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MR Imaging of Pancreatic Lesions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aim: The aim of this work was to evaluate the role of MRI in differentiating between benign and malignant pancreatic lesions and its correlation with histopathological results as the reference standard.

Patients and Methods: This MRI study included 30 patients, 17 females and 13 males with a mean age 50 years. Sixteen patients had malignant masses (14 patients were adenocarcinoma, one patient was lymphoma and one patient was metastasis) and 14 patients had benign masses (7 patients were pancreatic pseudocysts, two patients were pancreatic abscesses, three patients were simple cysts and two patients were focal pancreatitis). The main clinical symptom was abdominal pain and most of masses were located in the head of the pancreas.

Results: In our study, 25 cases of the 30 patients showed increased intensity at T2-weighted images. Most of malignant cases showed low or equal intensity on T1- and high intensity on T2-weighted images compared to normal pancreatic parenchyma. In our study, DW-MRI was performed on all subjects at b-values of 500 and 1000 s/mm^2. Benign pancreatic masses as pancreatic pseudocyst, simple cyst and abscess show low signal intensities on DWI, however malignant pancreatic masses as adenocarcinoma, lymphoma and metastasis show high signal intensities on DWI with a cut-off value of 1.5 $x10^{-3}$ s/mm^2 for the differentiation of benign from malignant pancreatic masses by b-value 1000 s/mm^2 with the sensitivity, specificity, PPV, NPV& p value were 100%, 83.33%, 100%, 88.88% and <0.001 respectively.

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Conclusion: MRI plays an important role in the diagnosis of different pancreatic lesions and can assess the neoplastic pancreatic lesions with accurate detection of extension, nodal involvement and hepatic metastatic lesions. It also has a major role in differentiation between benign and malignant pancreatic lesions by the aids of DWI.

Keywords: MR imaging; pancreatic lesions.

ABBREVIATIONS

ADC : Apparent diffusion coefficient
DWI : Diffusion-weighted MRI
DW-MRI :Diffusion Weighted Magnetic Resonance Imaging
ERCP :Endoscopic retrograde cholangiopancreatography
MRCP :Magnetic resonance cholangiopancreatography
MRI : Magnetic resonance imaging
NPV : Negative predictive value
PPV : Positive predictive value

1. INTRODUCTION

The pancreas is a non-encapsulated retroperitoneal organ composed of a head, uncinate process, neck, body, and tail [1].

Pancreatic abnormalities may manifest as pancreatic enlargement (tumor, acute pancreatitis), pancreatic atrophy (cystic fibrosis, chronic pancreatitis), cystic lesions (pseudocysts, congenital simple cysts, autosomal dominant polycystic renal disease, von HippleLindau disease, cystic fibrosis, cystic neoplasms), or fatty replacement (cystic fibrosis, shwachman-diamond syndrome, obesity) [2].

Imaging modalities for pancreas include plain radiography, contrast studies (barium meal studies, PTC / Endoscopic retrograde cholangiopancreatography (ERCP), Angiography), ultrasonography, CT Scanning, Magnetic resonance imaging (MRI) including Magnetic resonance angiography (MRA) and Magnetic resonance cholangiopancreatography (MRCP) [3].

Computed tomography plays a primary role in the diagnosis and imaging workup of patients with pancreatic diseases. However, advanced magnetic resonance imaging (MRI) techniques offer images of the pancreas with excellent contrast resolution in a reasonable examination time [4].

MRI plays a triple role in the evaluation of the pancreas: Diagnosis, staging and detection of complications. The role of MRI has increased, especially in the imaging patients with suspected pancreatic neoplasms [5].

Technical innovation in MRI, such as use of phased-array coils, allows improved spatial resolution and faster T1- and T2-weighted sequences for imaging the entire upper abdomen in a single breathhold and providing cross-sectional images of pancreatic parenchyma [6].

Magnetic resonance cholangiopancreatography (MRCP) is used for noninvasive work-up of patients with pancreaticobiliary disease. MRCP is comparable with invasive endoscopic retrograde cholangiopancreatography (ERCP) for diagnosis of extrahepatic bile duct abnormalities [7].

Diffusion-weighted MRI (DWI) is a technique in which phase defocusing and refocusing gradients are used to evaluate the rate of microscopic water diffusion within tissue. Quantitative measurements of the diffusivity of water are described by the apparent diffusion coefficient (ADC) [8].

DWI is becoming an important noninvasive technique in the characterization of biologic tissues based on their water diffusion properties, especially those with high b value. A few recent reports have suggested that DWI with single-shot echo-planar imaging may be helpful in the detection of pancreatic adenocarcinoma [9].

2. PATIENTS AND METHODS

This prospective study included 30 patients with pancreatic lesions and their ages ranged from 30 years to 70 years with a mean age 51 years. The study was carried out from May 2019 to October 2020 .They were referred from Surgery, Internal Medicine and Oncology Departments to Radiodiagnosis and Medical Imaging Department in our institute. Conventional MRI examinations were performed for all patients. The results of the 30 patients were histopathologically correlated in 21 cases and clinical follow up was carried out for the remaining 9 patients. A written informed consent was obtained from all patients' guardiancies after full explanation of the benefits and risks of procedure.

2.1 Inclusion Criteria

- Patients who were suspected or known to have pancreatic disease regardless to gender.
- Patients who agreed to join the study according to the ethical considerations and a written informed consent was obtained from all the included patients.

2.2 Exclusion Criteria

- All patients with relative or absolute MRI contraindications:
  - Patients with a heart pacemaker or cardiac defibrillator.
  - Patients who have an aneurysm clip in their brain.
  - Patients who have cochlear implant.
  - Patients who have implanted neural stimulator.
- Patients with poor renal functions.
- Patients unable to tolerate baseline MRI scan or scan not of adequate quality for analysis (e.g. too much movement artifacts).

2.2.1Patients were subjected to the following

2.2.1.1 Clinical assessment

- Detailed meticulous history taking.
- Clinical examination:
- Laboratory investigations:

2.2.1.2 Radiological assessment

a. Conventional MR imaging:

Instructions and preparation of the patients:

- Ferromagnetic materials were removed.
- The method of examination was fully explained to all patients before imaging to obtain their consent.

b. **Diffusion Weighted Magnetic Resonance Imaging (DW-MRI) and apparent diffusion coefficient (ADC) maps:** Were performed for all patients.

2.3 Histopathological Correlation

Histopathological correlation between diffusion weighted magnetic resonance readings and histopathological sections was performed in 21 cases where biopsy was done either by:

- US guided fine needle aspiration: in 3 cases.
- Postsurgical histopathology: in 14 cases.
- Core biopsy: in 4 cases.

2.4 Technique of Examination

Patients were positioned in supine position and were instructed to hold breath to reduce respiratory artifacts during the examination. Circularly polarized body coil was placed over the upper abdomen.

A fast scout scan in sagittal, axial and coronal planes was obtained.

All patients with pancreatic masses underwent DW-MRI. This was obtained in axial plane and performed without injection of contrast material. DW-MRI was obtained using a multi-section single shot spin echo EPI sequence (TR/TE/NEX: 3395/100ms/1) with diffusion sensitivities of b-values = 0,500 and 1000 s/mm^2.

The diffusion gradients were applied sequentially in the three orthogonal directions. Sections of 2-4 mm thickness, inter-slice gap of 1mm, a 230-255 mm FOV, and a 256 x 256 matrix were used with average scan time of 35s.

ADC maps were formed automatically by the device, a circular regions of interest (ROI) ranging from 10 to 40 mm^2 according to the size of the mass, were placed in the center of the lesion for each b-value (same slide location).

ADC value was obtained with b-values 500and 1000 s/mm^2.

The ADC values are expressed in square millimeters per second.

3. RESULTS

There was a statistical significant difference between mean ADC values of benign and malignant pancreatic masses. The mean ADC values of benign and malignant masses done by b-1000 were statistically significant higher than done by b-500. One male patient was diagnosed by DWI as malignant lesion as it has restricted diffusion and low ADC values but histopathological results diagnosed it as benign lesion (focal pancreatitis).

Table 1. Comparison between ADC value of benign and malignant pancreatic masses

	Benign (14)	Malignant (16)	t-test	P-value
Mean ADC value $x10^{-3}$ s/mm^2 (b=500 s/mm^2)	3.006 (2.31-3.56)	1.34 (1.15-1.52)	-4.5	0.001***
Mean ADC value $x10^{-3}$ s/mm^2 (b=1000 s/mm^2)	2.49 (2.12-3.01)	1.24 (1.01-1.49)	-2.09	0.002**

Table 2. Validity of DW-MRI in the diagnosis of pancreatic masses by b value 500 s/mm^2

	Malignant group	Benign group	Total
+Ve:Postive	True +ve 15	False +ve 3	18
-Ve:Negative	False –ve 1	True –ve 11	12
Total	16	14	30

Table 3. Validity of DW-MRI in the diagnosis of pancreatic masses by b value 1000 s/mm^2

	Malignant group	Benign group	Total
+Ve	True +ve 16	False +ve 2	18
-Ve	False –ve 0	True –ve 12	12
Total	16	14	30

Table 4. Cut off value between benign and malignant pancreatic masses by b value 1000 s/mm^2

	Cut off	sensitivity	Specificity	PPV	NPV	P value
(b=1000 s/mm^2)	<1.5	100.0	83.33	88.88	100.0	0.001***

PPV: positive predictive value; NPV: negative predictive value

DWI images by b value 500 s/mm^2 detect pancreatic masses with sensitivity of 93.8 %, specificity of 78.6%, positive predictive value (PPV) of 88.88% and negative predictive value of 100 %

DWI images by b value 1000 s/mm^2 detect pancreatic masses with sensitivity of 100 %, specificity of 83.33%, positive predictive value (PPV) of 93.33% and negative predictive value of 100 % .

The cut-off value for the differentiation of benign from malignant pancreatic masses was 1.5 $x10^{-3}$ s/mm^2 with the sensitivity, specificity, PPV, NPV& p value were 100%, 83.33%, 100%, 93.33%, and <0.001 respectively .

3.1 Laboratory Results Show

Serum amylase and lipase were high on first 48h then return to normal values, Normal liver & kidney function tests and no elevation in total or direct bilirubin.

3.1.1 MRI revealed

(A&B): Axial T1&T2 WIs reveal a well defined cystic lesion displaying low T1&high T2 signal with irregular border measuring about 3x2.5cm and showing internal septation at the region of body of pancreas (arrows).

(C&D): Axial DW image & ADC map image with b-value of 500 s/mm^2 show low and high signal intensity respectively of the lesion denoting free diffusion (arrows). ADC Value = 2.94 $x10^{-3}$ mm^2/sec.

(E&F): Axial DW image & ADC map image with b-value of 1000 s/mm^2 show low and high signal intensity respectively of the lesion denoting free diffusion (arrows). ADC Value = 2.41 $x10^{-3}$ mm2/sec.

3.1.2 Diagnosis

Overall MRI findings are consistent with pancreatic pseudocyst.

3.2 Laboratory Results Show

Moderate increase in total & direct bilirubin with increased Direct/Total bilirubin (D/T)ratio, moderate increase in urine bilirubin and impaired liver function tests (increased AST, ALT & alkaline phosphatase).

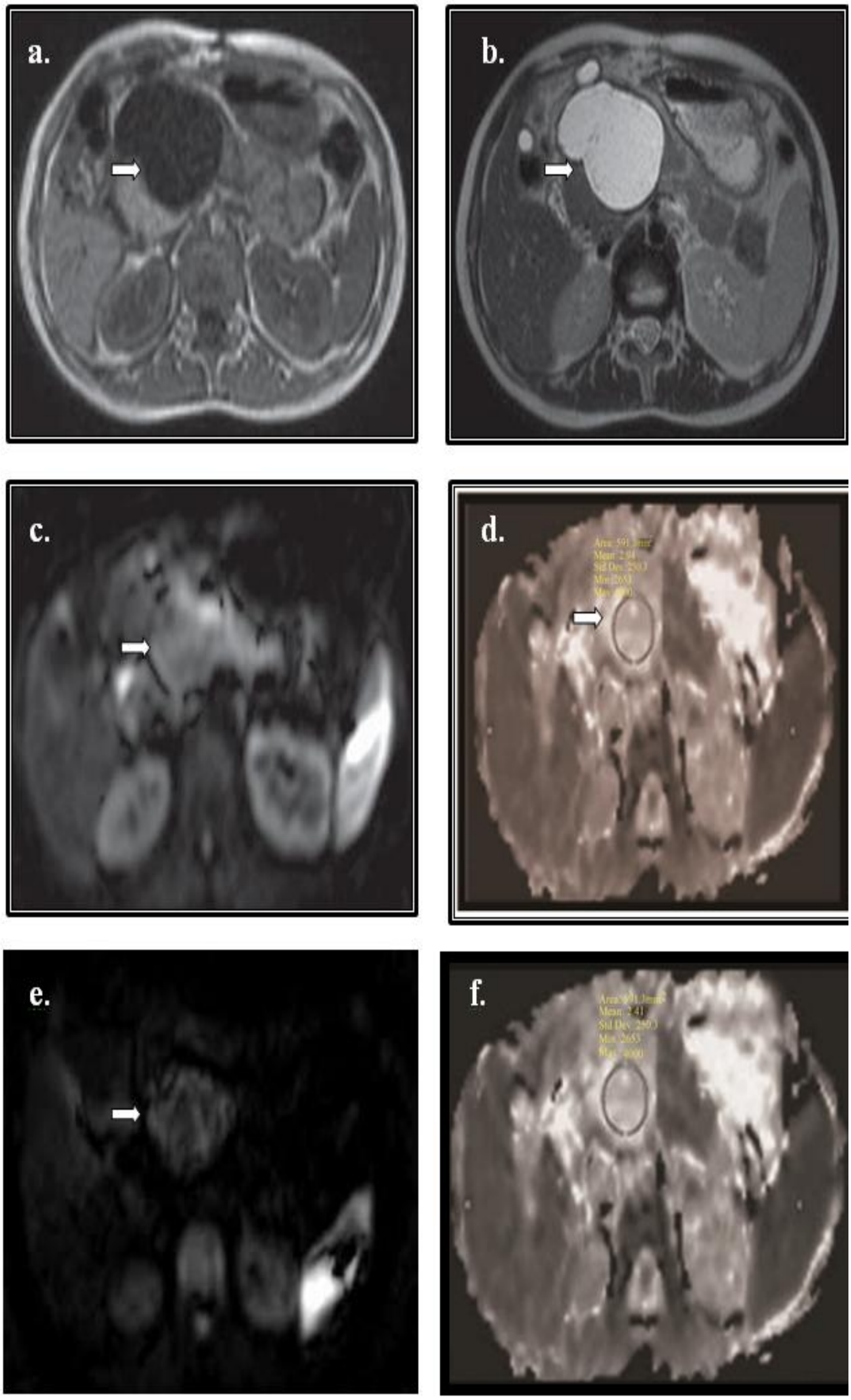

Fig. 1. Female patient 36 years old presented with abdominal pain giving history of acute pancreatitis two weeks ago

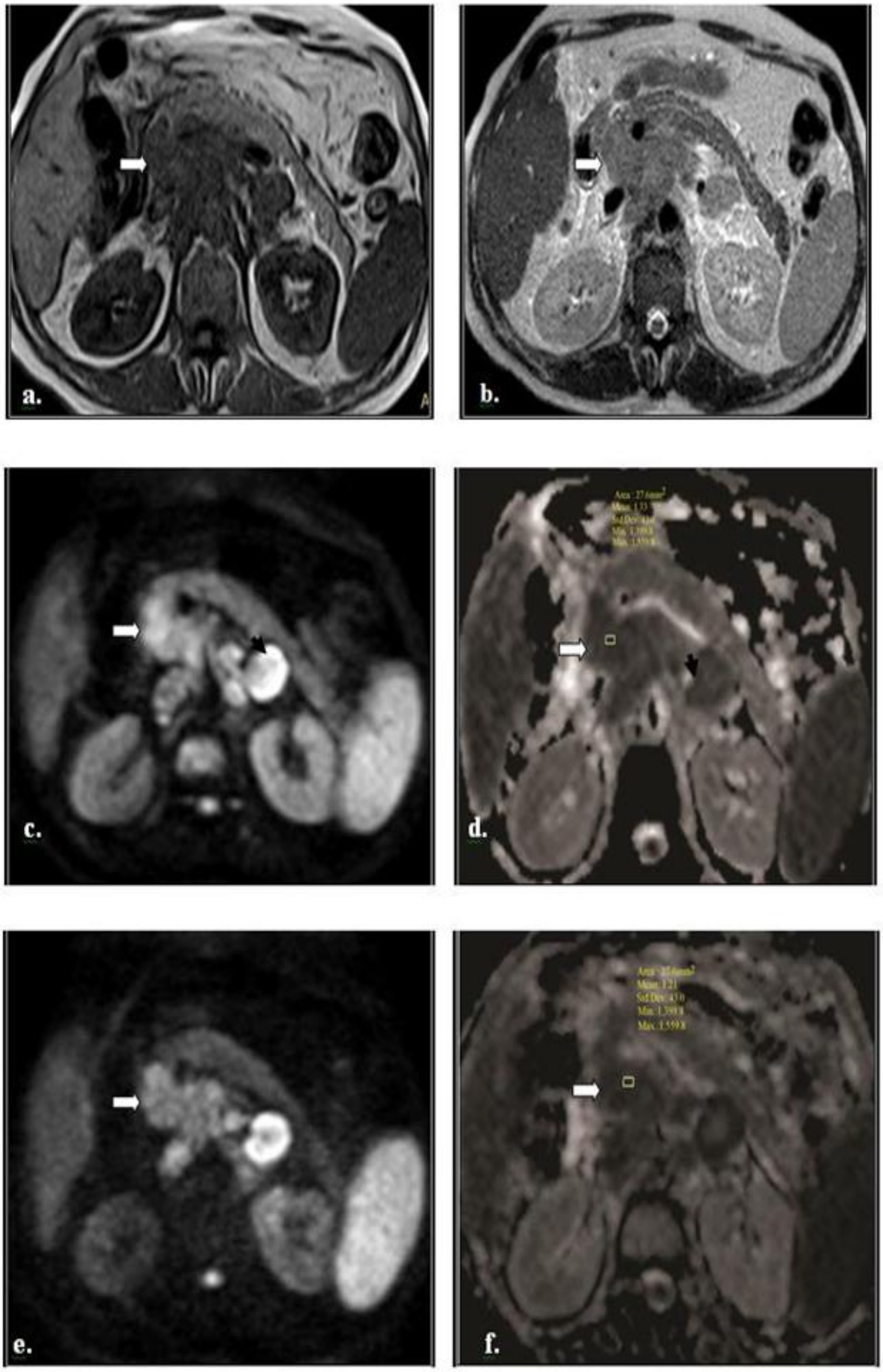

Fig. 2. Male patient 55 years old presented with jaundice, weight loss and abdominal pain

3.2.1 MRI revealed

(A&B): Axial T1&T2 WIs reveal an ill defined lesion at the region of head of pancreas displaying heterogeneous hypointense T1&isointense T2 signal measuring about 4.0cmx3.5cm and encasing pancreatic vessels (arrows).

(C&D): Axial DW & ADC map image with b-value of 500 s/mm^2 show high and low signal intensity respectively of the lesion denoting restricted diffusion (arrows). ADC Value = 1.33x10^{-3} mm^2/sec.

(E&F): Axial DWI & ADC map image with b-value of 1000 s/mm^2 show high and low signal intensity respectively of the lesion denoting restricted diffusion (arrows). ADC Value = 1.21x10^{-3} mm^2/sec.

3.2.2 Associated findings

Dilated pancreatic duct with abrupted end. There are multiple enlarged para-aortic lymph nodes being hypointense on T1WIs and isointense on T2WIs and show restricted diffusion in the DWIs, largest one measures 10x8mm (black arrows).

3.2.3 Diagnosis

Radiological: Pancreatic head carcinoma
Pathological: Pancreatic ductal adenocarcinoma

4. DISCUSSION

Our study included 30 patients with pancreatic lesions. Their ages ranged from 30 to 70 years with a mean age 51 years. The most common age group was from 50-60 years. That was going with the same findings as Ichikawa et al [9].

In the present study, the most common clinical presentation was abdominal pain, less commonly jaundice, anorexia, weight loss, fever or accidentally discovered pancreatic mass during sonographic examinations. That was going with the same findings as Inan et al [10].

In the current study, the pancreatic lesions were more common in females (17 cases) than males (13 cases). This is similar with the findings by Kartalis et al [11].

In our study, the pancreatic masses were more common in the head of the pancreas (17 cases). This is in agreement with the finding by Wang et al [12].

In our DWI study, b values were 0, 500& 1000 sec/mm^2, with the application of parallel imaging and breath triggering technique, a satisfying image quality has been achievable on a 1.5-T scanner within an acceptable acquisition time with an exclusion rate of 0% of patients.

Pancreatic pseudocyst and pancreatic cyst tend to be hypointense relative to normal pancreas on T1-weighted images and hyperintense on T2-weighted images [13]. These results coincide with our results, as there were 7 cases had pseudocyst and three cases had simple cysts were hypointense relative to pancreatic parenchyma in T1-weighted images and hyperintense on T2-weighted images.

Signal intensities of cystic lesions were high on diffusion weighted images with lower b values; however, with a higher b-value (b = 1,000 s/mm^2) signal intensities of pseudocysts were isointense to the pancreas [11]. These results coincide with our results, as there were 7 cases had pseudocyst were isointense compared with the pancreas on DWI by b-value 1000 s/mm^2.

Signal intensities of simple cysts were hypointense on diffusion-weighted images due to low cellularity which provides a larger extra-cellular space for diffusion of water molecules [11]. That was going hand in hand with our present study, as there were three cases of simple cysts were hypointense relative to pancreas on DWI by b-value 1000 s/mm^2 and display T2-shine through effect DWI by b-value 500 s/mm^2.

Pancreatic abscesses remained hyperintense. Therefore, the hyperintensity of abscesses, on 1000 s/mm^2 b factor images cannot be totally attributed to the T2 shine-through effect. Diffusion can be quantitatively evaluated by ADC, which is free of the T2 shine-through effect. The high signal on diffusion weighted images is due to the reduced diffusion in abscesses, because abscesses have a viscous content, they have restricted diffusion with high ADCs value [14]. That was in agreement with our study, where two cases of pancreatic abscess were hyperintense compared with pancreas.

Pancreatic adenocarcinomas are typically hypointense relative to normal pancreatic tissue on T1-weighted images. The normal pancreas appears hyperintense with this sequence and of variable intensity on T2-weighted images [15]. That was going hand in hand with our present study, as there were 14 cases of pancreatic adenocarcinomas hypointense in T1-weighted images and in 11 out of 14 cases hyperintense in T2-weighted images.

However, small or non-contour-deforming pancreatic adenocarcinomas may lack classic imaging features and may not be detected on conventional MR images [12].

Therefore, The additional use of diffusion weighted imaging may allow earlier detection of pancreatic adenocarcinoma, since these neoplasms have increased signal intensity on diffusion weighted images with high b-values (b > 500 sec/mm²) and relatively low ADC values because of the restricted diffusion associated with fibrosis [12]. That was going with the results of our study where 13 out of 14 cases of pancreatic adenocarcinomas were high signal intensity seen at diffusion-weighted images and low signal intensity seen at ADC map images with low ADC values.

Kartalis et al. [11] presented a study in 36 patients with pancreatic lesions (12 malignant and 24 benign) and 39 patients without lesions were included. MRI-c and DWI (free breathing, b-values 0 and 500 s/mm2) were performed prospectively and consecutively in a 1.5-T system. The analysis was retrospectively performed blinded by two radiologists in consensus. The sensitivity, specificity, accuracy, and positive and negative predictive values of DWI and MRI-c were 92, 97, 96, 85, 98% and 100, 97, 97, 86, 100%, respectively. Mean ADC values of malignant lesions were significantly lower than those of benign lesions.

Ichikawa et al. [9] presented a study in 26 patients with pancreatic adenocarcinoma were included in the study. All patients and subjects underwent DWI (free breathing, b values 1000 s/mm2) reported a sensitivity of 96.2% and a specificity of 98.6%.

Inan et al. [10] presented a study in which 42 patients with different cystic lesions of pancreas were included in the study. All patients and subjects underwent DWI (free breathing, b values 500 and 1000 s/mm2) reported a sensitivity of 70% and a specificity of 90%.

In our study, the sensitivity, Specificity, PPV, NPV& p value were 92.8%, 83.33%, 92.8%, 83.33% respectively for b value 500 s/mm².

Also, the sensitivity, Specificity, PPV, NPV& p value were 100%, 83.33%, 93.33%, 100%, and <0.001, respectively for b value 1000 s/mm2.

CONCLUSION

MRI plays an important role in the diagnosis of different pancreatic lesions and can assess the neoplastic pancreatic lesions with accurate detection of extension, nodal involvement and hepatic metastatic lesions. It also has a major role in differentiation between benign and malignant pancreatic lesions by the aids of DWI.

CONSENT

1. Written informed consent was obtained from all patients' guardiancies after full explanation of the benefits and risks of procedure.
2. Any unexpected risks appeared during the course of the research were cleared to all parents.
3. The privacy of the participants and confidentiality of data were guaranteed during the various phases of the study. The results will be used as scientific material only and will not be used by any legal authorities.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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