Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 12, (2023)
https://www.jneonatalsurg.com

OPEN ACCESS

The Role of Magnetic Resonance Imaging in Preliminary Screening as a Diagnostic Hallmark of Early Acute Pancreatitis

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Cite this paper as A S M Shahidul Hossain, Mahmud Hasan Mostofa Kamal, Mohammad Ali Kabir, Md. Nazrul Islam, Mohammed Shoaib Chowdhury, (2023) The Role of Magnetic Resonance Imaging in Preliminary Screening as a Diagnostic Hallmark of Early Acute Pancreatitis..*Journal of Neonatal Surgery*, 12, 147-153

Submitted on 16th August, 2023, Accepted on 20th October,2023, Published on 30th November, 2023.

ABSTRACT

Background: Early diagnosis of acute pancreatitis remains challenging when ultrasonography (USG) and computed tomography (CT) findings are inconclusive. Magnetic resonance imaging (MRI) provides superior soft-tissue contrast and early pathological visualization.

Objective: To evaluate the diagnostic effectiveness of MRI in detecting early acute pancreatitis in patients with negative USG and CT findings but positive serum amylase levels.

Methods: This prospective cross-sectional study was conducted at Ibne Sina Diagnostic & Consultation Center (Uttara), Popular Diagnostic Center (Savar), Super Medical Hospital (Savar) And Enam Medical College Hospital (Savar), Dhaka, Bangladesh, from January 2021 to July 2022. A total of 53 patients with acute abdominal pain and elevated serum amylase and lipase, but negative USG and CT findings, were included. MRI was performed using T1, T2, fat-suppressed, and diffusion-weighted sequences to detect early features of pancreatitis.

Result: MRI demonstrated a diagnostic sensitivity of 92.5% (49/53 patients), significantly surpassing CT and USG ($p<0.001$). While conventional T2/STIR sequences identified pancreatic enlargement (88.7%) and edema (84.9%), the DWI/ADC combination was pivotal. All positive cases exhibited restricted diffusion, quantified by a significantly lower mean ADC value in inflamed tissue ($1.10 \pm 0.14 \times 10^{-3}$ mm²/s) versus normal tissue ($1.51 \pm 0.12 \times 10^{-3}$ mm²/s; $p<0.001$).
Conclusion: MRI, with its functional DWI/ADC component, is a highly sensitive non-invasive tool for the preliminary screening and diagnosis of early acute pancreatitis, serving as a crucial diagnostic hallmark when traditional imaging fails.

Keywords: *Acute pancreatitis, Early diagnosis, Imaging, MRI, Screening, Serum amylase*

1. INTRODUCTION

Acute pancreatitis (AP) is a common gastroenterological emergency with a global incidence that is steadily increasing, leading to significant healthcare burdens [1]. The diagnosis is traditionally established by the fulfillment of at least two of

the following three criteria: characteristic abdominal pain, a serum amylase or lipase level greater than three times the upper limit of normal, and confirmatory findings on cross-sectional imaging [2]. While the clinical and biochemical criteria are often the first to manifest, their specificity can be confounded by other acute abdominal conditions, making imaging a cornerstone for definitive diagnosis and staging [3]. In this diagnostic paradigm, contrast-enhanced computed tomography (CECT) of the abdomen is widely regarded as the gold standard for assessing established AP, particularly for detecting necrosis and complications [4]. However, its utility in the very early stages of the disease, often within the first 24-48 hours, is markedly limited. During this initial phase, morphological changes in the pancreas may be subtle or absent, leading to a high rate of false-negative or inconclusive CT reports [5]. Transabdominal ultrasonography (USG), while useful for detecting gallstones and ruling out other pathologies, is frequently hampered by overlying bowel gas, obscuring clear visualization of the pancreatic parenchyma [6]. This creates a critical diagnostic gap where patients present with classic symptoms and elevated enzymes, yet lack the imaging confirmation required for definitive diagnosis and appropriate management, potentially delaying intervention. Magnetic Resonance Imaging (MRI) has emerged as a powerful alternative, offering superior soft-tissue contrast without ionizing radiation. Conventional MRI sequences, including T2-weighted turbo spin echo (T2 TSE) and fat-suppressed T2-weighted (STIR) imaging, are highly sensitive for detecting early inflammatory changes such as parenchymal edema, peripancreatic fluid collections, and subtle fat stranding that are often missed by CT [7,8]. The multi-planar capability of MRI further allows for comprehensive evaluation of the pancreas and its surrounding structures. The most significant advancement in pancreatic MRI has been the integration of functional imaging through diffusion-weighted imaging (DWI) and the quantitative apparent diffusion coefficient (ADC) map. DWI is a technique that measures the random Brownian motion of water molecules within tissue. In the setting of acute inflammation, as seen in early AP, cytotoxic edema, cellular infiltration, and increased intracellular space restrict the free diffusion of water. This phenomenon is visualized as high signal intensity on high b-value DWI images and a corresponding reduction in the quantitative ADC value [9,10]. Several recent studies have begun to highlight the potential of DWI/ADC in diagnosing AP, suggesting it can detect abnormalities even before changes are apparent on conventional T2-weighted sequences [11,12]. However, the specific role of DWI/ADC as a primary screening hallmark in patients with clinically and biochemically suspected AP but negative initial CT and USG remains a critical area of investigation. This particular clinical scenario represents a common challenge in emergency and surgical units. Therefore, this study aims to rigorously evaluate the diagnostic performance of a comprehensive MRI protocol, with a dedicated focus on the inverse relationship between DWI signal and ADC values, in establishing an early and accurate diagnosis of acute pancreatitis, thereby bridging the existing diagnostic gap.

2. METHODOLOGY

Study design and population: This cross-sectional study was conducted in the Department of Radiology and Imaging at Ibne Sina Diagnostic & Consultation Center (Uttara), Popular Diagnostic Center (Savar), Super Medical Hospital (Savar) And Enam Medical College Hospital (Savar), Dhaka, Bangladesh, from January 2021 to July 2022. A total of 53 patients who presented with acute upper abdominal pain and elevated serum amylase levels, but had non-diagnostic or negative findings on both ultrasonography (USG) and contrast-enhanced computed tomography (CECT), were recruited. All participants were clinically evaluated by a gastroenterologist before MRI referral, and informed written consent was obtained from each.

Inclusion criteria:

The study enrolled patients based on the following criteria:

Clinical presentation of acute upper abdominal pain suggestive of pancreatitis.

Elevated serum amylase and/or lipase levels greater than three times the upper limit of normal.

Absence of definitive findings for acute pancreatitis on both USG and CECT.

Age between 15 to 60 years.

Exclusion criteria:

Patients were excluded from the study based on the following:

History of chronic pancreatitis, pancreatic surgery, or pancreatic malignancy.

Evidence of biliary obstruction, significant ductal dilatation, or jaundice.

Renal impairment contraindicates the use of gadolinium-based contrast agents (not administered in this protocol).

Any general contraindication to MRI, such as incompatible metallic implants or claustrophobia.

Study procedure: All MRI examinations were performed using a 1.5 Tesla MRI scanner. The imaging protocol was specifically tailored to evaluate pancreatic parenchyma and included the following sequences: axial, sagittal, and coronal T2-weighted turbo spin echo (T2 TSE); axial and sagittal Short-Tau Inversion Recovery (STIR); and axial diffusion-weighted imaging (DWI) with multiple b-values (e.g., 0, 50, 400, and 800 s/mm²). Apparent diffusion coefficient (ADC) maps were generated automatically by the system software. Magnetic resonance cholangiopancreatography (MRCP) was performed selectively. The diagnosis of early acute pancreatitis on MRI was based on established morphological signs (e.g., pancreatic

enlargement, T2/STIR parenchymal hyperintensity, peripancreatic fat stranding) and functional evidence of restricted diffusion on DWI/ADC sequences.

Data analysis: The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 23.0. Descriptive statistics were presented as means ± standard deviations for continuous variables and as frequencies and percentages for categorical variables. The diagnostic sensitivity of MRI was calculated. The inverse relationship between DWI signal intensity and quantitative ADC values was assessed using a paired t-test to compare mean ADC values in affected versus normal-appearing pancreatic tissue. A p-value of less than 0.05 was considered statistically significant.

3. RESULT

A total of 53 patients (mean age 42.5 ± 12.1 years) were enrolled, with a distribution of 20.8% (n=11) aged 15-29, 24.5% (n=13) aged 30-39, 30.2% (n=16) aged 40-49, and 24.5% (n=13) aged 50-60. The cohort showed a male predominance of 58.5% (n=31) compared to 41.5% (n=22) females, though this difference was not statistically significant (p=0.24). Clinically, all patients (100%) presented with epigastric pain, followed by nausea/vomiting (71.7%, n=38), abdominal distension (50.9%, n=27), and fever (35.8%, n=19). Biochemical analysis confirmed significant pancreatic inflammation, with mean serum amylase and lipase levels elevated to 528.4 ± 138.2 U/L and 669.5 ± 201.7 U/L, respectively, both highly significant compared to normal ranges ($p<0.001$). Magnetic Resonance Imaging (MRI) demonstrated a decisive diagnostic advantage, identifying positive findings in 49 of the 53 patients, yielding a sensitivity of 92.5%. This was significantly superior to CT and USG, which had a 0% detection rate ($p<0.001$). Conventional T2 TSE and STIR sequences revealed morphological abnormalities in a majority of cases, with pancreatic enlargement and T2, STIR hyperintensity present in 84.9% (n=45) of patients. The most critical findings, however, came from diffusion-weighted imaging. All 49 MRI-positive cases exhibited restricted diffusion, characterized by parenchymal hyperintensity on DWI (b=800) and a corresponding significant reduction on ADC maps. Quantitative analysis confirmed that the mean ADC value in affected areas was 1.10 ± 0.14 x 10^{-3} mm^2/s, significantly lower ($p<0.001$) than the reference value of 1.51 ± 0.12 x 10^{-3} mm^2/s in normal tissue, definitively establishing the inverse DWI/ADC relationship as the key imaging hallmark for early acute pancreatitis.

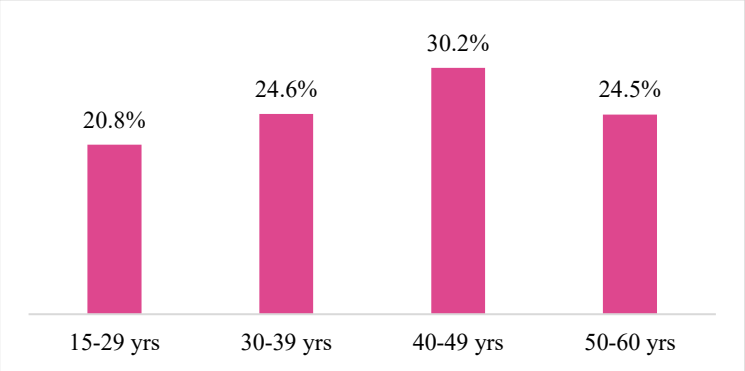
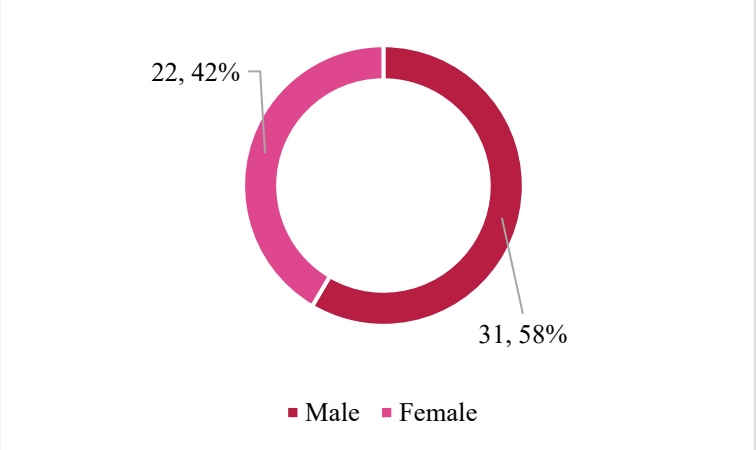


Figure 1: Age distribution of the study participants



Statistical Test: Chi-square goodness-of-fit test; p-value = 0.24

Figure 2: Gender distribution of the study cases

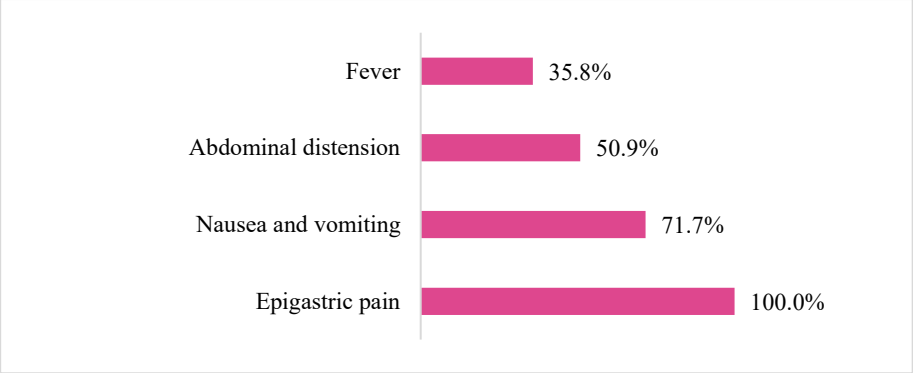


Figure 3: Presenting clinical symptoms

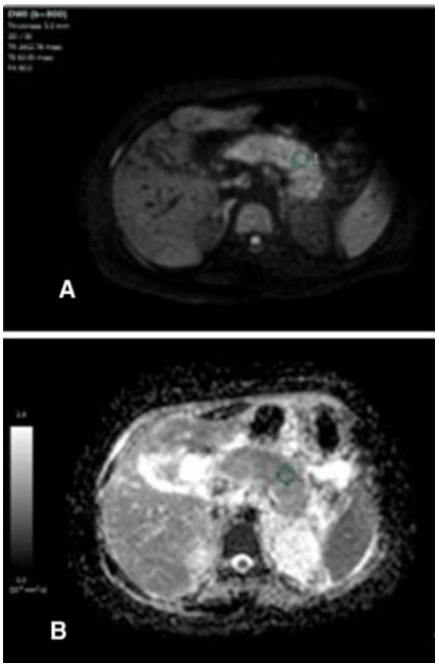


Figure 4: DWI showing restricted pancreas and low ADC value of pancreatic body on ADC map 0.87 x 10-3 mm2/s

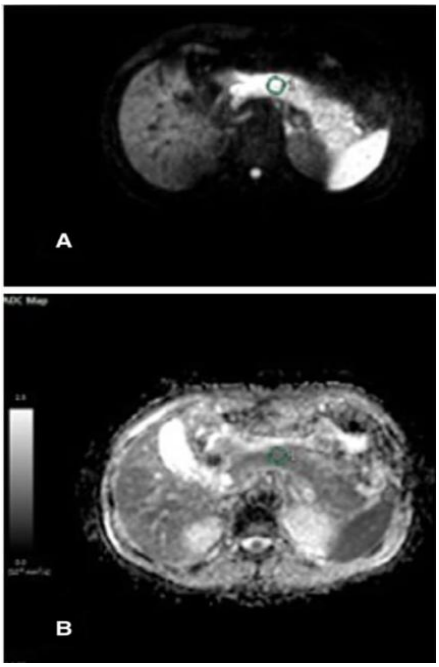


Figure 5: DWI showing restricted pancreas and low ADC value 1.01 x 10-3 mm2/s of pancreatic body on ADC map

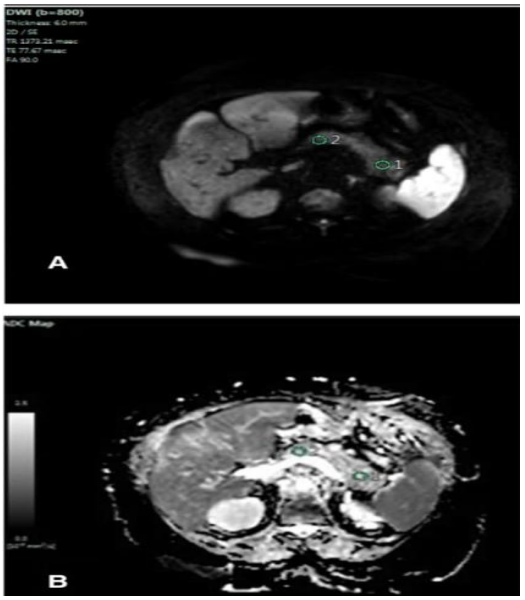


Figure 6: A–B. Diffusion-Weighted Imaging (DWI) and Corresponding ADC Map Demonstrating Regions of Interest (ROIs) in the Pancreas.

Table 1: Serum pancreatic enzyme levels at presentation

Parameter (U/L)	Mean ±SD	p-value
S. amylase	528.4 ±138.2	< 0.001
S. lipase	669.5 ±201.7	< 0.001

Statistical Test: One-sample t-test

Table 2: Morphological abnormalities on T2 TSE and STIR sequences

MRI finding	n	%
Minimal peripancreatic fluid	35	66.0%
Peripancreatic fat stranding	42	79.2%
T2 FSE & STIR hyperintensity	45	84.9%
DWI marked hyperintensity	49	92.5%
Corresponding ADC marked hypointensity	49	92.5%

Table 3: Comparative diagnostic sensitivity of imaging modalities

Diagnostic modality	n	%
MRI (Overall)	49	92.5%
CT	0	0%
USG	0	0%

Statistical Test for MRI vs. CT/USG: McNemar's test; p-value < 0.001

Table 4: Quantitative and qualitative analysis of DWI and ADC findings

MRI sequence	Qualitative finding (Affected)	Quantitative finding	p-value
		Mean ±SD	
DWI (b=800 s/mm²)	Marked parenchymal hyperintensity	Not applicable	< 0.001
ADC map	Corresponding parenchymal hypo-intensity	$1.10 \pm 0.14 \times 10^{-3}$ mm²/s	< 0.001
Reference ADC	Normal pancreatic parenchyma	$1.51 \pm 0.12 \times 10^{-3}$ mm²/s	

Statistical Tests: McNemar's test for DWI detection rate; Paired t-test for ADC value comparison

4. DISCUSSION

The findings of this study robustly affirm the superior diagnostic capability of Magnetic Resonance Imaging (MRI) for early detection of acute pancreatitis, particularly in the clinically challenging cohort in which conventional imaging modalities are inconclusive. Our results demonstrate that MRI achieved a diagnostic sensitivity of 92.5%, significantly outperforming both USG and CT, which failed to identify any positive cases. This aligns with a growing body of evidence suggesting that MRI's exquisite soft-tissue resolution makes it uniquely suited to detect the subtle inflammatory and edematous changes that characterize the initial phase of the disease [7,14]. The limitations of USG and CT in this context are well-documented. USG is frequently impeded by overlying bowel gas, while CT, despite its utility in assessing established necrosis and complications, lacks the soft-tissue contrast necessary to visualize incipient parenchymal edema [5,6]. Our study population, selected specifically for their negative CT and USG findings despite strong clinical and biochemical suspicion, represents this critical diagnostic gap. The high yield of positive findings on MRI in this group underscores its indispensable role as a problem-solving tool, enabling a definitive diagnosis and preventing potential delays in management [15]. While conventional MRI sequences (T2 TSE and STIR) were highly effective, revealing abnormalities like pancreatic enlargement and parenchymal T2 hyperintensity in a majority of cases, the most pivotal contribution of this study lies in the quantitative validation of the DWI/ADC sequence. The consistent observation of parenchymal hyperintensity on high b-value DWI with a corresponding and statistically significant reduction in the mean ADC value ($1.10 \pm 0.14 \times 10^{-3}$ mm²/s vs. $1.51 \pm 0.12 \times 10^{-3}$ mm²/s in normal tissue, $p<0.001$) provides an objective and reproducible diagnostic hallmark. This inverse relationship is a direct reflection of restricted water diffusion secondary to cytotoxic edema, inflammatory cell infiltration, and increased intracellular space within the inflamed pancreatic acinar cells [9,16]. Our findings are in strong agreement with recent studies by Barral et al. and He et al., who also highlighted DWI's exceptional sensitivity for detecting AP, often surpassing that of conventional sequences [10,11]. The quantitative nature of the ADC map adds a layer of objectivity, reducing inter-observer variability and solidifying the imaging diagnosis [17,18]. By focusing on this specific clinical scenario and providing quantitative ADC data, our study moves beyond merely confirming MRI's utility; it establishes a clear diagnostic pathway. We posit that the DWI/ADC combination should be considered the cornerstone of MRI evaluation for suspected early Acute Pancreatitis (AP). Its ability to confirm restricted diffusion offers a functional insight into the pancreatic parenchyma that is not available with anatomic imaging alone, making it a powerful biomarker for early inflammation [18,19].

5. LIMITATIONS:

This study has certain limitations. Its single-center, cross-sectional design and relatively modest sample size warrant validation through larger, multicenter prospective studies. Furthermore, the absence of histopathological confirmation is an inherent constraint in human AP studies, though the clinical and biochemical follow-up served as a reliable reference standard.

6. CONCLUSION

For patients with a strong clinical and biochemical profile for acute pancreatitis but non-contributory USG and CT scans, MRI emerges as a decisive diagnostic modality. The integration of conventional T2/STIR sequences with functional DWI and quantitative ADC mapping provides a comprehensive and highly sensitive approach. The significant reduction in ADC values in affected parenchyma serves as a critical, objective hallmark for early diagnosis, enabling clinicians to initiate timely and appropriate therapeutic interventions.

7. RECOMMENDATION:

We recommend incorporating MRI, specifically the DWI/ADC sequence, into the preliminary diagnostic algorithm for suspected early acute pancreatitis when clinical findings are discordant with inconclusive CT and USG results, to facilitate a definitive and timely diagnosis

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