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Evaluation of the role of diffusion-weighted imaging in various pancreatic pathologies

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ABSTRACT

Background: Diffusion-weighted imaging (DWI) can confidently characterize the nature of a lesion. "Apparent diffusion coefficient" (ADC) has a role in evaluating malignant lesions of the pancreas when conventional sequences appear normal. **Aims and Objectives:** The aim of the study was to determine the role of DWI and ADC to differentiate benign from malignant pancreatic lesions.**Materials and Methods:** An observational study was carried out on 75 participants with a suggestion of pancreatic pathologies at a tertiary care institute. Twenty-five participants, who had normal parenchyma of the pancreas, were taken as controls. Magnetic resonance imaging protocol was done, including DWI and ADC. Data analysis was done using coGuide software. ADC was the primary outcome of interest. **Results:** Out of the 75 cases, 76.9 % (n = 60) were males. 15.4 % (n = 9) of pathologies were malignant. A significant decrease of ADC values in subjects with acute diffuse pancreatitis (1.12×10^{-3}), acute on chronic pancreatitis (1.14×10^{-3}), chronic pancreatitis (1.32×10^{-3}) as well as adenocarcinoma pancreas (0.92×10^{-3}) was seen in comparison to the controls (1.41×10^{-3}). ADC values for acute pancreatitis, chronic pancreatitis, and acute on chronic pancreatitis were significantly higher than malignancy. **Conclusion:** DWI and ADC is a useful tools complementing conventional MR imaging and other imaging modalities in characterizing pancreatic pathologies. Mean ADC values of various pancreatic diseases can be determined without major overlap and a reasonable cutoff value can be obtained for differentiating benign and malignant lesions.

Key words: Diffusion-weighted imaging; Apparent diffusion coefficient; Pancreatic disease; Acute pancreatitis; Chronic pancreatitis; Benign and malignant

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INTRODUCTION

Pancreas is a J-shaped, lobulated gland situated in the anterior pararenal space of the retroperitoneum. "Acute pancreatitis" has the potential to cause mortality.[1,2] The overall mortality for pancreatitis is around 1%.[3] In participants, who are hospitalized with pancreatitis, or with failure of organs, the mortality rate is higher at 30–40%.[4] About 10% of participants experiencing first episode of acute pancreatitis develop chronic pancreatitis, in comparison to 36% with recurrent acute pancreatitis.[5] Gallstones, use of alcohol, metabolic causes such as hypercalcemia and hypertriglyceridemia, infection, malnutrition, neoplasm, drugs, congenital or genetic conditions, and other idiopathic conditions lead to acute pancreatitis. Acute pancreatitis can lead to sequelae even long after clinical resolution. According to a recent meta-analysis, the average annual percent change of acute pancreatitis from 1961 to 2016 is 3.07% (2.3–3.84%). The incidence has been stable in Asia, compared to North America and Europe.[6]

The role of imaging in the pancreas is crucial for early and appropriate diagnosis as well as for staging of the diseases of the pancreas.[7] "Ultrasonogram" (USG), "computed

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tomography" (CT), and "Magnetic resonance imaging" (MRI) are various tools available for the evaluation of the pancreas. MRI is one of the superior imaging tools, which helps in the extensive characterization of cystic lesions and the identification of tumors of the pancreas.[8-10] USG is primarily used as a screening modality. Multidetector CT is widely used for the evaluation of the pancreas. The use of MRI is increasing for the assessment and characterization of severe pancreatic diseases, including benign and malignant lesions. "Diffusion-weighted imaging" (DWI) was introduced for increasing the diagnostic outcome in acute cerebrovascular accidents like stroke. Following technical and better pulse sequence updates, its applicability has further been extended to several parenchymal pathologies, including the pancreas.[11-14] DWI can be confidently used to characterize the nature of a lesion without the need for a more invasive histopathological correlation or when gadolinium-enhanced images are contraindicated. "Apparent diffusion coefficient" (ADC) is a quantitative parameter that has been derived based on DWI, corepresenting the effects of capillary perfusion and water molecule diffusion. Lesions with high cellularity showing reduced diffusivity and lower ADC values indicate a more malignant nature as compared to a benign tumor of low cellularity showing facilitated diffusion with high ADC values.[15,16] There has also been contrasting evidence about the role of DWI to conventional MRI for differentiation of cancer of the pancreas from chronic pancreatitis.[17] Hence, the present study was undertaken with the following objectives.

Aims and objectives

Primary objective

1. The aim of the study was to determine the role of DWI with ADC in differentiating benign from malignant pancreatic lesions
2. The aim of the study was to determine the role of ADC values in detecting acute pancreatitis when conventional sequences appear normal.

Secondary objective

1. The aim of the study was to compare the ADC values of pancreatic pathologies (both benign and malignant) with that of normal pancreatic parenchyma.

MATERIALS AND METHODS

A "hospital-based observational study" was done in the radiodiagnosis department of a tertiary care institute in Chennai. The study was undertaken after clearance from the "institutional ethics committee". The study sample included 75 participants referred to the radiodiagnosis department for evaluation of abnormalities of the pancreas, for MRI abdomen/magnetic resonance cholangio pancreatography (MRCP). An additional 25 participants, who had normal parenchyma of the pancreas, were taken as controls. The sampling method was purposive.

Patients with pancreatic abnormalities detected on USG/computed tomography (CT) or MRI, consenting to be a part of the study and patients who have their final definitive diagnosis/histopathological results, were included in the study.

Participants with "cardiac pacemakers, any metallic implants, implants of cochlea, prosthetic heart valves" were excluded from the study. Participants with a history of claustrophobia and those not willing to give consent were also excluded from the study.

MRI protocol

All the participants, selected for the study were first explained in detail about the procedure of MRI. Then "written informed consent" was taken. The clinical history was taken in detail. The information regarding the past medical history was recorded. Participants were then screened for the presence of any metallic objects and placed for MRI. Findings of MRI, DWI, and ADC values were compared and correlated with clinical/laboratory parameters and final diagnosis, including HPE, whenever available. For performing MRI/magnetic resonance cholangio pancreatography, "Philips Multiva 1.5 tesla MRI" using 8-channel sense torso surface coil was used. MRI protocol was done with a supine position, feet first orientation, and body torso coil.

The MRI protocol

- Axial T2 (coronal and sagittal). B-fast field echo 2d coronal and sagittal
- TFE, thick slab, and 3D MRCP
- DWI
- Contrast is given whenever clinically indicated.

Before administering the contrast, DWI was acquired in an axial plane. A single-shot echo-planar imaging sequence ("TR/TE effective range, 1000/74 ms; slice thickness 6 mm; FOV: 36–42 cm; matrix: 384×256"). A b-value 1000 s/mm^2 was applied in three orthogonal directions (Z, Y, and X). Conventional MRI and DWI imaging data, including ADC values obtained, were analyzed.

ADC map was displayed in grayscale. Following the ADC map, the region of interest (ROI) was placed in areas showing true diffusion restriction which was free from hemorrhage and necrosis. Two ROI of size 50±10 mm^2 were placed. ADC was then computed automatically by preset software. From these, the mean ADC value was then calculated as the average of the above-obtained values.

Data entry was done with "Microsoft Excel worksheet" and data were analyzed with "coGuide software".[18] The main variable of interest was ADC. Pancreatic pathology was the explanatory variable. The presenting complaints and conventional findings in MRI were other relevant variables. For comparing the quantitative variables across the groups, "independent sample t-test" was used. For qualitative variables, "Chi-square test/Fischer's exact test" was used. $P<0.05$ was considered for determining the level of statistical significance.

Ethics statement

Ethical and informed consent: Ethical approval was obtained from the institutional review board (Ref: SMC/IEC/2018/11/229 of the center concerned). Informed written consent was obtained before the study started and confidentiality was maintained throughout.

RESULTS

The final analysis included a total of 100 participants.

Seventy-five (75.00%) participants were in case groups and 25 (25.00%) were in control groups (Table 1). The difference in gender distribution across the groups was not significant statistically ($P=0.123$) (Table 2).

In the cases group, the majority of participants 32 (42.67%) had abdomen pain, followed by epigastric pain 29 (38.67%), vomiting 24 (32.00%), and fever 14 (18.67%) (Table 3).

In the cases group, 20 (26.67%) participants had reported CT, 18 (24.00%) had reported USG, and 24 (32.00%) had reported USG and CT. In the cases group, the majority of participants 28 (37.33%) had acute pancreatitis features in MRI imaging followed by acute on chronic pancreatitis 15 (20.00%) and pancreatic mass 9 (12.00%). In the cases group, the majority of participants 25 (33.33%) had diffuse interstitial pancreatitis and 13 (81.25%) had tissue-based diagnosis (Table 4).

Table 1: Descriptive analysis (n=100)

Study group	Frequency	Percentages
Cases	75	75.00
Control	25	25.00

Table 2: Comparison of baseline parameters (n=100)

Parameter	Study group		P-value
	Cases (n=75)	Control (n=25)	
Age (in years)	42.15±15.5	45.16±17.72	0.419*
Gender (%)			
Male	57 (76)	15 (60)	
Female	18 (24)	10 (40)	0.123†

*Independent sample t-test, †Chi-square test

The mean of ADC was 1.11±0.22 in cases and it was 1.41± 0.11 in controls. Mean difference in ADC values between cases and controls was statistically significant with $P<0.001$ (Table 5).

DISCUSSION

Acute pancreatitis is a disease capable of causing high mortality.[1,2] The overall mortality for pancreatitis is around 1%.[3] According to a review article, the yearly

Table 3: Descriptive analysis of presenting complaints among the cases (n=75)

Presenting complaints	Frequency	Percentages
Abdomen pain	32	42.67
Epigastric pain	29	38.67
Vomiting	24	32.00
Fever	14	18.67
Jaundice	10	13.33
Radiating pain to the back	2	2.67
Loin Pain	1	1.33

Table 4: Summary of outcome parameters among cases (n=75)

Outcome parameters	Frequency	Percentages
Other imaging investigations		
Computed tomography	20	26.67
Ultrasonogram	18	24.00
Ultrasonogram and computed tomography	24	32.00
Nil	13	17.33
Conventional magnetic resonance findings		
Acute pancreatitis	28	37.33
Acute on chronic pancreatitis	15	20.00
Pancreatic mass	9	12.00
Periampullary mass	5	6.67
Chronic calcific pancreatitis	3	4.00
Chronic pancreatitis	3	4.00
No evident abnormality	3	4.00
Acute edematous pancreatitis	2	2.67
Acute focal pancreatitis	2	2.67
Ampullary mass	2	2.67
Head of pancreas mass	2	2.67
Indeterminate pancreatic lesion	1	1.33
Final diagnosis		
Diffuse interstitial pancreatitis	25	33.33
Acute on chronic pancreatitis	16	21.33
Pancreatic adenocarcinoma	12	16.00
Focal pancreatitis	11	14.67
Chronic pancreatitis	7	9.33
Pancreatic mucinous cystadenoma	2	2.67
Groove pancreatitis	1	1.33
Solid pseudopapillary neoplasm	1	1.33
Follow-up		
CA-19/9-157	1	6.25
Evolved to pseudocyst	1	6.25
Fine-needle aspiration proven	1	6.25
Histopathology proven	13	81.25

Table 5: Comparison of mean of apparent diffusion coefficient values (n=100)

Parameter	Study group		P-value
	Cases (n=75)	Control (n=25)	
DWI with ADC	1.11±0.22	1.41±0.11	P<0.001

DWI: Diffusion-weighted imaging, ADC: Apparent diffusion coefficient

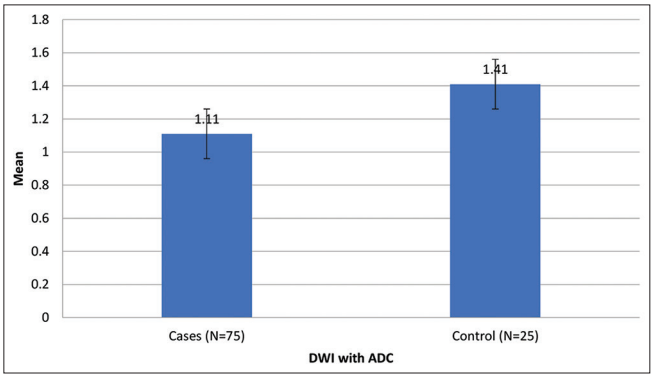

Figure 1: Comparative bar chart of mean of apparent diffusion coefficient values (n=100)

global incidence of acute pancreatitis was reported as 34 cases, chronic pancreatitis as 10 cases, and incidence of diabetes mellitus, and post-pancreatitis was reported as six cases.[19] In the current study, 75 participants referred for an MRI abdomen/MRCP with a suggestion of pancreatic pathologies and a control group of 25 patients were included in the study. There was a significant reduction of ADC values in patients with acute diffuse pancreatitis (1.12×10^{-3}), acute on chronic pancreatitis (1.14×10^{-3}), chronic pancreatitis (1.32×10^{-3}) as well as adenocarcinoma pancreas (0.92×10^{-3}) in comparison to the control group (1.41×10^{-3}) (Figure 1). ADC values for acute pancreatitis, chronic pancreatitis and acute on chronic pancreatitis were significantly higher than malignancy in our study. In three patients clinically diagnosed with acute pancreatitis, conventional MRI did not reveal any abnormality, whereas DWI showed restricted diffusion with reduced ADC values.

The study group included 75 cases and 25 controls. Out of the 75 cases, 57 (76%) were males and 18 (24%) were females. The majority presented in their 3rd decade, followed by the 5th and 2nd decades of life. The age of presentation varied widely from 13 years of age to 85 years. The major presenting complaints were abdominal pain, epigastric pain, vomiting, fever, jaundice, and anemia. ADC map was obtained from the DWI sequence. The ADC values were calculated by placing the ROI of area 50±10 mm^2. The mean ADC values of the pancreas in the control group were-head 1.43×10^{-3}, body 1.42×10^{-3}, tail $1.39\times10^{-3,}$ and mean of pancreas (whole) 1.41×10^{-3}. Thus pancreas can be considered a homogenous organ in terms of ADC distribution.

Barral et al.,[20] in their (2015) study showed the mean ADC of pancreatic parenchyma to be 1.611×10^{-3}. They also compared and studied normal pancreas ADC values in several other studies with varying population groups. ADC values of acute pancreatitis (1.355×10^{-3}) were found to be significantly lower than the control group (1.611×10^{-3}). They reported the marked variations in ADCs of normal pancreas. Furthermore, they suggested that these variations in ADCs may be a result of difference in the patient population studied, applied imaging sequences, and specific b values used for ADC calculation.

84.6% (n=66) had benign pathologies, while 15.4% of pathologies were malignant. There was a significant ADC values reduction in patients with acute diffuse pancreatitis (1.12×10^{-3}), acute on chronic pancreatitis (1.14×10^{-3}), chronic pancreatitis (1.32×10^{-3}) as well as adenocarcinoma pancreas (0.92×10^{-3}) in comparison to the control group (1.41×10^{-3}). ADC values for acute pancreatitis, chronic pancreatitis, and acute on chronic pancreatitis were significantly higher than malignancy in our study. In 3 patients clinically diagnosed with acute pancreatitis, conventional MRI did not reveal any abnormality, whereas DWI showed restricted diffusion with reduced ADC values.

DWI has specific advantages such as it can be performed in a relatively shorter time interval, totally non-invasive, requires no exogenous contrast administration, and its ability to detect subtle changes. Initially, there were considerable limitations in the application of DWI in abdominal imaging due to significantly increased scan times and patient respiration artifacts. However, with technical advances, special mention to high amplitude faster gradients, parallel imaging, high density phased array coils, and use of optimized ultra-fast echo-planar techniques, DWI has become much more practical in routine MRI.[21]

Thus, DWI can be confidently used to characterize the nature of a lesion without the need for a more invasive histopathological correlation[22] or when gadolinium-enhanced images are contraindicated.[23] Lesion differentiation and image contrast in DW imaging relies on the mobility of water molecules between the issues. As the need for exogenous

contrast administration is not required, its application in patients with renal impairment gains significance.

Limitations of the study

A small sample size limits the generalisability of the results of the present study. Furthermore, the inability to establish a significant difference of ADC values between focal mass-forming pancreatitis and pancreatic adenocarcinoma is a major limitation. Further study with higher b -values in increased magnetic strengths can be considered a solution.

CONCLUSION

DWI and ADC is a useful tools complementing conventional MRI and other imaging modalities in the characterization of pancreatic pathologies. Mean ADC values of various pancreatic diseases have been determined without major overlap and thereby obtained a reasonable cut-off value to differentiate benign lesions from malignant lesions.

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Authors Contribution:
DCSS and GG- Have conceptualized the study and played primary role in compiling, analysis and interpretation of the data; **DCSS, GS, GG, SA, NP-** All the drafts were prepared, reviewed and the final draft was approved; **DCSS, GS, SA, NP**- Have contributed in fine-tuning of the proposal, contributed in data collection and entry, reviewed the results and contributed to preparation and review of drafts. All the authors have read and approved the final version of the manuscript. All the authors take complete responsibility for the content of the manuscript

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