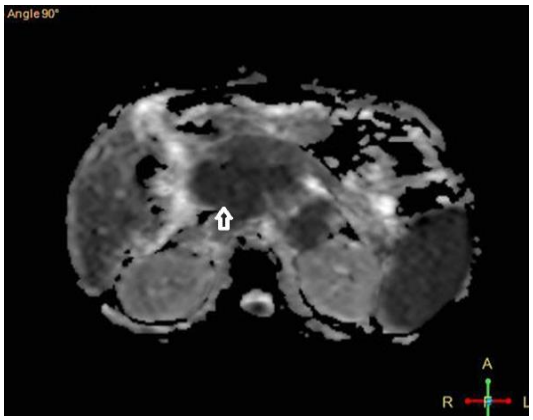
(d)

**Figure 1 (A-D):** Pancreatic cyst in a male patient presented with abdominal pain. (a) Axial T1WI shows a well defined cystic lesion at pancreatic tail displaying hypointense signals (b) Axial T2WI show homogenous hyperintense signals (c) Axial DWI at b value 1000, (d) Axial DWI with inverted black and white image contrast clearly show the pancreatic cyst (arrow). ADC value 3.01 $x10^{-3}mm^2$/sec at b=1000.




(a)


(b)

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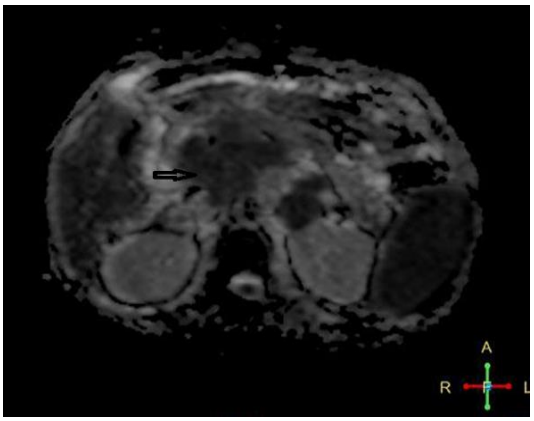


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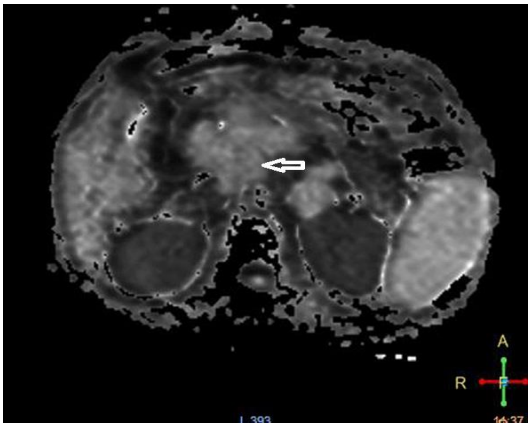
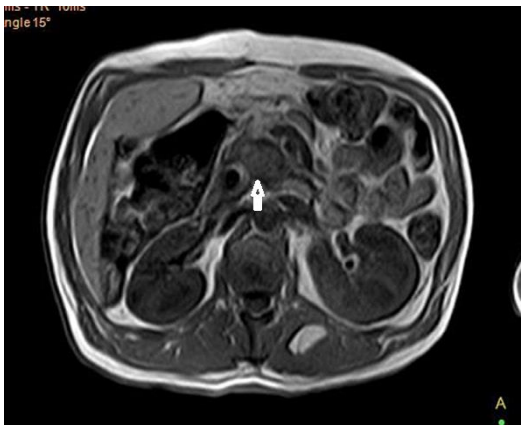



(e)

**Fig. 2 (A-E)**: Pancreatic adenocarcinoma in a male patient presented with weight loss and mild jaundice. (a) Axial T1WI shows a hypointense pancreatic head ill-defined mass (arrows), (b) Axial T2WI shows isointense pancreatic head mass,(c,d) axial DWI at b value 500 and 1000 respectively show low signal intensity denoting restricted diffusion,(e) ADC map shows hyperintense signal with ADC 1.21 $x10^{-3}mm^2$/sec at b value 1000.



(a)

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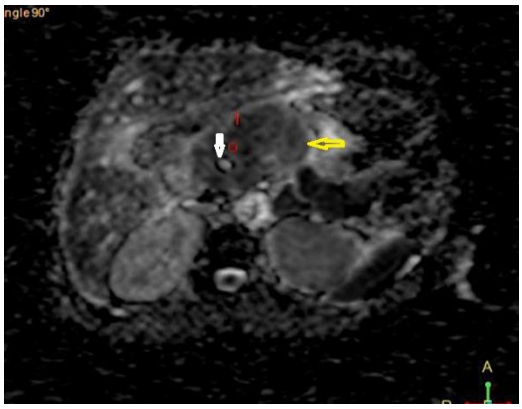

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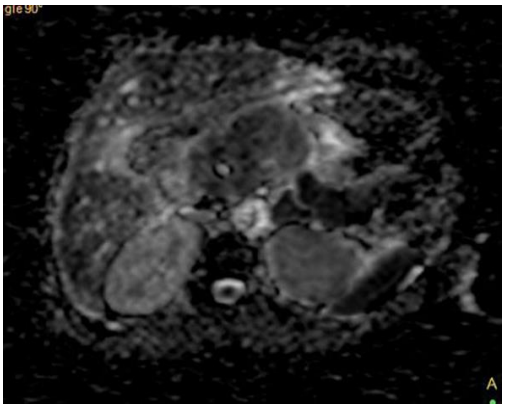
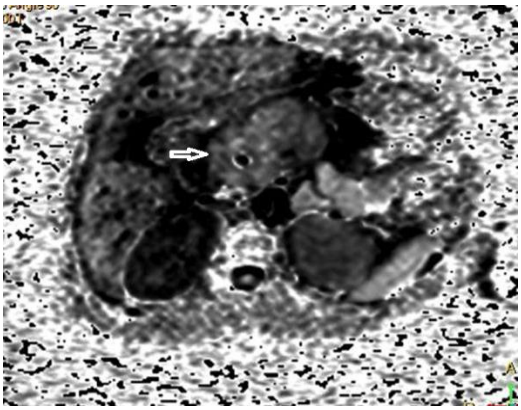


(d)



(e)

**Fig.3 (A-F)**: Pancreatic adenocarcinoma in a male patient presented with acute abdominal pain and jaundice (a,b) Axial T1WI and T2WI show a hypointense and iso to hypointense signal pancreatic head mass (horizontal arrows) with inserted stent (vertical arrow) inside CBD, (c,d) Axial DWI at b value 500 and 1000 show iso to hyperintense signal pancreatic head mass with high intensity stent,(e) Axial DWI with inverted black and white image contrast clearly depict pancreatic head mass with inserted stent (arrow). ADC value 1.03 $x10^{-3}mm^2/sec$.

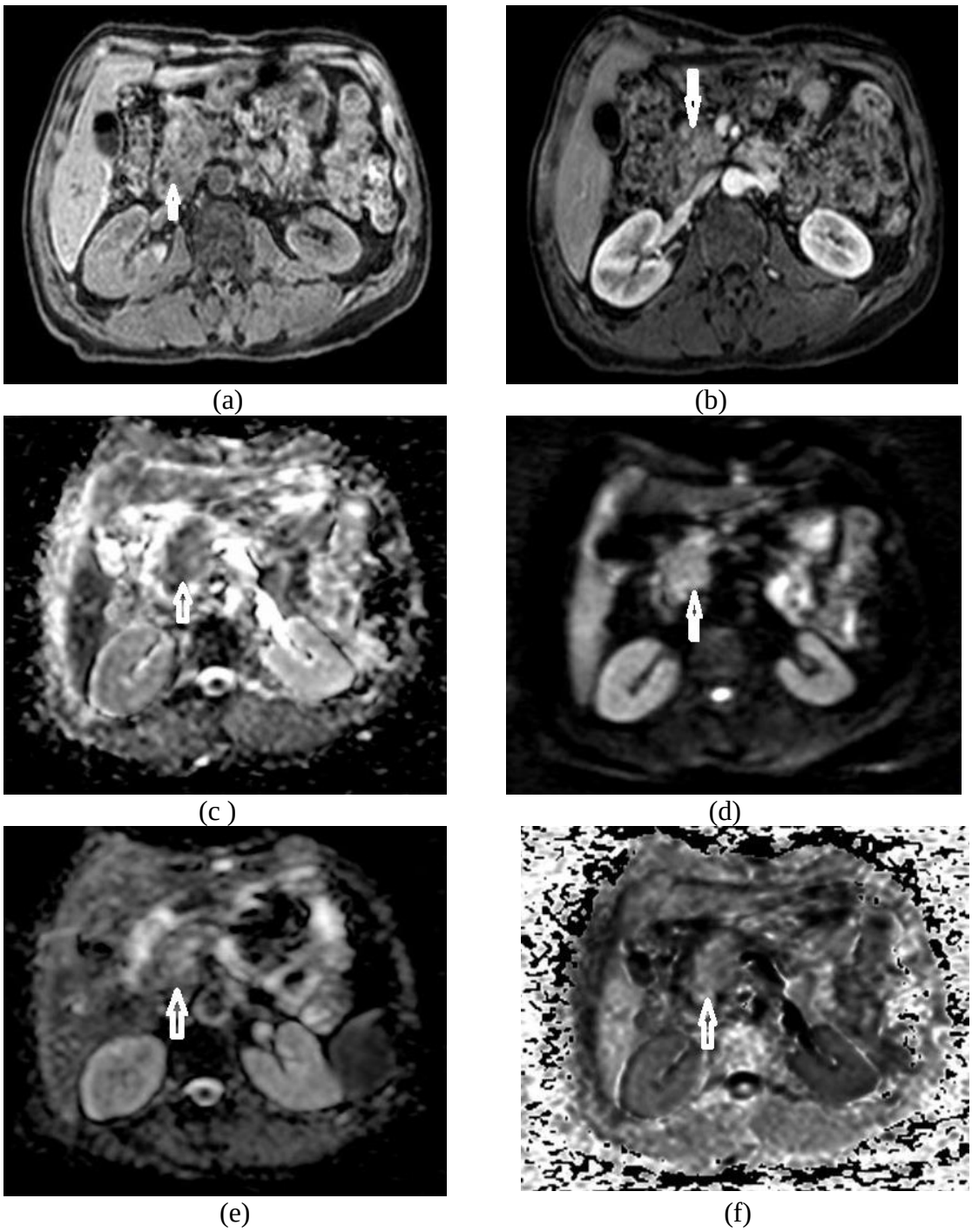



**Fig. 4 (A-F):** Pancreatic carcinoma in a female patient presented with weight loss and mild jaundice. (a,b) Axial T1W pre and post-contrast images show partially ill-defined pancreatic head mass (arrows) with a hypointense signal and poorly enhanced mass respectively, (c) Axial DWI at b value 500 shows hypointense pancreatic head mass, (d,e) Axial DWI and ADC at b value 1000 mild high signal and iso to low intensity respectively suggesting restricted diffusion (f) Axial DWI with inverted black and white image contrast clearly depict mass (arrow). ADC value 1.09 $x10^{-3}mm^2/sec$.

## DISCUSSION

Pancreatic carcinoma has unfavorable overall 5-years survival of about 5%, mainly due to a later diagnosis. At first time diagnosis, less than ten percent of patients are suitable for surgical resection [2,7]. The goal in evaluating pancreatic mass is to differentiate between benign and malignant pancreatic masses and to determine if malignant masses are resectable or not. So, the patient with pancreatic carcinoma can treated adequately at an earlier stage to minimize possible

mortality and morbidity, and avoiding unnecessary surgery in patients with benign nodules [8].

Radiologic examinations play an important role in characterization of pancreatic lesions. The sensitivity, specificity, and the detection of extrapancreatic extension, are generally superior with MRI, comparing with other imaging modalities [9, 10].

Our study included 20 patients with pancreatic masses. The most common age group from 50-60 years. This was going with the same findings of Ichikawa et al,2007[8].

In our study, the most common clinical presentation was abdominal pain, less common presentations were jaundice, anorexia, weight loss, or fever. This was going with the same findings of Inan et al., 2008[11].

DWI may provide additional information in assessing patients with different pancreatic neoplasms [5,13]. Also, Wang et al., 2011 reported that quantification of DWI as ADC value is useful in tissue characterization.

Pancreatic pseudocysts and pancreatic cysts tend to be hypointense relative to normal pancreas on T-1WI and hyperintense in T-2WI [13]. These results coincide with our results, as there were 3 cases pseudocysts and one case simple cyst were hypointense in T-1WI and hyperintense in T-2 WI.

The high DWI signal intensity of pancreatic abscesses is due to restricted diffusion, because abscesses have a viscous contents that reduce diffusion [14].

The most frequent pancreatic malignant tumors are adenocarcinomas [15,16]. Unfortunately, most of early and curable pancreatic adenocarcinomas are clinically silent and are presented with nonspecific symptoms [17].

Body MRI and DWI were increasingly applied in detection and characterization of pancreatic neoplasms [18-20].

DWI allows earlier detection of pancreatic adenocarcinoma, specially by using reduced FOV, since these neoplasms are hyperintense on DWI at high b value ( 500 or 1000 sec/mm$^2$) and of low ADC values due to reduced diffusion and fibrosis [5,6,21].

This was in agreement with our results, where 11 out of 12 pancreatic adenocarcinomas were high signal intensity at DWI and low signal intensity at ADC map with low ADC values.

In our results, one female patient was diagnosed as benign mass by using (b=500 mm$^2$/sec), as ADC value was 1.91x $10^{-3}$ mm$^2$/sec, however, the same lesion was diagnosed as malignant mass by using (b=1000 s/mm$^2$), with ADC value of 1.44 x$10^{-3}$ mm$^2$/sec. The lesion confirmed by histopathology as adenocarcinoma, a result that favor accuracy of b= 1000.

Our results showed that the mean ADC value of benign pancreatic masses was 2.49x$10^{-3}$ mm$^2$ /sec (at b= 1000 mm$^2$/sec) and 3.006 x$10^{-3}$ mm$^2$/sec (at b= 500 mm$^2$/sec) & the mean ADC value of malignant pancreatic masses was 1.24x10-3 mm$^2$/sec ( b= 1000 mm$^2$/sec) and was 1.34x$10^{-3}$ mm$^2$/sec ( b= 500 mm$^2$/sec).

Kartalis et al., 2009[7], found that the sensitivity, specificity, accuracy, positive and negative predictive values of DWI at b= 500, were 92, 97, 85, 98 and 100%.

Ichikawa et al., 2007[8], reported 96.2% sensitivity and 98.6 % specificity of DWI & ADC value in detection and characterization of pancreatic adenocarcinoma at b=1000.

Our results showed that the sensitivity, specificity, PPV and NPV were 92.8%, 83.33%, 92.8%, 83.33% respectively at b value 500 mm$^2$/sec. However, sensitivity, specificity, PPV, NPV were 100%, 83.33%, 93.33%, 100% respectively, at b value 1000 mm$^2$/sec. *P* value was < 0.001.

We found that, by using ADC cutoff value of 1.5x$10^{-3}$ mm$^2$/sec for characterizing benign and malignant pancreatic masses, *p* value was < 0.001 at b value 1000 mm$^2$/sec.

## CONCLUSION

DWI has the advantage that it can be obtained without breath-holding, using respiratory triggered technique and it is simple and non-invasive. So, we recommend using DWI and ADC value in conjunction to conventional MRI as a useful modality that aids in assessment and characterization of pancreatic masses with b value 1000 s/mm$^2$, as it has the highest sensitivity and specificity.

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