

Role Of Contrast-Enhanced Magnetic Resonance Imaging and Diffusion- Weighted Magnetic Resonance Imaging In evaluation of the pancreatic Lesions

Ahmed Okasha^a, Ghada Mohamed Abd-Elrazek^a, Mohamed Ahmed Negm^b and Shimaa Mohamed Ahmed Abd-Elghani^{a*}

^a Diagnostic Radiology Department, Faculty of Medicine, South Valley University, Qena, Egypt

^b Pediatric Surgery Department, Faculty of Medicine, South Valley University, Qena, Egypt

Abstract

Background: Pancreatic tumor is a very lethal human tumors that needs earlier diagnosing. US, CT and MRI are various imaging methods employed to diagnose of pancreatic masses. Contrast-enhanced MRI (CE-MRI) Diffusion-weighted magnetic resonance imaging [DW-MRI] are progressively utilized or detection and characterization of various pancreatic lesions.

Objectives: The current study aimed to evaluate the utility of contrast-enhanced MRI (CE-MRI) and [DW-MRI] in characterizations of pancreatic lesions.

Patients and methods: This work was prospective study performed at The Department of Radiology, Qena University Hospitals, with cases with pancreatic lesions over an interval of 12 months who previously discovered by other imaging modalities that desire more characterizations via MRI.

Results: The DWI imaging sensitivity was 100%, specificity was 100%, NPV was 100% and PPV was 100% with accuracy of 100% for detecting benign and malignant tumors. ADC value was significant at cutoff value $<2.2 \times 10^{-3}$ mm²/s for detecting malignant lesions with sensitivity of 92% and specificity of 80% with PPV 82% and NPV 91%.

Conclusion: We concluded that CE-MRI and DW-MRI is a reliable screening and diagnosing method for characterization of pancreatic lesions.

Key words: Pancreatic lesions, DWI imaging, Contrast-Enhanced Magnetic Resonance Imaging

Introduction

Despite the advances in management, pancreatic cancer remains fatal for the majority of patients. When possible, complete surgical resection is the first line of treatment, although a rise in tumor size is a major risk factor for poor surgical outcomes (Mourad et al., 2013).

As a result, one of the leading causes of poor prognosis is that many lesions go untreated until they have progressed or are no longer surgically resectable. Despite data from various trials showing that screening individuals with a family history of pancreatic cancer is associated with more curative resections (P = 0.011) and enhanced median survival (p 0.001), pancreatic cancer screening programs for the general population are not currently recommended (Zhang et al., 2017).

A cystic pancreatic lesion can be detected by abdominal ultrasound (US). However, this approach lacks acceptable spatial and soft-tissue resolutions, and picture quality suffers significantly in obese individuals. When compared to abdominal ultrasound, endoscopic ultrasound (EUS) can provide better images; nonetheless, EUS is an intrusive procedure. (Kalb et al., 2009).

Multi-slice CT may attain high-resolution scans of the pancreas and can detect small pancreatic cysts. But the nature of the fluids within the cyst in addition to the existence of septations is not adequately assessed via CT due to inadequate soft-tissues contrast resolution (Waters et al., 2008).

The usage of MR imaging with its novel quicker sequences for diagnosis of pancreatic cancers may decrease motion artifacts and facilitate characterization of various pancreatic damages (Hänninen et al., 2002).

Diagnosis of pancreatic tumour at an early stage isn't satisfactory via US, multi-detector CT and MRI. New techniques are needed for earlier diagnosing (Jemal et al., 2008).

MRI's strong soft tissue contrast is especially useful for highlighting the internal characteristics of pancreatic lesions and distinguishing normal from diseased pancreatic tissue. Furthermore, when compared to other modalities, the ability to analyse the pancreaticobiliary ductal system noninvasively with MRCP gives MRI a particular advantage for assessing various pancreatic disorders. Specific instances in which MRI can be used to solve problems in pancreatic disease will be discussed below (Semelka et al., 1996).

The excellent usage of DW-MRI for detection and characterization of various pancreatic injuries. High b-value DW-MRI may be a good tool for detection of pancreatic adenocarcinoma with elevated sensitivity & specificity (Wang et al., 2011; Klimstra et al., 2009). The current work aimed to evaluate the utility of CE-MRI and DW-MRI in characterization of the pancreatic lesions.

Patients and methods

This study was prospective study carried out at The Department of Radiology, Qena University Hospitals, with patients with pancreatic lesions during the period of 12 months who previously detected by other imaging modalities that desire more characterization by MRI.

Inclusion criteria: Patients with pancreatic lesions with age ranged from 10 to 70 years diagnosed by other imaging methods.

Exclusion criteria: patients who have pace maker and patients who have severe claustrophobia.

Methods

The utilities of CE-MRI and DW-MRI in characterization of the pancreatic lesions:

- **MRI method:** it has been done by 1.5 T magnet Philips Acheiva (Germany) Conservative MRI comprised of axial T2-WI with fat suppressions, T1-WI fat saturation in addition to DWI by means of different b values, $b = 0, 500$ and 1000 sec/mm^2 . Axial images were reconstructed to 256×256 matrix images there after scan.
- **Imaging assessment:** The morphological characteristics of every lesion recorded formed of size, shape, boundary, signal features, shape of enhancement in the dynamic imaging in addition to the site of the injury. Then temporary diagnosing was described. Second, we revised the diffusion scans with ADC values for ultimate radiologic characterizations and detections of the pancreatic injuries.
- **ADC calculations:** We determined the mean ADC value of the lesions diagnosed by drawing the region of interest (ROI) over the injury. The ROI is traced along the borders of the by the electronic cursor. It is manually located to be ensured that it is smaller in extent than the real lesion not including the normal tissues (Do et al., 2020)

Administrative and Ethical Design: An official permission was obtained from Department of Radiology, Faculty of Medicine, Qena University Hospitals., and approval from ethical committee in the faculty of medicine (Institutional Research Board IRB).

Statistical Analysis: Collected data was statistically analyzed via the windows-based SPSS-20 (IBM, USA) and Med-Calc 13 package (Belgium). Data were tested for normal distribution by means of the Shapiro-Wilk testing. Qualitative data has been presented as frequency and relative percent. Chi square testing (χ^2) and Fisher exact has been utilized to calculate the difference among the qualitative variables as showed. Quantitative data have been presented as mean \pm SD.

Results

Table shows that age of the study population ranged from 42 - 76 weeks with and (72%) of them

were males with mean BMI was 25.66kg/m²,(Table .1).

Table shows that most of the patient (86%) presented with jaundice, while 38% presented with epigastric pain and 18% presented with palpable mass,(Table .2).

The most frequent finding was adenocarcinoma (32%). Moreover, 25 (50%) of the patients had benign lesions, meanwhile malignant lesions were found in 50% of the patients,(Table .3).

In the studied patients, the commonest site was body (60%) followed by head (50%).

* Note that the lesion may extend in more than one site, (Table .4).

Regarding MRI features among the studied patients revealed that in T1 weighted image .(50%) of the patients show hyper intense signal intensity and the other (50%) show hypo intense signal intensity .in T2 weighted image (66%) of patients show hyper intense signal intensity and (34%) show hypo intense signal intensity . with contrast study (38%) of patients show heterogeneous enhancement and (62%)show homogenous enhancement.in DW MR image (68%)of patients show restricted diffusion and (32%)show non restricted diffusion , (Table .5).

Regarding DWI revealed that 50% of the patients had benign lesion and the other 50% had malignant lesion, (Table .6).

Regarding the Enhancement results among studied patients (22%) of patients show early enhancement of the wall (20%) show maximum enhancement in delayed phase (16%) show early enhancement with delayed washout (12%)show strong early enhancement(8%) show early wash in/ early washout enhancement (6%) show Marked early Enhancement of capsule (4%) show Early intense Arterial enhancement (4%)show Early enhancement(4%) show enhancement in delayed phase (2%) show Intermediate enhancement with delayed washout (2%) show early arterial enhancement, (Table .7).

In the studied patients, 25 of 25 benign lesions detected by c-MRI were correctly characterized with visual assessment, (Table .8).

The c-MRI imaging sensitivity was 100%, specificity was 100%, NPV was 100% and PPV was 100% with accuracy of 100% for detecting benign and malignant lesions,(Table .9).

ADC value was significantly elevated in malignant lesions in comparison to benign tumors, (Table .10).

In the studied patients, 25 of 25 benign lesions detected by c-MRI were correctly characterized with visual assessment,(Table .11).

ADC value was significant at cutoff value <2.2 x10⁻³ mm²/s for detecting malignant lesions with sensitivity of 92% and specificity of 80% with PPV 82% and NPV 91%. (Fig.1).

Table 1. Demographic distribution of the studied patients

| Variables | | All patients (n=50) |
|---------------------------------------|--------|-------------------------|
| Age (years) Mean ± SD Range | | 56.54 ± 8.64 42 – 76 |
| Sex | Male | 36 (72%) |
| | female | 14 (28%) |
| BMI (kg/m ²) Mean ± SD | | 25.66 ± 2.67 |
| Tumor size (cm) Mean ± SD Range | | 3.71 ± 1.88 1 – 8.4 |

Table 2. Clinical presentation distribution among the studied patients

| Variables | All patients (n=50) | |
|-----------------|---------------------|----|
| | N | % |
| Epigastric pain | 19 | 38 |
| Jaundice | 43 | 86 |
| Palpable mass | 9 | 18 |

Table 3. Laparoscopy and histopathology findings distribution among the studied patients

| Variables | All patients (n=50) | |
|-----------------------|---------------------|----|
| | N | % |
| Adenocarcinoma | 16 | 32 |
| Focal pancreatitis | 4 | 8 |
| Giant cell tumor | 3 | 6 |
| Hemangioma | 1 | 2 |
| Insulinoma | 3 | 6 |
| Pancreatic pseudocyst | 11 | 22 |
| Pancreatitis | 6 | 12 |
| Papillary carcinoma | 6 | 12 |

Table 4. Site of the lesion among the studied patients

| Variables | All patients (n=50) | |
|-----------|---------------------|-----|
| | N | % |
| Head | 25 | 50% |
| Body | 30 | 60% |
| Tail | 8 | 16% |
| Diffuse | 6 | 12% |

Table 5. MRI characteristics among the studied patients

| Variables | All patients (n=50) | |
|------------------|---------------------|----|
| | N | % |
| T1 | | |
| Hyperintense | 25 | 50 |
| Hypointense | 25 | 50 |
| T2 | | |
| Hyperintense | 33 | 66 |
| Hypointense | 17 | 34 |
| Contrast | | |
| Heterogeneous | 19 | 38 |
| Homogeneous | 31 | 62 |
| Diffusion | | |
| Restricted | 34 | 68 |
| Not restricted | 16 | 32 |

Table 6. DWI findings among the studied patients

| Variables | All patients (n=50) | |
|------------------|---------------------|----|
| | N | % |
| Benign lesion | 25 | 50 |
| Malignant lesion | 25 | 50 |

Table 7. Enhancement results among the studied patients.

| Variables | All patients (n=50) | |
|---|---------------------|----|
| | N | % |
| Enhancement in delayed phase | 2 | 4 |
| Intermediate enhancement with delayed washout | 1 | 2 |
| Early Arterial enhancement | 1 | 2 |
| Early enhancement | 2 | 4 |
| Early enhancement é delayed washout | 8 | 16 |
| Early enhancement of the wall | 11 | 22 |
| Early intense Arterial enhancement | 2 | 4 |
| Early wash in/ Early wash out | 4 | 8 |
| Marked early Enhancement of capsule | 3 | 6 |
| Max Enhancement in delayed phase | 10 | 20 |
| Strong early enhancement | 6 | 12 |

Table 8. Comparison of c-MRI imaging for detecting benign and malignant lesion according to laparoscopy

| MRI | Laparoscopy | | | | Total | P |
|-----------|---------------|------|------------------|------|----------|-------------|
| | Benign (n=25) | | Malignant (n=25) | | | |
| | N | % | N | % | | |
| Benign | 25 | 100% | 0 | -- | 25 (50%) | .000 |
| Malignant | 0 | -- | 25 | 100% | 25 (50%) | |
| Total | 25 | 100% | 25 | 100% | 50 | |

Table 9. Diagnostic value of c-MRI imaging for detecting benign and malignant lesions

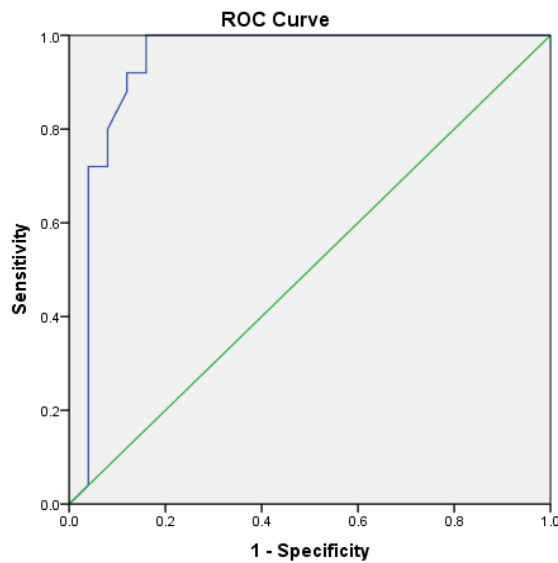
| Statistic | Value | 95% CI |
|---------------------------------|-------|---------------|
| Sensitivity | 100% | 86.28% - 100% |
| Specificity | 100% | 86.28% - 100% |
| Positive Predictive Value (PPV) | 100% | -- |
| Negative Predictive Value (NPV) | 100% | -- |
| Accuracy | 100% | 92.89% - 100% |

Table 10. ADC value of the studied patients according to lesion types

| Variables | Benign (n=25) | Malignant (n=25) | MU | P |
|--|------------------|---------------------|------|------|
| ADC value($\times 10^{-3}$ mm ² /s) Mean \pm SD | 2.78 \pm 0.424 | 1.82 \pm 0.824 | 37.5 | .000 |

Table 11. Comparison of c-MRI imaging for detecting benign and malignant lesion according to laparoscopy

| MRI | Laparoscopy | | | | Total | P |
|-----------|------------------|------|---------------------|------|----------|-------------|
| | Benign (n=25) | | Malignant (n=25) | | | |
| | N | % | N | % | | |
| Benign | 25 | 100% | 0 | -- | 25 (50%) | .000 |
| Malignant | 0 | -- | 25 | 100% | 25 (50%) | |
| Total | 25 | 100% | 25 | 100% | 50 | |



Diagonal segments are produced by ties.

Fig .1. ROC curve for ADC value for detecting malignant lesions

| AUC | S.E. | Sig. | 95% Confidence Interval | Sensitivity | Specificity |
|------|------|------|-------------------------|-------------|-------------|
| .940 | .041 | .000 | .860 - 1.000 | 92% | 80% |

Case presentation

Case (1):

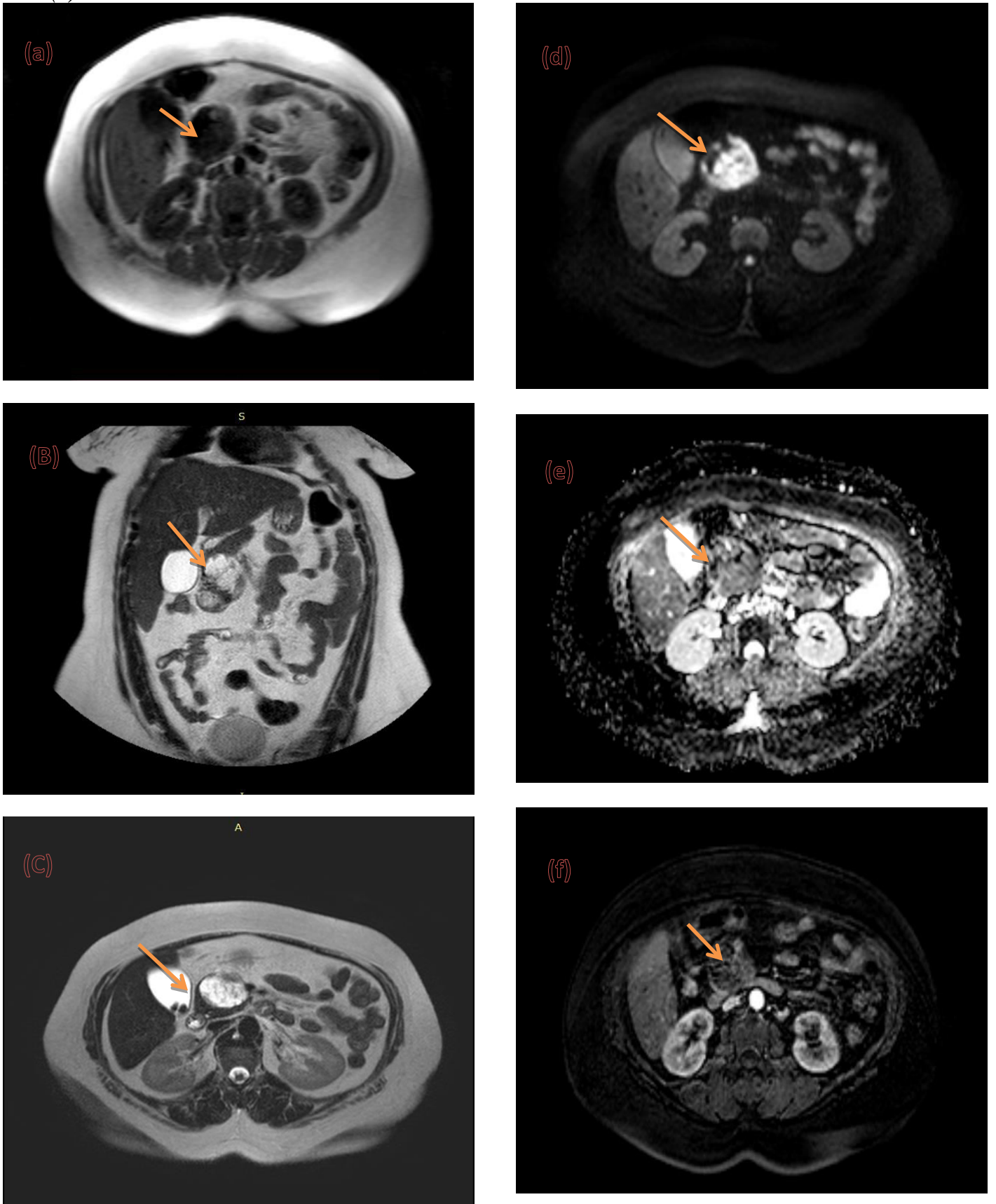


Fig.2. A 55 years old female case with proven by histopathology as pancreaticadenocarcinoma of pancreatic head ,the injury show low signal intensities in axial T1w(a) heterogonous bright signal in T2w (b,c), Axial DW MR image and ADC map show restricted diffusion (d,e) with heterogeneous enhancement in post contrast study (f) .

Case (2):

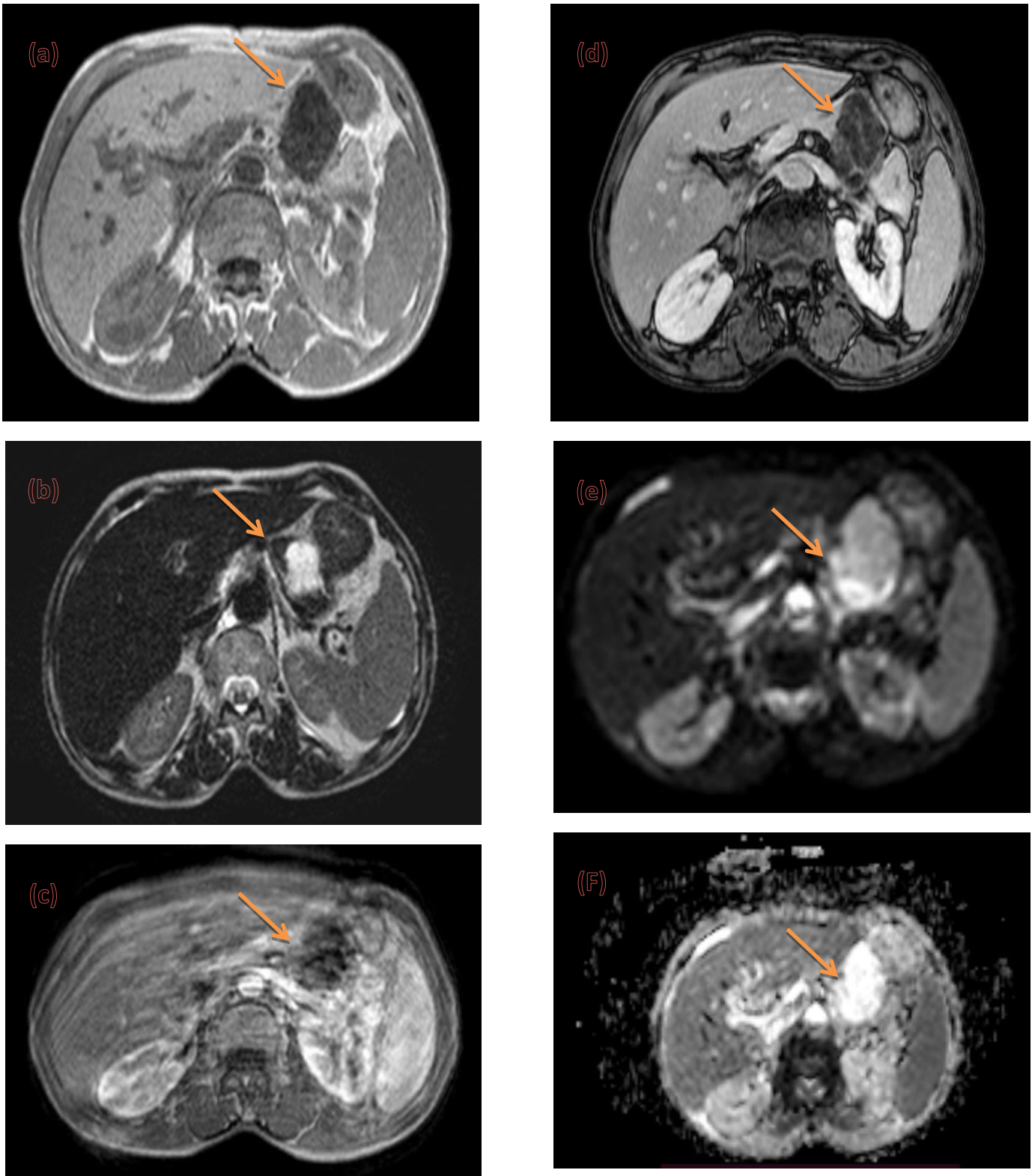


Fig.3. Sixty –three years old female patient presenting with loss of weight showing pancreatic body mass with mixed cystic and solid components is seen displaying low signal intensity in T1 (a) heterogeneous bright signal in T2 (b) with heterogeneous enhancement in post contrast study arterial phase (c) Porto venous phase (d) DWI and ADC map show restricted diffusion (e,f),it was proved pancreatic body serous cyst adenocarcinoma.

Discussion

Despite considerable progress in multidetector computed tomography and magnetic resonance imaging, diagnosing pancreatic cancer remains difficult due to overlapping imaging characteristics with benign lesions (MRI). However, accurate detection and characterization of pancreatic lesions is required because prognosis is related to tumour type and grade, as well as proper staging based on accurate imaging; in fact, a pancreatic cancer that infiltrates lymphatic vessels can manifest as peri pancreatic tissue infiltration. This local invasion can lead to an underestimating of the disease's true extent and severity. To enhance staging and clinical results, an imaging technique with a higher tumour conspicuity would be preferable. (Kim et al., 2017)

The use of dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) to conduct a quantitative assessment of perfusion parameters has been suggested. Diffusion-weighted imaging (DWI) is another magnetic resonance approach for assessing perfusion and diffusion objectively and quantitatively to aid in the diagnosis of malignancies.— DWI can help diagnose focal pancreatic lesions by confirming that solid malignant tumors have more restricted diffusion than benign inflammatory tumors. (Liu et al., 2015)

DWI is a exclusive MRI technique that delivers info around the micro-structural features of biological tissue by detection of the thermally persuaded arbitrary molecular motions of water molecules, and produces illustrative ADC values that signify the micro-circulation of blood (perfusions) besides molecular diffusions of water (Wang et al., 2011).

Our study aimed to gage the function of contrast- enhanced MRI and DW-MRI in characterization of pancreatic lesions.

The study included 50 patients with pancreatic lesions with age ranged from 10 to 70 years diagnosed by other imaging modalities that study, regarding MRI and DWI findings among the studied patients. Results were equal and revealed that 50% of the patients had benign lesion and the other 50% had malignant lesion.

Also, regarding ADC value of the studied patients. The mean ADC value was significantly elevated in malignant lesions (2.78 ± 0.424 SD)

compared to benign lesions (1.82 ± 0.824 SD). $P=0.000$.

Also In the studied patients, 25 of 25 benign lesions detected by c-MRI were correctly characterized with visual assessment. Finally the c-MRI imaging sensitivity was 100%, specificity was 100%, NPV was 100% and PPV was 100% with accuracy of 100% for detecting benign and malignant lesions

In the report by (El-Shinnawy et al., 2013), they revealed that Changes on DWI and ADC measures aid to distinguish pancreatic tumour, mass forming focal pancreatitis, and ordinary pancreas. On high-b-value (800 s/mm²) DW scans, PC was somewhat more hyper-intense, comparative to the residual pancreas, than MFFP. The mean value of ADC for PC ($1.22 \pm 0.101 \cdot 10_3$ mm²/sec) was significantly lesser than the residual pancreas ($1.99 \pm 0.21 \cdot 10_3$ mm²/sec; P value < 0.001), MFFP ($1.5 \pm 0.122 \cdot 10_3$ mm²/sec; P value < 0.001), and the pancreatic gland in the control group ($1.80 \pm 0.06 \cdot 10_3$ mm²/sec; P value < 0.001). There was as well a significant difference among the mean ADC of MFFP and the residual pancreas (1.53 ± 0.122 versus $1.89 \pm 0.169 \cdot 10_3$ mm²/s; P value < 0.001). The quantitative investigation of DWI may deliver info that could not be attained solely from anatomic scanning. New technique reduce the acquisitions period and upgraded the signal to noise ratio, consequently DWI is nowadays frequently utilized as a share of the abdomen-MRI examining protocol. The ADC values of the various disorder procedures in addition to the ordinary values of the solid abdomen organs were reported. Many researchers have assessed this method for the valuation of PDAC and have settled that adding DWI sequence can advance the grading. Nevertheless, the value of DW still isn't entirely clarified in PDAC (De Robertis et al., 2015).

Few reports have evaluated the significance of DWI in the differentiation diagnosing of solid pancreatic tumours. This is probably due to of that the ADCs extensively overlap in different malignant pancreatic masses so they can't distinguish between the injuries (Yao et al., 2013). The pancreatic masses, assessed in our study, differed significantly regarding the ADC values benign and malignant injuries.

In the present work, on MRI-DW, the majority of the malignant pancreatic masses show restricted diffusion on qualitative scans and low

ADC values as compared to the surrounding normal pancreatic tissues. A significant difference was found among the mean ADCs of the malignant pancreatic masses and the neighbouring pancreatic tissues. At the end the c-MRI imaging sensitivity was 100%, specificity was 100%, NPV was 100% and PPV was 100% with accuracy of 100% for detecting benign and malignant lesions.

With high sensitivity & specificity, several reports have concluded that visual analysing and ADC measurements, in DWI, may differentiate pancreatic adenocarcinoma from the back-ground parenchyma precisely. Pancreatic tumours show diffusion restriction, even if small in size (**Legrand et al., 2015**).

From all the aforementioned data we can conclude that, new MRI modalities as DWI MRI and contrast enhanced-MRI can be utilized as effective screening and diagnosing tool for pancreatic cancer. This makes a great advancement in managing these lethal tumour because the early diagnosis can improve the prognosis greatly. DWI MRI should be included in diagnosis protocols of such lesions.

Conclusion: enhanced MRI and [DW-MRI] is an effective screening and diagnosing tool for characterization of pancreatic lesions.

References:

- **De Robertis R, Martini PT, Demozzi E, Dal Corso F, Bassi C, Pederzoli P, et al. (2015).** Diffusion-weighted imaging of pancreatic cancer. *World journal of radiology*, 7(10):319.
- **Do RK, Reyngold M, Paudyal R, Oh JH, Konar AS, LoCastro E, et al. (2020).** Diffusion-weighted and dynamic contrast-enhanced MRI derived imaging metrics for stereotactic body radiotherapy of pancreatic ductal adenocarcinoma: preliminary findings. *Tomography*, 6(2): 261.
- **El-Shinnawy MA, Zidan DZ, Maarouf RA (2013).** Can high-b-value diffusion weighted imaging differentiate between pancreatic cancer, mass forming focal pancreatitis and normal pancreas?. *The Egyptian Journal of Radiology and Nuclear Medicine*, 44(4):687-95.
- **Hänninen EL, Amthauer H, Hosten N, Ricke J, Bohmig M, Langrehr J, et al (2002).** Prospective evaluation of pancreatic tumors: accuracy of MRI with MR cholangio-pancreatography and MR angiography *Radiology*, 224:34-41
- **Jemal A , Siegel R , Ward E , Hao Y , Xu J , Murray T, et al. (2008).** Cancer statistics *CA Cancer J Clin*, 58 (2): 71-96.
- **Kalb B, Sarmiento JM, Kooby DA, Adsay NV, Martin DR. (2009).** MR imaging of cystic lesions of the pancreas *1 Radiographic*, 29 (6): pp. 1749-1765.
- **Kim HW, Lee JC, Paik KH, Kang J, Kim YH, Yoon YS, et al. (2017).** Adjunctive role of preoperative liver magnetic resonance imaging for potentially resectable pancreatic cancer. *Surgery*, 161(6), 1579-1587.
- **Klimstra DS, Pitman MB, Hruban RH. (2009).** An algorithmic approach to the diagnosis of pancreatic neoplasms *Arch Pathol Lab Med*, 133 (3): 454-464.
- **Legrand L, Duchatelle V, Molinié V, Coletta I B, Sibuleau E, Zins M (2015).** Pancreatic adenocarcinoma: MRI conspicuity and pathologic correlations. *Abdomen Imaging*, 40:85–94.
- **Liu K, Xie P, Peng W, & Zhou Z (2015).** Dynamic contrast-enhanced magnetic resonance imaging for pancreatic ductal adenocarcinoma at 3.0-T magnetic resonance: correlation with histopathology. *Journal of computer assisted tomography*, 39(1), 13-18.
- **Mourad AF, Sayed MM, Fakhry H. (2018).** Is magnetic resonance diffusion-weighted imaging superior in the diagnosis of pancreatic adenocarcinoma and does it have a prognostic value?. *The Egyptian Journal of Radiology and Nuclear Medicine*, Dec 1;49(4):908-13.
- **Semelka RC, Kelekis NL, Thomasson D, Brown MA, Laub GA. (1996).** HASTE MR imaging: description of technique and preliminary results in the abdomen. *J Magn Reson Imaging*, 6:698–699.
- **Wang Y, Miller FH, Chen ZE (2011).** Diffusion-weight MRI of solid and cystic lesions of the pancreas *Radio-Graphics*, 31 (3): E 47-4.
- **Waters JA, Schmidt CM, Pinchot JW, White PB, Cummings OW, Pitt HA, et al. (2008).** CT vs MRCP: optimal classification of IPMN type and extent *J Gastrointestinal Surg*, 12 (1): 101-109.
- **Yao XZ, Yun H, Zeng MS, Wang H, Sun F, Rao AX, et al. (2013).** Evaluation of ADC measurements among solid pancreatic masses

by respiratory-triggered diffusion-weighted MR imaging with inversion-recovery fat-suppression technique at 3.0T. *MagnReson Imaging*, 31:524–8.

- Zhang TT, Wang L, Liu HH, Zhang CY, Li XM, Lu JP, et al. (2017). Differentiation of

pancreatic carcinoma and mass-forming focal pancreatitis: qualitative and quantitative assessment by dynamic contrast-enhanced MRI combined with diffusion-weighted imaging. *Oncotarget*. =Jan 3;8(1):1744.