Abdominal imaging

ORIGINAL ARTICLE

Role of Diffusion Weighted MRI in Characterization of Abdomino-Pelvic Lymphadenopathy

Mustafa Mohamed Elshahat Hafez, Yasser Ali Mohamed Abd El Mawla, Ahmed Mohamed Hussein, Mohamed Yosry
Radiology Department, Faculty of medicine, Ain shams university, Egypt

SUBMISSION: 21-08-2024 | ACCEPTANCE: 21-10-2024

ABSTRACT

Background: Abdomino-pelvic lymphadenopathies, are classified either benign or malignant. The benign lymphadenopathies include infection and inflammation while the malignant group consists of two subtypes, primary as lymphoma and secondary as metastatic.

Objective: The aim of the study was to determine if diffusion weighted magnetic resonance imaging could help in discrimination between benign and malignant abdomino-pelvic lymph nodes.

Patients and Methods: Twenty-four patients with pelvic-abdominal lymphadenopathies were included in this study. The study was performed in Ain Shams university hospital, Air forces specialized hospital & Cairo specialized Hospital - Cleopatra Hospital Group (CHG) between December 2020 and June 2023. Full clinical history of all patients was taken and their laboratory Investigations, Histopathological data and previous imaging were reviewed.

All patients underwent conventional MR imaging using a 1.5&3T machine (Achieva and Ingenia, Philips medical system, Eindhoven, Netherlands) using a phased array coil, for characterization and detection of the lymph nodes, including; Axial T1 WI, Axial T2 Wi, Axial T2 SPAIR fat suppression, diffusion and ADC map sequences.

Results: We found a significant difference between ADC values of benign and malignant abdomino-pelvic lymph nodes, with a threshold ADC value equal to 1.1x 10^{-3} mm^2/sec. identified. This value could be used in the

CORRESPONDING AUTHOR, GUARANTOR

Mustafa Mohamed El Shahat Hafez
E mail: mostafaelshahat123@gmail.com
Designation: Professor of Radio-diagnosis, Radiology Department, Faculty of medicine, Ain shams university, Egypt.

pre-treatment phase for better oncologic staging and assessment. The higher accuracy of DWI using high b Values (500&1000 sec/mm^2),as compared with conventional MR imaging, was most beneficial in the detection of not only the enlarged but also the sub-centimetric metastatic lymph nodes.

These findings suggest that DWI can be complementary to conventional MRI hence the related size and morphologic criteria lack sufficient reliability for better detection and characterization of nodal metastasis. A significant difference between the ADC value of lymphoma and metastatic lymph nodes was also detected in our study, with a threshold equal to 0.78 x 10^{-3}mm^2/sec identified.

Conclusion: DWI can be a considered supportive tool in differentiation between benign and malignant lymph nodes and can to a lesser extent differentiate between the types of malignant lymphadenopathies.

KEY WORDS | Diffusion Weighted MRI, Abdomino-Pelvic Lymphadenopathy

Introduction

Lymphadenopathy means abnormal increase in size and/or altered consistency of the lymph nodes. It is important to differentiate benign from malignant lymph nodes [1].

The evaluation of lymphadenopathy is important as they serve as an excellent clue to underlying problems. They could be due to infections, autoimmune disorders or malignancies (whether metastatic or lymphomas) [2].

Assessment of lymphadenopathy remains one of the most challenging and often unsatisfactory issues for radiologists. Characterizing lymphadenopathy as benign or malignant using cross sectional imaging is currently limited and a biopsy is often needed to obtain a definitive diagnosis [3].

CT and MRI, with cross sectional imaging, use morphological characteristics for the nodal staging, such as size and shape (oval or round) of the node. The criteria used as indicators of metastatic node are a diameter, in short axis, >1 cm for oval nodes and >0.8 cm for round nodes. With such criteria, a meta-analysis was done and confirmed the limited value of morphological exams in lymph node staging [4].

Biopsy & Histopathology of the lymph node is accepted as the gold standard for accurate diagnosis of these neoplasms. However, biopsy is an invasive procedure, which not only increases the patient's pain but also is costly, time consuming and has complications [5] .

18-F fluorodeoxyglucose (FDG) positron emission tomography/computed tomography (PET/CT) is widely used for initial tumour staging, evaluation of treatment response, and detection of tumour recurrence. Consequently, the number of PET/CT detected suspicious lymph nodes is increasing, particularly in the neck. However, benign lymphadenopathy may also reveal hypermetabolism mimicking metastasis because PET/CT provides information about tissue glucose metabolism [6].

MRI is an ideal tool to evaluate lymph nodes due to its excellent soft tissue contrast. Diffusion weighted imaging (DWI) is a method of signal contrast generation based on the differences in Brownian motion. DWI is a method to evaluate the molecular function and micro-architecture of the human body. DWI signal contrast can be quantified by apparent diffusion coefficient maps and it acts as a tool for treatment response evaluation and assessment of disease progression [7].

Mean ADC for malignant lesions could be lower than that for benign entities. DW-MRI could improve the diagnostic accuracy in differentiation between benign and malignant lymph nodes [1].

Objective

The aim of the study was to determine if diffusion weighted magnetic resonance imaging could help in discrimination between benign and malignant abdomino-pelvic lymph nodes. In this study, we reviewed the ADC values of lymph nodes visualized on abdomen-pelvic MRI images and correlate their values with lymph nodes morphological pattern, PET/CT and / or histopathology results.

Patients and Methods

Patients

Twenty-two patients with pelvi-abdominal lymphadenopathies were included in this study. The study was performed in Ain Shams university hospital, Air forces specialized hospital & Cairo specialized Hospital – CHG between December 2020 and June 2023. Full clinical history of all patients was taken and their laboratory Investigations, Histopathological data and previous imaging were reviewed.

Methodology

All patients underwent conventional MR imaging using a 1.5&3T machine (Achieva and Ingenia, Philips medical system, Eindhoven, Netherlands) using a phased array coil, for characterization and detection of the lymph nodes, including: axial T1 WI: TR= 10 msec, TE=4.58 msec. Matrix 179/320. Slice thickness 7-8 mm. slice gap 1-2 mm & FOV: 355 mm, axial T2 WI: TR > 445 msec, TE= 26-28 msec. Matrix 180-200x240. Slice thickness 7-8 mm. Slice gap 1-2 mm & FOV 365, axial T2 SPAIR fat suppression sequence: TR>U400 msec, TE=80 msec. Matrix 204x384, Slice thickness 7-8 mm, Slice gap 1-2 mm & FOV 365.

Then, Diffusion sequences

Respiratory-triggered fat-supressed single-shot echo planar DW performed in transverse plane with tri-directional diffusion gradients by using b values 0, 500 & 1000 sec/mm2 to increase sensitivity to cellular packing. TR> 1880 msec, TE=70 msec, NEX=3. Matrix 256x256, slice thickness 7-8 mm, slice gap 1-2 mm and FOV as small as possible with 52% rectangular field of view. All imaging results were verified against a standard of reference.

ADC maps were generated at b values 500 & 100 sec/mm2, by drawing ROI on the solid part of the selected lymph node.

Imaging evaluation

The morphological features of each lymph node were recorded including size, shape, margin, signal characteristics as well as their number and sites. Then provisional diagnosis was reported and the diffusion images and ADC map were also reviewed. To calculate ADC value of each lymph node, we drew ROI directly on ADC map within the solid part of each lymph node at the slice in which the largest ROI can be drawn.

The results were documented, calculated and analysed using suitable statistical analysis. Then, we correlated the ADC values of each lymph node with its morphological pattern, PET/CT and/or histopathology results.

The final diagnoses were reached according to Standard of reference (SOR):

For lymph nodal characterization, all imaging results were refined against a predefined SOR. A range of procedures were identified as valid "gold standards" for the characterization of the benign and malignant lymph nodes. 14 cases of lymphomas and abdominopelvic malignancies were pathologically proven. The standard of reference for 8 cases was the FDG PET CT findings (2 cases with malignant lymph nodes; Cancer colon & HCC, and 6 cases with benign reactive lymph nodes). A lymph node was considered malignant if its SUV max value was greater than 4 and it was considered benign if the SUV max value was less than 2.5.

Statistical Analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Shapiro-Wilk test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

Case 1:

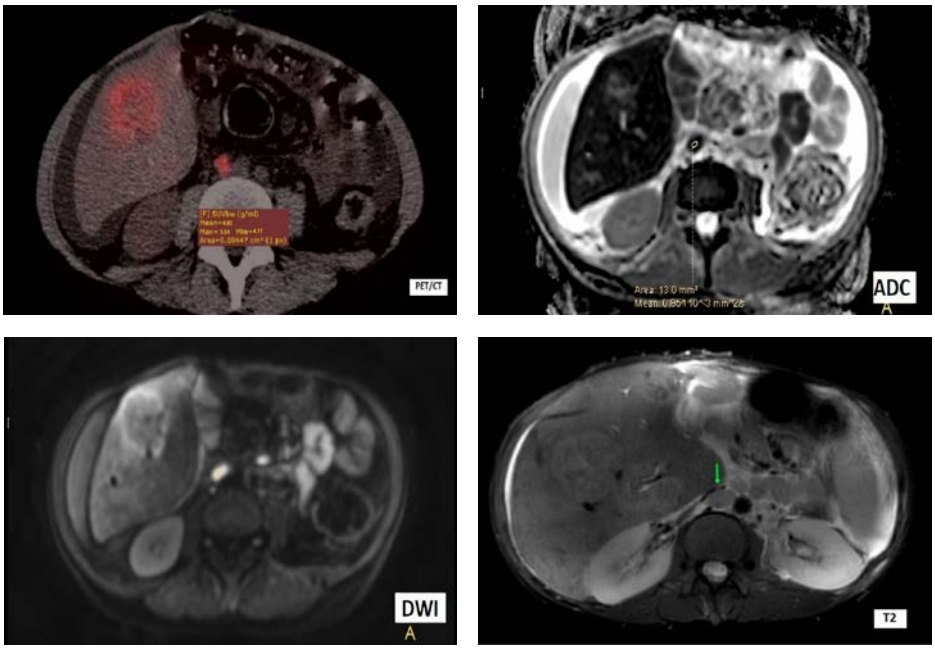
Clinical history: 37 years old lady with history of surgically managed cancer colon since 2018 followed by chemotherapy (CTH) currently presented with metastatic bi-lobar hepatic masses.

MRI findings: Multiple enlarged lymph nodes are seen at porta hepatis, precaval, interaortocaval and pre pancreatic groups, and all shows high signal in DWI and low signal in ADC denoting diffusion restriction.

ADC Value: $0.85x10^{-3}$ mm^2/sec.

PET/CT findings: The enlarged porta hepatis, precaval, interaortocaval and pre pancreatic lymph nodes appeared FDG-avid with SUV max 4.8.

Diagnosis: Malignant metastatic pre-aortic, porta hepatis and precaval lymph node.



Case 2:

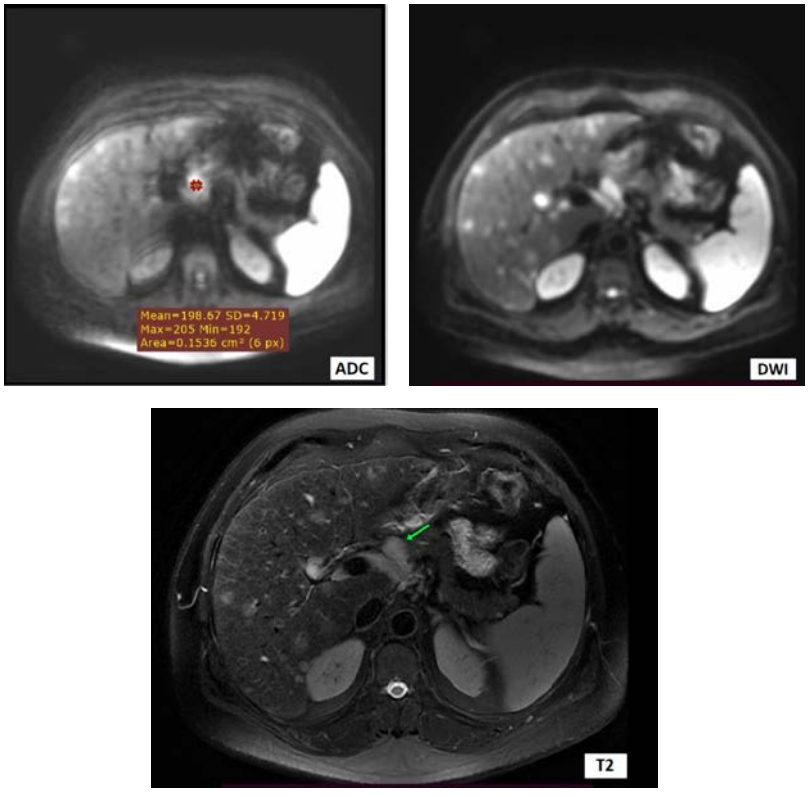
Clinical history: 50 years old Gentleman with history of jaundice and abdominal pain underwent imaging studies.

MRI findings: Bulky pancreatic head with multiple hepatic focal lesions and enlarged pre pancreatic lymph node showing high signal in DWI and low signal in ADC denoting diffusion restriction.

ADC Value: 1.9x10-3 mm2/sec.

PET/CT findings: The enlarged peri-pancreatic lymph nodes appeared Non FDG-avid.

Diagnosis: Inflammatory enlarged peri pancreatic lymph node.



Case 3:

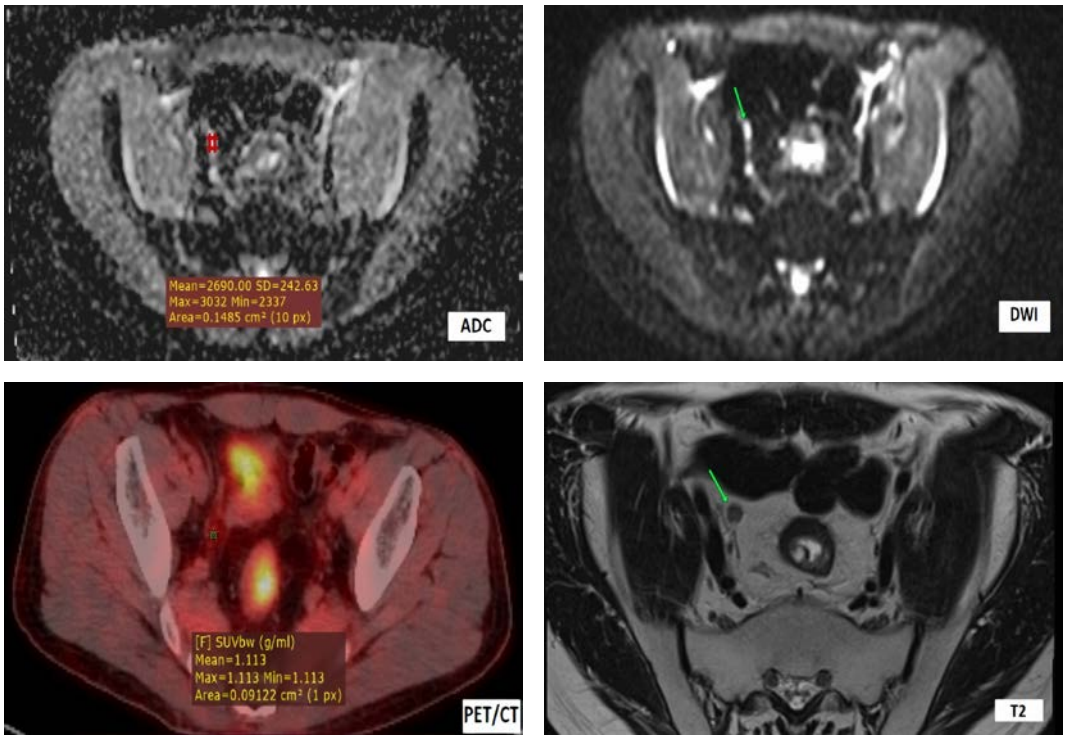
Clinical history: 40 years old Gentleman with history of medically treated cancer upper rectum.

MRI findings: Few prominent lymph nodes are seen at right internal iliac groups showing high signal in DWI and low signal in ADC denoting diffusion restriction.

ADC Value: 2.6x10-3 mm2/sec.

PET/CT findings: No metabolically active prominent internal iliac lymph nodes. SUV max=1.1.

Diagnosis: Non-Malignant prominent mesorectal lymph node.



Case 4:

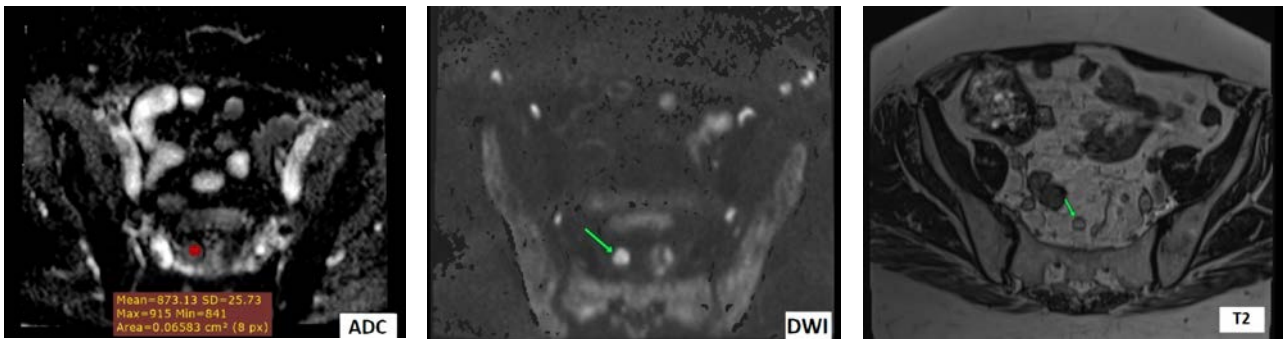
Clinical history: 54 Years old lady with history of biopsy proven rectal carcinoma of adenocarcinoma type.

MRI findings: Few prominent pre sacral suspicious enlarged lymph nodes, all shows high signal in DWI and low signal in ADC denoting diffusion restriction.

ADC Value: 0.87x10-3 mm2/sec.

Biopsy findings: proved metastatic adenocarcinoma.

Diagnosis: Malignant metastatic pre sacral lymph node.



Case 5:

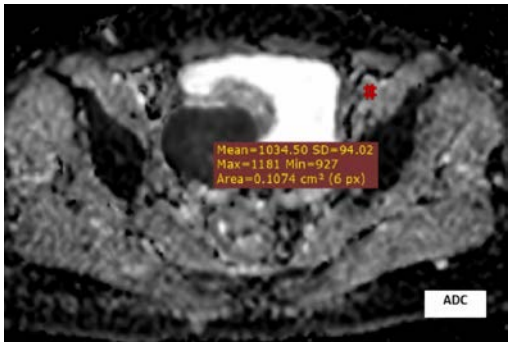
Clinical history: 54 years old Lady with given history of TAH & BSO for pathologically proven benign findings including endometrial hyperplasia, adenomyosis, degenerated leiomyoma, chronic cervicitis and adnexal mucinous cystadenoma and tubo-ovarian abscess with no reported malignancy with recent history of bleeding per vagina and altered bowel habits.

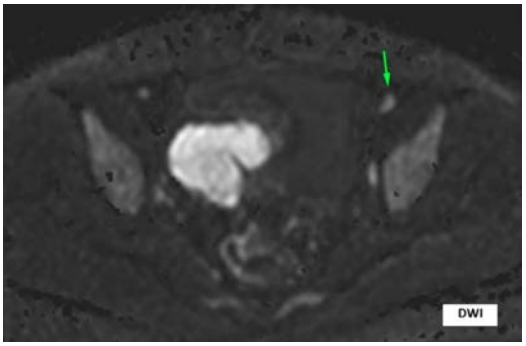
MRI findings: bilateral internal iliac enlarged lymph nodes.

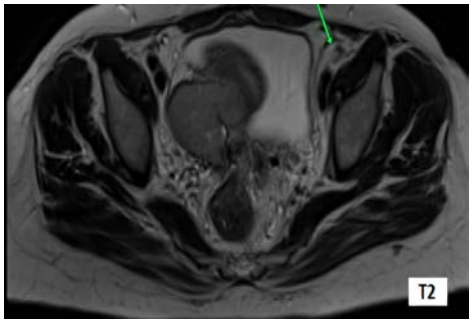
ADC Value: 1.03x10-3 mm2/sec.

Biopsy findings: No evidence of malignancy.

Diagnosis: Inflammatory reactive left internal iliac lymph node.







Results

This study was carried out on 24 patients with evident or suspected abdominal or pelvic lymphadenopathy referred to Ain Shams university hospital, Air forces specialized hospital & Cairo specialized Hospital. The results will be showed in the following tables and figures.

Table (1): Demographic data among the studied patients.

Description		Studied cases (N= 24)	
		N	%
Gender	Male	16	66.7%
	Female	8	33.3%
Age groups	30- 40 years	3	12.5%
	41- 50 years	9	37.5%
	51- 60 years	6	25.0%
	> 60 years	6	25.0%
Age (years)	Mean± SD	52.63± 10.46	
	Range	37.0 – 71.0	

SD: standard deviation

Table (1) shows demographic characteristics of studied cases. The age of studied cases ranged between 37 years and 71 years with mean age was 52.63± 10.46 years. The age group between 41-50 years was the most frequent (37.5%). Regarding gender, there were 16 (66.7%) males and 8 (33.3%) females with male to female ratio was 2:1.

Table (2): Diseases (source of lymphadenopathy) among the studied patients.

Parameters		Studied patients (N= 24)	
		N	%
Diseases	HCC	5	20.8%
	Rectal carcinoma	4	16.7%
	Metastatic cancer colon	3	12.5%
	Hodgkin lymphoma	3	12.5%
	Pancreatic mass	2	8.3%
	Hepatitis	2	8.3%
	Non-Hodgkin lymphoma	1	4.2%
	Chronic cervicitis	1	4.2%
	Pancreatitis	1	4.2%
	Endometrial hyperplasia	1	4.2%
	Tubo-ovarian abscess	1	4.2%

HCC: Hepatocellular carcinoma

Hepatocellular carcinoma was the most common disease found in the studied cases representing (20.8%) followed by rectal carcinoma in 4 (16.7%) cases then metastatic cancer colon in 3 (12.5%) cases, Hodgkin lymphoma in 3 (12.5%) cases, pancreatic mass, Hepatitis in two (8.3%) cases. Other diseases were illustrated in **table (2)**.

Table (3): L.N MRI characteristics among the studied patients.

Description		Studied cases (N= 24)	
		N	%
Number of L.Ns	≤ 10 L.Ns	11	45.8%
	> 10 L.Ns	13	54.2%
	Mean± SD	13.17± 8.41	
	Median	12.5	
	Range	4.0 – 32.0	
Size of L.Ns (mm)	Mean± SD	9.86± 3.33	
	Median	10.0	
	Range	4.0 – 18.0	
Site of L.Ns	Pre-pancreatic	6	8.3%
	Int. iliac	3	4.2%
	Para-aortic	3	4.2%
	Rt. Mesorectal	3	8.3%

Description		Studied cases (N= 24)	
		N	%
Site of L.Ns	Iliac	2	4.2%
	Porta hepatis	2	4.2%
	Aorto-caval	1	4.2%
	Ext. Iliac	1	4.2%
	pre sacral	1	4.2%
	pre caval	1	4.2%
	All	1	4.2%

SD: standard deviation

Table (3) shows that the mean number of lymph nodes in a patient was 13.17± 8.41 and ranged from 4 to 32 L.Ns with half of cases (54.2%) had more than 10 L.Ns. The mean size of lymph nodes that measure as length of short axis of LN was 9.86± 3.33 mm and ranged from 4 to 18 mm. According to site of L.Ns, Pre-pancreatic site was the most frequent site found (8.3%).

Table (4): MRI findings among the studied patients.

Description		Studied cases (N= 24)	
		N	%
DWI	Restricted	24	100.0%
ADC Value	Mean± SD	1.95± 0.56	
	Median	0.97	
	Range	0.58 – 2.60	

SD: standard deviation

Table (4) shows MRI findings among the studied patients. All cases had restricted DWI. The mean ADC Value was 1.95± 0.56 and ranged from 0.58 to 2.6.

Table (5): PET/CT Standardized Uptake Values (SUVs) and biopsy among the studied patients.

		Studied cases (N= 24)	
PET/CT (SUVs) (n= 12)	Mean± SD	2.94± 2.51	
	Median	1.90	
	Range	1.1 – 7.5	
Biopsy	Done	12	50.0%
	Not done	12	50.0%

SD: standard deviation, SUVs: Standardized Uptake Values

Table (5) shows that the mean PET/CT Standardized Uptake Values (SUVs) was 2.94± 2.51 and ranged from 1.1 to 7.5. Biopsy was taken for 12 cases only.

Table (6): Pathology of L.Ns studied patients regarding grade.

Parameters		Studied patients (N= 24)	
		N	%
Pathology	Benign	11	45.8%
	Malignant	13	54.2%

n: number, %: percentage

It was observed that there were 11 (45.8%) cases had benign lesions while 13 (54.2%) cases had malignant lesions **(Table 6)**.

Table (7): Demographic data among malignant and benign L.Ns.

		Benign		Malignant		Test value	p- value*
		N	%	N	%		
Gender	Male	8	72.7%	8	61.5%	X^2= 0.336	0.562
	Female	3	27.3%	5	38.5%		
Age (years)	Mean± SD	51.45± 9.87		53.62± 11.24		T=0.496	0.625
	Range	38.0 – 70.0		37.0 – 71.0			

p≤0.05 is statistically significant, p≤0.01 is highly statistically significant, SD: standard deviation, X^2: Chi-Square Test, T: Student T Test

This table shows no significant difference was found between benign and malignant lesions regarding gender (p=0.562) and age (p=0.625).

Table (8):): L.N characteristics among Benign and malignant lesions.

Description		Benign (N= 11)		Malignant (N= 13)		Test value	p- value*
		N	%	N	%		
Number of L.Ns	Mean± SD	10.91± 9.31		15.08± 7.39		T=1.223	0.234
	Range	4.0 – 32.0		4.0 – 30.0			
Size of L.Ns (mm)	Mean± SD	8.82± 3.37		10.75± 2.75		T=1.447	0.162
	Range	4.0 – 15.0		7.0 – 18.0			
Site of L.Ns	All	0	0.0%	1	7.7%	X^2= 37.9	**<0.001**
	Aorto-caval	1	9.1%	0	0.0%		
	Ext. Iliac	0	0.0%	1	7.7%		
	Iliac	0	0.0%	2	15.4%		
	Int. iliac	2	18.2%	1	7.7%		
	Para-aortic	1	9.1%	2	15.4%		
	Porta hepatis	2	18.2%	0	0.0%		
	Pre-caval	0	0.0%	1	7.7%		
	pre-sacral	0	0.0%	1	7.7%		
	Pre-pancreatic	4	36.4%	2	15.4%		
	Rt. Mesorectal	1	9.1%	2	15.4%		

p≤0.05 is statistically significant, p≤0.01 is highly statistically significant, SD: standard deviation, X2: Chi-Square Test, T: Student T Test

This table shows no significant difference was found between benign and malignant lesions regarding number and size of L.Ns. While, there was significant difference was found between them regarding site of L.Ns (p<0.001).

Table (9): MRI findings among the studied patients.

Description		Benign (N= 11)		Malignant (N= 13)		Test value	p- value*
		N	%	N	%		
DWI	Restricted	11	100.0%	13	100.0%	-	-
ADC Value	Mean± SD	1.65± 0.54		0.81± 0.13		T=5.452	**<0.001**
	Range	1.1 – 2.60		0.58 – 1.00			

p≤0.05 is statistically significant, p≤0.01 is highly statistically significant, SD: standard deviation, T: Student T Test

This table shows the mean ADC value was 1.65± 0.54x10^{-3} in benign lesions and 0.81± 0.13x10^{-3} in malignant lesions. ADC Value was significantly lower in malignant lesions compared to benign lesions (p<0.001).

Table (10): PET/CT Standardized Uptake Values (SUVs) among the studied patients.

		Benign (N= 11)	Malignant (N= 13)	Test value	p- value*
PET/CT (SUVs) (n= 12)	Mean± SD	1.5± 0.4	6.2± 2.2	-	-
	Median	1.5 (1.1- 1.9)	7.5 (3.7- 7.5)	^{Z}MWU =2.415	**0.017**
	Range	1.1 – 2.0	3.7 – 7.5		

p≤0.05 is statistically significant, p≤0.01 is highly statistically significant, SD: standard deviation, ^{Z}MWU: Mann-Whitney Test

This table shows the median (range) of PET/CT (SUVs) was 1.5 (1.1- 2) in benign lesions and 7.5 (3.7- 7.5) in malignant lesions. PET/CT (SUVs) was significantly higher in malignant lesions compared to benign lesions (p=0.017).

Table (11): ROC curve analysis of ADC value in differentiating benign from malignant lesions.

Variable	AUC	P-value	Cutoff	Sensitivity	Specificity	PPV	NPV
ADC value	0.846	**<0.001***	1.0	74.6%	81.8%	80.4%	76.3%

ROC curve analysis and table (11) shows that ADC value of MRI are good predictor for differentiating benign from malignant lesions with area under the curve 0.846 and sensitivity and specificity was 74.6% and 81.8% respectively (p< 0.001).

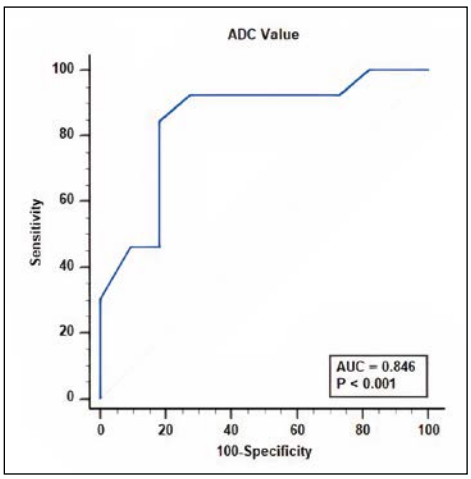


Figure (1): *ROC curve of ADC value in differentiating benign from malignant lesions.*

Table (12): ROC curve analysis of PET/CT in differentiating benign from malignant lesions.

Variable	AUC	P-value	Cutoff	Sensitivity	Specificity	PPV	NPV
PET/CT	0.881	**0.004**	3.7	66.7%	100%	100%	75%

ROC curve analysis and table (11) shows that ADC value of MRI are good predictor for differentiating benign from malignant lesions with area under the curve 0.846 and sensitivity and specificity was 74.6% and 81.8% respectively (p< 0.001).

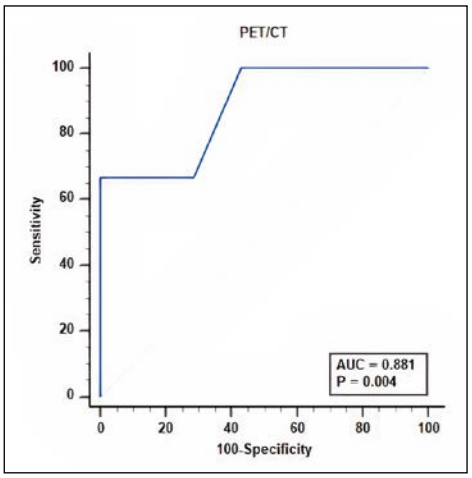


Figure (2): *ROC curve of PET/CT in differentiating benign from malignant lesions.*

Discussion

The enlargement of lymph nodes is referred to as lymphadenopathy. The lymph nodes are tiny glands that filter fluid from the lymphatic system. As the lymphatic system is a complicated component of the immune system engaged in filtering substances in the body, they are split into parts known as follicles, which are further separated into B zones and T zones, which constitute the basic location of lymphocytic maturation [8].

Because abnormal lymphocyte proliferation can be caused by inflammation, infection, or cancer, clinicians must perform a detailed history and physical to screen for lymphadenopathy. Careful examination of all pertinent anatomic regions, including the neck, supraclavicular, axillary, and inguinal regions, should be performed. With a few exceptions, the size of a typical lymph node in an adult should be less than 1 cm [9].

There are several potential causes of lymphadenopathy, ranging from infectious, autoimmune, malignant, and lymphoproliferative. In addition, abdominal pain represents a frequent symptom for referral to emergency departments and/or internal medicine outpatient setting. Similarly, fever, fatigue and weight loss are non-specific manifestations of abdomino-pelvic lymphadenopathy [10]. The early diagnosis and proper staging of cancer lymph nodes using imaging is critical in clinical practice. To differentiate between pathological and normal states, traditional CT or MRI rely on size thresholds and subjective, non-quantitative assessment of morphologic features. This approach has been demonstrated to have low diagnostic accuracy [11].

Whole body diffusion weighted MRI (WB-DWI) has emerged as a functional imaging technique, which can aid lymph node characterization by providing information on tissue characteristics over a large field of view within reasonable acquisition times - properties, which make it a desirable staging and screening technique. WB-DWI was deemed an alternative to established 18FDG PET/CT for lymphoma staging. DWI detects microstructural and cellular alterations in malignant versus benign lymph nodes and can be quantified by calculation of the apparent diffusion coefficient (ADC) [12].

Therefore, the aim of the present study was to determine if diffusion weighted magnetic resonance imaging can help in discrimination between benign and malignant abdomino-pelvic lymph nodes, review the ADC values of lymph nodes visualized on abdomen-pelvic MRI images and correlate their values with lymph

nodes morphological pattern, PET/CT and / or histopathology results.

The current study was a retrospective study conducted on 24 patients with abdomino pelvic lymphadenopathy. The number of included patients is considered an average number when compared to that included in similar studies, where Muehe et al. concluded a similar study on 42 patients [13]. Akdumanet et al. conducted a similar study on 28 patients [14]. Eiber et al. conducted a similar study in cases of prostatic cancer and included 29 patients [15], and Rechichi et al. included 40 patients in his study on nodal metastasis in endometrial carcinoma [16]. Papalia et al., included 36 patients in his study, which was on nodal metastasis in urinary bladder cancer patients [17]. Other studies included a large number of patients such as Theony et al. who included 120 patients in his study [18] and Kim et al., who included 125 patients [19].

The study was conducted with high b value (500 & 1000 sec/ mm²) to overcome the effect of capillary diffusion in extracellular extravascular space, as high as b value will result in the reduction of signal from moving protons in the vessels and fluid in the bowel. Thus, improving the specificity of the contrast on DWI. Furthermore, the differences in the relative contrast ratio between malignant and benign lesions were increased at high b values. This was similar to other studies which also used high b values. Where Thoeny et al. also used b values 500 & 1000 sec/ mm² and Rechichi et al. and Yo Mizukami et al. used b value of 1000 sec/ mm² [16,17,19].

In our study, Malignant lymph nodes had significantly lower ADC values than benign lymph nodes. The mean ADC value for malignant lymph nodes is 0.81± 0.13x10-3 mm2/sec and for benign lymph nodes is 1.65± 0.54x10-3 mm2/sec. The ADC measurements of benign and malignant lymph nodes were significantly different with a P value <0.0001. This supports similar previous findings where Muehe et al reported that the mean ADC value for normal lymph nodes was 1.578 +0.420 x10-3 mm2/sec and 0.852 + 0.206 x10-3mm2/sec for malignant lymph nodes, with P values <0.0001 [13]. Beer et al. reported that a highly significant difference was observed between the mean ADC values in benign and malignant lymph nodes (ADC values of 1.60+0.24 Vs. 1.09+0.23x10-3mm2/sec respectively) with P values <0.0001 [21]. Eiber et al. stated that there was a statistically significant difference between the ADC values of malignant lymph nodes (1.07+0.23x10-3mm2/sec) and benign lymph nodes (1.54+0.25x10-3mm2/sec) with a P value 0.01 [15]. Also, Akudumanet et al., stated that the ADC values of malignant (1.84+0.37x10-3mm2/sec) were significantly lower than those of benign (2.38+0.29x10-3mm2/sec) of a P value <0.0005 [22].

In our study, we found a good accuracy of the ADC value differentiation between malignant and benign lymph nodes at a cutoff value 1x10-3mm2/sec with sensitivity of 74.6% and specificity of 81.8%. This result is rather comparable to that concluded by Eiber et al., who concluded a higher ADC value cut off (1.30x10-3mm2/sec) with 86.0% sensitivity and 85.3% specificity [15]. Papalia et al. ,2012 concluded a cut off ADC value 0.86 x10-3mm2/sec with a slightly higher sensitivity (76.4%), and slightly higher specificity (89.4%) [17]. Rechichi et al. concluded a cut off for minimum ADC value 0.807 x10-3mm2/sec with a higher sensitivity (100%) and specificity(98.3%) [16].

In our study, the mean ADC value of metastatic lymph nodes (0.9¬5+ x10-3mm2/sec) was significantly higher than that of lymphomatous lymph nodes 0.68+ x10-3mm2/sec with a P value <0.001. An ADC cut off value of 0.76x10-3mm2/sec was conducted to differentiate between them 80% sensitivity and 87.5% specificity. Similar findings were stated by Y. Zhang et al., in a study on the role of DWI in cervical lymphadenopathies, where they stated that the mean ADC value of the solid component of metastatic lymph nodes is 0.9+0.16 x10-3mm2/sec, was significantly higher (p<0.01) than that of lymphomatous lymph nodes (0.64+0.13 x10-3mm2/sec) [23]. They concluded a slightly higher ADC value cut off (0.77x x10-3mm2/sec) with 83% sensitivity and 89% specificity.

Similar findings were stated by Freihat et al. in a study on role of DWI derived for Pet/MRI for lymph nodes assessment in patents with head and neck squamous cell carcinoma , where they stated the mean ADC value for metastatic lymph nodes is 0.899¬+0.99 x10-3mm2/sec while the ADC mean value of normal lymph nodes (1.267+0.88x10-3mm2/sec), with a cut off value about 1.138+0.75x10-3mm2/sec) was used as an optimal threshold value to differentiate between metastatic and normal nodes. They concluded a higher sensitivity (92.3%) and higher specificity (98.6%) [24].

The absolute ADC values of the different types of lymph nodes were not similar to these of other studies,

which is probably due to differences in technique applied (b Value breath measurement methods and mathematical technique applied).

Qayyum et al, stated that ADC measurements obtained from breath hold diffusion weighted technique can't be directly translated into those obtained with free breathing or respiratory triggered technique , which are reportedly associated with high ADC values. Also, stated that ADC measurements may vary not only with different imaging parameters, but also within different types of scanners [25].

In our study, four patients with metastatic lymph nodes, have undergone follow-up MRI after receiving a course of therapy, either radiotherapy, chemotherapy or combined. The lymph nodes show size regression denoting good therapeutic response. In DWI, these lymph nodes show less diffusion restriction and a high ADC value in the follow-up MRI. Similar findings were stated by Thoeny & Ross et al., where they stated that studies have shown that successful treatment of many tumor types can be detected using DWI- MRI as an early increase in the apparent diffusion co-efficient values [26]. They also stated during successful treatment, the loss of cellularity in the tumor in lower intensity in the high b-value image or high signal intensity on the corresponding ADC map. **R**

References

1. Abou Youssef HA, Elzorkany MA, Hussein SA, et al. Evaluation of mediastinal lymphadenopathy by diffusion weighted MRI; correlation with histopathological results. Adv Respir Med. 2019;87(3):175-183. doi:10.5603/ARM.2019.0033
2. Usama Elsaied Ghieda, Ahmed Abdul-Raheem Badr. Diffusion-Weighted Magnetic Resonance Imaging in Characterization of Neck Lymph Nodes in Head and Neck Cancer. Int. J. Med. Imaging 2020,8(1), 6-15. doi: 10.11648/j.ijmi.20200801.12
3. Buré L, Boucher LM, Blumenkrantz M, et al. Can magnetic resonance spectroscopy differentiate malignant and benign causes of lymphadenopathy? An in-vitro approach. PLoS One. 2017;12(8):e0182169. Published 2017 Aug 8. doi:10.1371/journal.pone.0182169
4. Muteganya R, Goldman S, Aoun F, et al. Current Imaging Techniques for Lymph Node Staging in Prostate Cancer: A Review. Front Surg. 2018;5:74. Published 2018 Dec 7. doi:10.3389/fsurg.2018.00074
5. Elhamdoust E, Motamedfar A, Gharibvand MM, et al. Investigation of the value of ultrasound-guided core needle biopsy from pathologic lymph nodes to the diagnosis of lymphoma. J Family Med Prim Care. 2020;9(6):2801-2805. Published 2020 Jun 30. doi:10.4103/jfmpc.jfmpc_1260_19
6. Ryu KH, Yoon S, Baek HJ, et al. Cervical Lymph Nodes Detected by F-18 FDG PET/CT in Oncology Patients: Added Value of Subsequent Ultrasonography for Determining Nodal Metastasis. Medicina (Kaunas). 2019;56(1):16. Published 2019 Dec 31. doi:10.3390/medicina56010016
7. Baliyan V, Das CJ, Sharma R, et al. Diffusion weighted imaging: Technique and applications. World J Radiol. 2016;8(9):785-798. doi:10.4329/wjr.v8.i9.785
8. Maini R, Nagalli S. Adenopathy. In: StatPearls. Treasure Island (FL): StatPearls Publishing; August 8, 2023.
9. Mohseni S, Shojaiefard A, Khorgami Z, et al. Peripheral lymphadenopathy: approach and diagnostic tools. Iran J Med Sci. 2014;39(2 Suppl):158-170.
10. Mirijello A, Ritrovato N, D'Agruma A, et al. Abdominal Lymphadenopathies: Lymphoma, Brucellosis or Tuberculosis? Multidisciplinary Approach-Case Report and Review of the Literature. Medicina (Kaunas). 2023;59(2):293. Published 2023 Feb 4. doi:10.3390/medicina59020293
11. Herneth AM, Mayerhoefer M, Schernthaner R, et al. Diffusion weighted imaging: lymph nodes. Eur J Radiol. 2010;76(3):398-406. doi:10.1016/j.ejrad.2010.08.016.
12. Kharuzhyk S, Zhavrid E, Dziuban A, et al. Comparison of whole-body MRI with diffusion-weighted imaging and PET/CT in lymphoma staging. Eur Radiol. 2020;30(7):3915-3923. doi:10.1007/s00330-020-06732-w.
13. Muehe AM, Siedek F, Theruvath AJ, et al. Differentiation of benign and malignant lymph nodes in pediatric patients on ferumoxytol-enhanced PET/MRI. Theranostics. 2020;10(8):3612-3621. Published 2020 Feb 18. doi:10.7150/thno.40606
14. Akduman EI, Momtahen AJ, Balci NC, et al. Comparison between malignant and benign abdominal lymph

nodes on diffusion-weighted imaging. Acad Radiol. 2008;15(5):641-646. doi:10.1016/j.acra.2007.12.023
15. Eiber M, Beer AJ, Holzapfel K, et al. Preliminary results for characterization of pelvic lymph nodes in patients with prostate cancer by diffusion-weighted MR-imaging. Invest Radiol. 2010;45(1):15-23. doi:10.1097/RLI.0b013e3181bbdc2f
16. Rechichi G, Galimberti S, Oriani M, et al. ADC maps in the prediction of pelvic lymph nodal metastatic regions in endometrial cancer. Eur Radiol. 2013;23(1):65-74. doi:10.1007/s00330-012-2575-2
17. Papalia R, Simone G, Grasso R, et al. Diffusion-weighted magnetic resonance imaging in patients selected for radical cystectomy: detection rate of pelvic lymph node metastases. BJU Int. 2012;109(7):1031-1036. doi:10.1111/j.1464-410X.2011.10446.x
18. Thoeny HC, Froehlich JM, Triantafyllou M, et al. Metastases in normal-sized pelvic lymph nodes: detection with diffusion-weighted MR imaging. Radiology. 2014;273(1):125-135. doi:10.1148/radiol.14132921
19. Kim JK, Kim KA, Park BW, et al. Feasibility of diffusion-weighted imaging in the differentiation of metastatic from nonmetastatic lymph nodes: early experience [published correction appears in J Magn Reson Imaging. 2009 May;29(5):1242]. J Magn Reson Imaging. 2008;28(3):714-719. doi:10.1002/jmri.21480
20. Mizukami Y, Ueda S, Mizumoto A, et al. Diffusion-weighted magnetic resonance imaging for detecting lymph node metastasis of rectal cancer. World J Surg. 2011;35(4):895-899. doi:10.1007/s00268-011-0986-x
21. Beer AJ, Eiber M, Souvatzoglou M, et al. Radionuclide and hybrid imaging of recurrent prostate cancer. Lancet Oncol. 2011;12(2):181-191. doi:10.1016/S1470-2045(10)70103-0.
22. Akduman EI, Momtahen AJ, Balci NC, et al. Comparison between malignant and benign abdominal lymph nodes on diffusion-weighted imaging. Acad Radiol. 2008;15(5):641-646. doi:10.1016/j.acra.2007.12.023
23. Zhang Y, Chen J, Shen J et al. Apparent diffusion coefficient values of necrotic and solid portion of lymph nodes: differential diagnostic value in cervical lymphadenopathy. Clin Radiol. 2013;68(3):224-231. doi:10.1016/j.crad.2011.04.002.
24. Freihat O, Pinter T, Kedves A, et al. Diffusion-Weighted Imaging (DWI) derived from PET/MRI for lymph node assessment in patients with Head and Neck Squamous Cell Carcinoma (HNSCC). Cancer Imaging. 2020;20(1):56. Published 2020 Aug 8. doi:10.1186/s40644-020-00334-x.
25. Qayyum A. Diffusion-weighted imaging in the abdomen and pelvis: concepts and applications. Radiographics. 2009;29(6):1797-1810. doi:10.1148/rg.296095521.
26. Thoeny HC, Ross BD. Predicting and monitoring cancer treatment response with diffusion-weighted MRI. J Magn Reson Imaging. 2010;32(1):2-16. doi:10.1002/jmri.22167

READY - MADE CITATION

Mustafa Mohamed Elshahat Hafez, Yasser Ali Mohamed Abd El Mawla, Ahmed Mohamed Hussein, Mohamed Yosry.
Role of Diffusion Weighted MRI in Characterization of Abdomino-Pelvic Lymphadenopathy *Hell J Radiol 2025*; 10(3): 13-26.