Benha Journal of Applied Sciences (BJAS) **print: ISSN 2356–9751**
Vol. (7) Issue (6) (2022), (47-55) **online: ISSN 2356–976x**
http://bjas.journals.ekb.eg

Role of Advanced MRI in Differentiation between Benign and Malignant Lung Lesions

S.M.Tawfik, M.M.Omar, T.S.Essawy, M.A.Nasr and S.M.Abo Yousef
Chest Diseases and Radiology, Dept., Faculty of Medicine, Benha Univ., Benha, Egypt
E-mail: Shaymaatawfik9@gmail.com

Abstract

The most prevalent cause of mortality in industrialised nations is lung cancer. 3:1 is the ratio of males to females. Tobacco use increases the incidence of lung cancer by 30 times. There are also additional risk factors, such as a long history of exposure to things like carcinogens, asbestos and pulmonary fibrosis. We want to see whether sophisticated MRI may help distinguish between malignant and nonmalignant lung lesions in this trial. Methods and Subjects: Patients hospitalised to Benha University Hospital's chest department between October 2018 and April 2021 were included in this research.

There were no misunderstandings about their agreement to the terms of the agreement. In order to diagnose the patients, they all had a direct chest X-ray and a CT scan. In this study, the lesions' morphological properties were examined. An MRI scan was performed on each patient, and the results were then analysed for pathology. Of the 32 lesions studied, 22 were malignant and 10 were benign.

The mean ADC value of benign lesions was 1.74 –0.27 –3mm2/s, whereas the mean ADC value of malignant lesions was 1.09 –0.18 –3mm2/s, which was considerably lower than that of the benign lesions (p = 0.02) 1.29 0.37 mean ADC in central area; 1.48 0.52 mean ADC in periphery.

There was a statistically significant difference in ADC between the centre and the peripheral (1.29 0.37) (P =.0.017) Malignant lesions had considerably lower mean ADCs in the centre and periphery than those with benign lesions (1.09 and 1.26, respectively) (1.74 and 1.97, respectively The p-values were 0.001 and 0.005. The ADC core and periphery were analysed for malignancy using ROC analysis.

Center (AUC = 0.964) and periphery (AUC = 0.859) had significant AUCs in this study. Optimal cutoff values for ADC centre and ADC periphery were 1.29 10–3 mm2/s and 1.54 10–3 mm2/s, respectively, with sensitivity and specificity of 95.5% and 90% for ADC centre and 86.4% and 80% for ADC peripheral. Diffusion-weighted MRI can distinguish between benign and malignant pulmonary masses, whereas ADC can distinguish between the two.

Key Words: Diffusion MRI, ADC, Benign, Malignant, Pulmonary lesions.

1. Introduction

Adult deaths from cancer are most often caused by lung cancer [25].

Radiographs or computed tomography scans of the chest show it to be a solid mass or nodule (CT).

It remains a problem for radiologists to distinguish between malignant and benign tumours on CT, despite the fact that numerous well-known features have been documented [15].

Fluorine-18 fluorodeoxyglucose positron emission tomography (PET) has been employed for this purpose in the last few years.

High radiation doses are delivered via CT and PET.

The PET scan may sometimes provide false-positive findings in inflammatory masses [30].

A safe and reliable alternate approach for determining malignant from benign lung lesions is still needed for these reasons.

MRI of the chest has recently benefited from recent developments in rapid imaging methods including echo-planar imaging [23].

Use of dynamic contrast MRI to detect lung masses has been documented [24].

In addition to the central nervous system, diffusion-weighted magnetic resonance imaging (DWI) has been increasingly employed in the mediastinum, pancreas and liver [14].

It is now possible to do chest MRI with great temporal resolution utilising rapid acquisition sequences and multichannel coils because to recent advances in gradient technology.

DWI applications in the thorax are still in their infancy, although early investigations have shown encouraging outcomes [17].

In a DWI, the acquisition of a magnetic resonance signal based on the "diffusion" of water protons in tissue is accomplished [27].

Tissue perfusion may be assessed in vivo using one of two primary types of magnetic resonance imaging (MRI).

Contrast agents are injected into the bloodstream to alter its magnetic susceptibility and hence the MR signal that is recorded periodically throughout the passage of the bolus [13].

Blood vessels are magnetically marked before it reaches the tissue under study, and the quantity of staining detected and compared to a control recording produced without spin-labelling constitutes the other category of arterial spin labelling (ASL) [8].

It has been shown that extracellular space is significantly reduced in malignant lesions (solid) owing to an increase in the number of compact and numerable cells, pleomorphism of cells, big cell volume and neoangiogenic vessels that are disordered.

The flow of water molecules will be restricted as a result of the enhanced microstructural density and structure.

Contrast that with situations of inflammation and infection, when interstitial edoema and inflammatory reactions increase extra-cellular space, the extravascular extracellular space is larger than the intracellular space.

As a result, water molecules will be able to travel more freely throughout the cell membranes because of the reduced contact between the two [3].

Among the most frequent mediastinal masses in adults are the main thymic neoplasms, thyroid tumours, and lymphomas.

50 percent of all mediastinal malignancies, such as thymoma, teratoma, thyroid illness, and lymphoma, originate in the anterior mediastinum.

When it comes to mediastinal masses, congenital cysts are the most prevalent, whereas tumours of the posterior mediastinum tend to be neurogenic in origin [7].

In cases of mediastinal and hilar lymphadenopathy, Diffusion-weighted MRI was shown to be an additional tool for separating lymphoma from sarcoidosis.

In lymphoma, the ADC value of enlarged lymph nodes was found to be lower than that in the sarcoidosis group, thus this may be determined [10].

As a result, DWI has lately been utilised to assist describe lung lesions, to identify tumour invasiveness in early stage lung cancer, to detect tumours in collapsed lungs, and to stage nodal nodes in instances of metastatic lung cancer [27].

There have been recent research and trials showing that MRI can reliably identify and stage lung cancer, and that this approach might be a good replacement for CT or PET/CT in the study of lung cancers and other disorders [12].

In a recent study, it was shown that DWI can readily see lung tumours because malignant compact lesions are bright and low in the ADC map (restricted) in diffusion series and that DWI can distinguish central lung cancer from post-obstructive lobar collapse (non restricted).

Similarly, quantitative DWI analysis may distinguish reactionary/inflammatory lymph nodes from metastatic ones by having a larger ADC value [10].

Along with X-ray and CT, MRI is quickly becoming a powerful lung imaging tool.

In a single examination, it provides both morphological and functional information without putting the patient at risk from radiation.

Before reaping the benefits of this procedure, new users should familiarise themselves with its specific advantages and limits, as well as its diagnostic scope [17].

2. Aim of the study

This study was carried out to assess the role of advanced MRI in the differentiation between malignant and benign pulmonary lesions.

3. Patients and methods

This study was conducted on 32 patients with lung lesions found on CT admitted at Benha University Hospital, chest department during the period from October 2018 to April 2021.

They all signed informed consent forms. All the patients were diagnosed by direct chest X-ray and underwent a CT scan. The morphological characteristics of the lesions were evaluated. Patients underwent MRI study followed by pathological assessment.

Inclusion criteria:

- -Presence of a parenchymal lung Lesion.
- -Ability of patients to lie supine and hold their breath in the MRI unit.

Exclusion criteria:

- -Known malignant patient on current administration of chemotherapeutic or radio therapeutic treatment.
- -Implanted pacemaker or defibrillator: Until recently, MRI was contraindicated for all patients with implantable cardiac devices because the fields generated have the potential to damage components and interfere with functioning.
- -Ferromagnetic aneurysm clips may move or become dislodged under the force of the magnetic field.
- -A cochlear implant can be damaged or create tissue damage in the presence of an MRI system.
- -The electrodes used in deep brain stimulation may cause injury or suffer damage during MRI.
- -Metallic foreign bodies: Shrapnel or other metallic objects in the body can be heated and/or moved by the magnetic field.
- -Some varieties of ocular implants pose a risk of damage to the eye due to metallic components.

All patients were subjected to the following:

-History and physical examination.

- -Full lab. Investigations (CBC, ESR, Liver function and kidney function tests, PT, PTT, INR).
- -CXR
- -CT chest with contrast.
- -MRI was done in the radiology department (DWI, quantative analysis).
- -Biopsies of lung lesions were done by different methods (FOB, U\S, CT guided) according to the site of the lesion.

Clinical assessment:

By history taking, patients were manifested by dyspnea, chest pain, hemoptysis, cough, Fever, weight loss and hoarseness of voice.

Radiological diagnosis

First, the calcification, necrosis, and GGO components were examined on CT images.

The lesions' contours were also examined using CT images (irregular or smooth).

The time between a CT scan and an MRI scan ranged from 0 to 10 days (mean, 5. 6 days).

DWI with an oval or circular area of interest (ROI).

In order to encompass at least two-thirds of the lesion while avoiding interference from the surrounding lung tissue, necrotic regions, and major blood arteries, we put the ROI in the middle of the lesion.

Using the ADC maps that were rebuilt from values of b = 0, the ADC maps were then used to compute ADCs.

Prior to MRI scanning, all patients completed breathing training that included holding their breath after taking a deep breath in order to eliminate artefacts caused by respiratory motion.

All MRIs were done using 1.5-T (SIEMENS) MRI and a body phased-array coil with the patients lying supine.

T1 and T2 conventional WI sequences, T2 fat sat imaging, and DWI were all used.

There were T1-weighted fast spin echo sequence parameters as follows:

A total of one signal was collected, with a TR/TE of 475.3 ms/15 ms; the field of view was 36 cm; slice thickness was 6 mm; the gap was 1 mm; and the matrix was 269 x 222 with a flip angle of 70°.

These settings were used to create a T2-weighted fast spin echo sequence: TR/TE,1250 ms/80 ms; echo train length, 80; number of signals recorded, 1; matrix, 281 281; field of view, 36 cm; slice thickness, 6 mm; gap, 1 mm.

A single-shot echo planar imaging sequence was used to apply diffusion gradients in the three orthogonal directions.

In order to get DWIs, b values ranging from zero to 1000 were used.

As a result of these factors,

TR/TE: 2027 ms/70 ms; 2 averages; 168 168 matrix; 36 cm field of view; 6 mm slice thickness; 6.6 mm gap; 90° flip angle; 77 ms echo train length.

The programme developed ADC maps based on the photos it gathered.

For this study, elliptical regions of interest (ROI) with average voxel sizes of 255 were drawn and used to determine the ADC value.

It was difficult to prevent artefacts, respiratory movement, and cardiac motion that alter DWI images in tiny lesions that may be overlooked due to breathing or motion, which we encountered as additional technical restrictions.

Diffusion weighted image evaluation:

The size, extent, and relationship to nearby structures of each lesion were all assessed.

The strength of the signal in all three pulse sequences (T1WI, T2WI, and ADC map) was assessed.

In the scanner processing station, the experienced imaging physician reviews the MRI scan routine sequence, focusing on the location and morphology of the lesion, measuring the lesion area in the high signal area on the DWI image, analysing the benign and malignant nature of the pulmonary lesion, and making a final diagnosis after discussing the images that are questionable.

Diagnosis pathologic:

We relied on histopathological analysis as our guide.

Fiberoptic bronchoscope, ultrasound-guided, or CT-guided biopsy were employed to obtain the tissue samples for histological evaluation.

This information was logged.

We counted the instances of benign and malignant tumours and studied their MRI scans and diagnostic findings for their imaging features.

With this information, the diagnostic effectiveness of MRI for a variety of lung lesions was evaluated using pathological diagnostic data as the gold standard.

Using picture blind reading, the imaging physician was not aware of the abnormal findings.

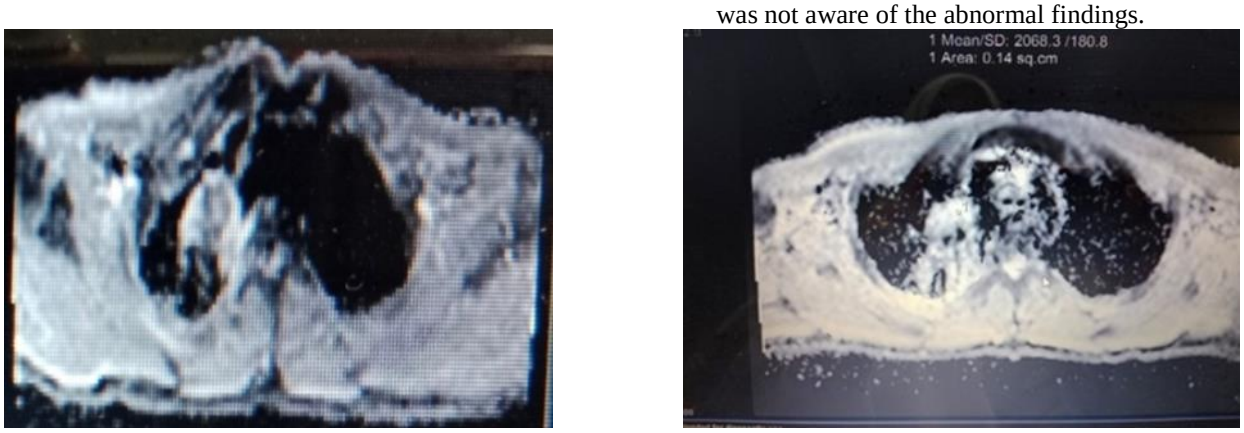

Fig. (1) Male patient 52years old with right upper lobe mass, core biopsy revealed non small cell carcinoma.

MRI showing an irregular shaped ill defined lesion is seen epicenered on the right lower lobe. Another ledion is seen in the right upper lobe (apical segment) extending to involves the upper part of the hilum. The lower lobe lesion shows intermediate T2 signal. The upper lobe lesion shows central low T2 core and peripheral lobular multilocular cystic part. Right hilar mediastinal lymphadenopathy. The lower lobe lesion ADC measures from lowest ROI is 1.199±192.2×10-3 mm2\sec. The upper lobe lesion ADC measures 1.383±0.0825×10-3 mm2\sec. Slow flow signal in the right pulmonary artery branch.

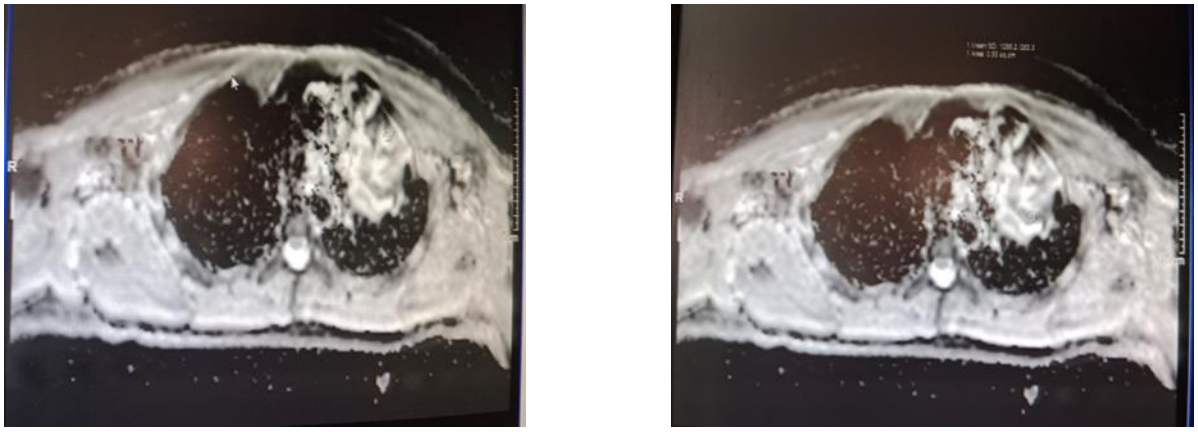

Fig. (2) male patient 41 years old, ultrasound guided biopsy revealed tissue consolidation, non specific inflammatory reaction with reparative changes. Old pneumonic patch negative for tumor tissue.

MRI: well defined lobulated left upper lobe lesion involving the anterior segment with associated lingual collapse. ADC measures from the lowest ROI is 1.218±192.2×10-3 mm2\sec. Some central foci with ADC 1.136±0.9×10-3 mm2\sec.

4. Results

This study was conducted on 32 patients with lung lesions found on CT, admitted at Benha University Hospital, Chest Department.

General characteristics

The mean age of the studied patients was 58 ±9 years, and males predominated in the study (75%). About two-thirds were smokers (62.5%).

Likely associated with high cellularity of chronic inflammatory changes. Collapse area ADC 2.01±3.0×10-33 mm2\sec. Non specific inflammation.

The data obtained were tabulated and statistically analyzed.

Biopsy and pathology findings

Biopsies done were US-guided (31.3%), CT-guided (34.4%), and bronchoscopic biopsy (34.4%). More than two-thirds (68.8%) had malignant lesions, and 68.2% of them were well differentiated. The most frequent benign lesion was nonspecific inflammation (60%), while the most frequent malignant lesion was NSCLC (86.4%). NSCLC types were adenocarcinoma (42.1%), squamous cell carcinoma (31.6%), and other types (26.3%). More than half of those with malignant lesions (54.5%) had metastasis **(Table 1).**

Table (1) Biopsy and pathology findings of the studied patients

		n (%)
Type of biopsy	US-guided	10 (31.3)
	CT guided	11 (34.4)
	Bronchoscopic biopsy	11 (34.4)
Type of lesion	Benign	10 (31.3)
	Malignant	22 (68.8)
Differentiation*	Well differentiated	15 (68.2)
	Poorly differentiated	7 (31.8)
Type of benign lesion**	Bronchial cyst	1 (10.0)
	Non-specific Inflammation	6 (60.0)
	Old pneumonic patch	1 (10.0)
	Pyogenic abscess	2 (20.0)
Type of malignant lesions*	SCLC	3 (13.6)
	NSCLC	19 (86.4)
Type of NSCLC***	Adenocarcinoma	8 (42.1)
	SQCC	6 (31.6)
	Other types	5 (26.3)
Metastases*	Present	12 (54.5)

* Percentages were calculated based on total 22 patients with malignant lesions
** Percentages were calculated based on total 10 patients with benign lesions
*** Percentages were calculated based on total 19 patients with NSCLC

MRI findings

More than two-thirds showed irregular morphology (68.8%). About one-third (62.5%) showed intermediate to low T2. The mean ADC in the center was 1.29 ±0.37, while in the periphery, it was 1.48 ±0.52. According to MRI, 87.5% of the patients had malignant lesions **(Table 2).**

Table (2) MRI findings of the studied patients

MRI findings			
Morphology	Regular	n (%)	10 (31.3)
	Irregular	n (%)	22 (68.8)
T2	Intermediate to low	n (%)	20 (62.5)
	Intermediate to high	n (%)	12 (37.5)
MRI diagnosis	Benign	n (%)	4 (12.5)
	Malignant	n (%)	28 (87.5)

ADC in the center and periphery of the lesion

ADC was significantly lower in the center (1.29 ±0.37) than the periphery (1.48 ±0.52) (P = .0.017) **(Table 3).**

Table (3) ADC in the center and periphery of the lesion

ADC	**Mean ±SD (× 10–3 mm2/s)**	**P-value**
Center	1.29 ±0.37	0.017*
Periphery	1.48 ±0.52	

Paired t-test was sued *Significant

General characteristics according to lesion type

The mean age was significantly higher in those with malignant lesions (61 ±8) than those with benign lesions (52 ±8) (P = 0.009). Also, smoking was significantly higher in those with malignant lesions (77.3%) than those without (30%) (P = 0.01). No gender difference was noted (P = 0.186) **(Table 4).**

Table (4) General characteristics according to lesion type

		Benign (n = 10)	**Malignant (n = 22)**	**P-value**
Age (years)	Mean ±SD	52 ±8	61 ±8	0.009*
Sex	Males n (%)	6 (60.0)	18 (81.8)	0.186
	Females n (%)	4 (40.0)	4 (18.2)	
Smoking	n (%)	3 (30.0)	17 (77.3)	0.01

Independent t-test was used was age. Chi-square test was used for sex and smoking * Significant

ROC analysis for ADC center and periphery for predicting malignancy

ROC analysis was done for the ADC center and periphery for predicting malignancy. It showed significant AUC for ADC center (AUC = 0.964, P < 0.001) and periphery (AUC = 0.859, P = 0.001). The best cutoff points were ≤ 1.29 for ADC center and ≤1.54 for ADC periphery, at which sensitivity and specificity were 95.5% and 90%, respectively, for ADC center and 86.4% and 80%, respectively, for ADC periphery**.**

MRI findings according to lesion type

Irregular morphology was significantly higher in those with malignant lesions (100%) than those with benign lesions (0%) (P < 0.001). Also, intermediate to low T2 was significantly higher in those with malignant lesions (90.9%) than those with benign lesions (0%) (P < 0.001). The mean ADC in the center and periphery were significantly lower in the malignant lesions (1.09 and 1.26, respectively) than those with benign lesions (1.74 and 1.97, respectively). P values were < 0.001 and 0.005, respectively (Table 4).

Table (5) MRI findings according to lesion type

			Benign (n = 10)	**Malignant (n = 22)**	**P-value**
MRI morphology	**Regular**	n (%)	10 (100.0)	0 (0.0)	<0.001*
	Irregular	n (%)	0 (0.0)	22 (100.0)	
T2	**Intermediate to low**	n (%)	0 (0.0)	20 (90.9)	<0.001*
	Intermediate to high	n (%)	10 (100.0)	2 (9.1)	
ADC (center)	**Mean ±SD**		1.74 ±0.27	1.09 ±0.18	< 0.001*
ADC (periphery)	**Mean ±SD**		1.97 ±0.6	1.26 ±0.29	0.005*

Independent t-test was used for ADC. Chi-square test was used for categorical data * Significant

ADC center and periphery in adenocarcinoma and squamous cell carcinoma

The mean ADC (center) was significantly lower in those with squamous cell carcinoma (1.05 ±0.15) than those with adenocarcinoma (1.22 ±0.13) (P = 0.045), while no significant difference was noted regarding ADC (periphery) (P = 0.741) **(Table 5).**

Table (6) ADC center and periphery in adenocarcinoma and squamous cell carcinoma

ADC		Adenocarcinoma	SQ C C	P-value
Center	Mean ±SD	1.22 ±0.13	1.05 ±0.15	0.045*
Periphery	Mean ±SD	1.41 ±0.26	1.36 ±0.18	0.741

Independent t-test was used * Significant

5. Discussion

In the differential diagnosis of lung masses, CT and PET-CT are the two most commonly used non-invasive methods, but these two methods have increased radiation exposure and the sensitivity of PET-CT is low in nodules smaller than 20mm, so another non-invasive method is required to avoid unnecessary biopsies that cause many risks and complications(KONO et al., 2007). [18].

For research and particular clinical applications, MRI is a great tool, but CT remains the gold standard when it comes to imaging lung pathomorphology in patients with cancer.

It is possible to perform multiple and repeated measurements, as well as assess motion and perfusion of the thoracic organs, using MRI rather than CT because it does not emit ionising radiation (BIEDERERA et al., 2008) [5].

The "Brownian motion" of water molecules in biological tissues is detected by Diffusion Weighted MRI, which assists in the identification of microstructural changes in tissue.

Physiological and morphological tissue parameters, such as cell density and tissue viability, are reflected in changes in water diffusion throughout different disease processes.

The Apparent Diffusion Coefficient (ADC) value may be used to quantify this (ALNAGHY et al., 2018) (4).

It's all about water molecules' molecular transitions.

According to Thony and colleagues, a decrease in ADC values correlates with increased tumour cellularity, which restricts water diffusion (26).

Intra-thoracic lesions are seldom studied, despite the fact that DWI has been utilised to distinguish between malignant and benign lesions in many other places (Koyama et al., 2010) [19].

Because of physical motion artefacts and technological constraints, the clinical use of pulmonary MRI was restricted.

A therapeutically viable approach for particular pulmonary diseases was made possible by technological advancements in recent years, however, and this is known as magnetic resonance imaging, or MRI [29].

32 individuals with lung masses were included in this research, 10 of whom had benign lesions and 22 of whom had malignant ones.

There were 24 males and 8 females in the study, with the mean age of the patients being 58 9 years (age range 41-74 years) (Table 4).

The mean age of individuals with malignant lesions (61 8) was substantially greater than that of those with benign lesions (52 8) (P = 0.009).

(P = 0.186) There was no difference in results between the sexes (Table 4).

20 of the patients were smokers (62.5 percent).

There was a statistically significant difference in smoking rates between individuals with cancerous tumours and those without (77.3%).

According to (Danson et al., 2016), this finding was in accordance with (7).

According to (HEBA ALLAH et al., 2019) (11) there was a statistically significant difference in smoking index between the benign and malignant groups (p-value 0.001).

Toxic symptoms (31.3 percent) and hemoptysis (93.8 percent) were the most common presenting symptoms, followed by dyspnea (90.6 percent), chest discomfort (50.0 percent), and cough (93.8 percent) (18.8 percent).

As far as symptoms like cough, dyspnea, hemoptysis, chest discomfort, and toxic symptoms are concerned, there were no differences between patients with benign and malignant tumours (all P values were zero).

It was established by histological examinations that the lesions were cancerous.

A total of 10 patients (31.3%), 11 patients (34.4%), and 11 patients (11.0%) had US-guided, CT-guided, or bronchoscopic biopsies (34.4 percent).

68.8% of the 32 lesions were malignant, while just 10% of them were benign (Table 1).

NSCLCs (non-small cell lung cancers) accounted for 86.4 percent of the malignant lesions, with 3 (13.6 percent) of them being small cell lung cancers. Of those, 15 (68.2 percent) were well differentiated and 7 (31.8%) were poorly differentiated.

There were eight adenocarcinomas, six squamous cell carcinomas, and five different kinds of NSCLC (26.3 percent).

Metastasis was found in 54.5 percent of patients with malignant tumours 12 (Table 1).

Nonspecific inflammation 6 (60%) was the most common benign lesion, followed by pyogenic abscess 2

(20%), bronchial cyst 1 (10%), and Old pneumonic patch 1 (60%) (10 percent).

More than two-thirds of MRI results indicated abnormal morphology 22 (68.8 percent).

(See Table 2 for further information).

Those with malignant lesions (100 percent) had considerably more irregular morphology than those with benign lesions (0%) (P 0.001).

(See Table 2 for further information).

T2 levels ranged from intermediate to low in 32 instances (62.5 percent), whereas intermediate to high T2 levels were found in 12 cases (37.5 percent) (Table 2).

The proportion of patients with malignant lesions (90.9 percent) who had intermediate to low T2 (P 0.001) was substantially greater than those with benign lesions (0%).

(See Table 2 for further information).

Statistically significant (p0.001) correlations between ADC value and histological parameters were found in 22 malignant and 10 benign lesions [31].

With (HEBA ALLAH et al., 2019) I was also in accord [11].

Many studies and investigations using the ADC value found that the ADC values of various malignant lesions affecting various organs in the body, such as hepatic, renal, prostatic and uterine tumours, were lower than those of benign lesions or normal tissues and showed high signal intensity (restricted pattern) in the DWI.

A non-invasive approach without the use of ionising radiation was expected to represent the histological tissue characteristics in the ADC results (LIU et al., 2010)

Malignant tumours had a considerably lower mean ADC value than benign tumours, which was 1.09 0.18 - 3mm2/s (p = 0.02), compared to 1.74 0.27 –3mm2/s (p = 0.02) in this research.

Results from (Liu et al., 2010) (20), (Gumustas et al., 2011) [9] and (Nasr et al., 2016) all agreed with this one [22].

The central ADC was 1.29 0.37, whereas the peripheral ADC was 1.48 0.52.

There was a statistically significant difference in ADC between the centre and the peripheral (1.29 0.37) (P =.0.017). (Table 3).

The mean ADC in the centre and periphery of malignant lesions were substantially lower than those of benign lesions (1.09 and 1.26, respectively) (1.74 and 1.97, respectively).

There were two p values that were less than or equal to 0.005. (Table 5).

According to (HEBA ALLAH et al., 2019) (11) research, the mean ADC value of benign lesions was 1.90.2 X10–3mm2/s and the malignant lesion ADC value was 1.04 0.4 X10–3mm2/s, which was substantially lower than the benign lesion ADC value.

When comparing the mean ADC value of various pathological lesions, there was a statistically significant difference (p-value >0.001)

ADC values of benign and malignant lesions are in agreement with (Alnaghy et al., 2018) [4], who found that the mean ADC value of benign lesions was 1.7–0.72 mm2/s, while the mean ADC value of malignant lesions was 1.09–0.0.19, which was significantly lower than the benign lesions with a p-value of 0.01.

For predicting malignancy, ROC analysis was performed on the ADC core and peripheral.

For the ADC core, the AUC was 0.964, and for the periphery, it was 0.859, with a P value of 0.001.

In the ADC centre, the optimal cutoff values were 1.29 10–3 mm2/s, while in the ADC periphery, they were 1.54 10–3 mm2/s. At these cutoff points, the sensitivity and specificity were 95.5 and 90 percent, respectively.

It has been observed that the cutoff ADC value (1.56 X 10–3mm2/s) has a sensitivity and specificity rate of 96% and 94%, respectively, according to (Abdel Razek et al, 2009).

Malignant lesions' mean ADC was lower than that of the benign group, however this difference was not statistically significant (p 0.675) despite the fact that malignant lesions had a lower ADC than the benign group.

95% sensitivity and 87% specificity were reported by (Gumustas et al., 2012) [9], who used a threshold ADC value of (1.39 X 10–3mm2/s).

According to (Liu et al., 2010), the ADC (1.4 X 10–3mm2/s) had various cutoff values.

Using an ADC cut-off value of 1.1x10-3 mm2/sec, (Mori et al., 2008) [21] discovered a substantial difference between malignant and benign lesions.

It was found that in (Alnaghy et al., 2018)[4] the ADC cut-off value was considered to be the threshold value, and 93.8 percent of patients were correctly diagnosed, while the area under the ROC curve was 0.84, with the sensitivity and specificity being 93.8 percent and 75 percent, respectively.

Figure 11.1 of Heba Allah et al. (2019) [11] stated that the area under the ROC curve was 0.98.

The threshold was set at 1.6 X 10–3mm2/s (m2/s).

The sensitivity and specificity were both 100 percent, the positive predictive value was 96.7 percent, and the negative predictive value was zero percent when the ADC value was 1.6 X 10–3mm2/s or higher (100 percent).

According to (Uto et al.2009) (28), there was no significant difference between lung cancer and benign lesions based on the ADC value. Our findings contradicted that finding.

Cancer cells in SCLC have large nuclei with almost no cytoplasm, making them highly cellular.

It was expected that these features would limit the diffusion of tissue and lower the ADC values.

SCLC is distinct from other types of lung cancer because of its rapid progression, extensive metastasis, and heightened sensitivity to chemotherapy and radiation.

In terms of treatment, there are significant differences between NSCLC and SCLC.

When it comes to NSCLC, surgery is the preferred method of treatment, whereas chemotherapy and radiation therapy are the norm for SCLC patients.

The distinction between the two is critical and of clinical importance (CAKMAK et al., 2016) [6].

SCLC and NSCLC subgroups had lower ADCs, however this difference was not statistically significant (p-value=0.1061) in this research.

According to (CAKMAK et al., 2016) [6] and (CAKMAK et al., 2016) [7], ADC levels of SCLC and NSCLC were shown to be insignificant.

Comparing NSCLC's mean ADC value to that in SCLC, it was found that the ADC value of SCLC was lower than NSCLC's, although there was no significant difference (p-value=0.106) between the two groups.

Heba Allah and colleagues (2019) [11].

Although the ADC value of SCLCs was lower than the NSCLC ADC value in this research (Gumustas et al., 2012) [9], the difference was not statistically significant (p 0.464).

Although the findings of (Abdel Razek et al., 2012) [3] did not concur with this, they discovered that SCLC groups in a comparable patient population had considerably lower ADC levels when compared with NSCLC groups.

[19] Also, no significant differences were detected across subtypes of lung cancer (Koyama et al., 2010).

As Liu et al. (2010) said, Similarly, [20] discovered that the ADC values for the SCLC group were considerably lower than the NSCLC group. He reported that the mean ADC value of small cell lung cancer was 1.06 10–3 mm2/s, which was lower than the mean ADC value of NSCLC.

Those with squamous cell carcinoma had a substantially lower mean ADC (central) than adenocarcinoma (1.22 0.13) (P = 0.045), whereas ADC (periphery) had no significant difference (P = 0.741) (Table 6).

The ADC centre used ROC analysis to tell adenocarcinoma and squamous cell carcinoma apart.

As a result of this study, the AUC was 0.823% (P 0.045).

The optimum cutoff value was > 1.035, which had a sensitivity of 87.5 percent and a specificity of 66.7 percent.

Adenocarcinoma had the greatest ADC (1.4400.107 X 10–3 mm/s) and large cell carcinoma had the lowest (0.7500.300 X 10–3 mm/s) values in the [11] research.

Adenocarcinomas with inadequate differentiation were shown to have considerably fewer ADCs compared to those with medium differentiation.

6. Conclusions

Functional imaging of lung cancer using Diffusion MR imaging complements anatomic MR imaging of the chest by probing the tumor's microstructure.

For the identification and characterisation of lung cancer, diffusion MR imaging has great promise.

References

[1] A.Abdel Razek, A.Fathy, T.Abdel Gawad Correlation of apparent diffusion coefficient value with prognostic parameters of lung cancer. J Comput Assist Tomogr.vol.35,pp.248–252,2011.

[2] A.ABDEL RAZEK, A.ELMORSY, M.ELSHAFEY. Assessment of mediastinal tumors with diffusion weighted single shot echo planar MR imaging. J. Mag. Reson. Imaging.vol.30,pp.535-40,2009.

[3] A.ABDEL RAZEK. Diagnostic magnetic resonanance imagimg of chest tumours. Cancer Imaging.vol.12,pp.452-63, 2012.

[4] E.ALNAGHY, M.EL-NAHAS, A.SADEK. Role of diffusion-weighted magnetic resonance imaging in the differentiation of benign and malignant pulmonary lesions. Polish Journal of Radiology.vol. 83,pp.585-94, 2018.

[5] J.BIEDERERA, C.HINTZE and FABEL M.: MRI Of pulmonary Nodules: Technique and Diagnostic Value, Cancer Imaging.vol. 8,pp.125-30, 2008.

[6] V.CAKMAK, F.UFUK, and KARABULUT N.: Diffusion-Weighted MRI of Pulmonary Lesions: Comparison of Apparent Diffusion Coefficient and Lesion-to-Spinal Cord Signal Intensity Ratio in Lesion Characterization, J. Magn. Reson. Imaging.vol.45,pp.144-180,2016.

[7] J.DANSON, C.H.ROWLAND, R.ROWE. The relationship between smoking and quality of life in ad-vanced lung cancer patients: A prospective longitudinal study Support Care Cancer.vol. 24,pp.1507-16, 2016.

[8] A.Detre, John; Rao, Hengyi. (May 2012). "Applications of arterial spin labeled MRI in the brain". Journal of Magnetic Resonance Imaging.vol.**35** (5),pp. 1026–1037,2017..

[9] S.GUMUSTAS, N.INAN and SARISOY H.: Malignant versus benign mediastinal lesions: Quantitative assessment with diffusion weighted MR imaging. Eur. Radiol.vol.21,pp.2255-60, 2011.

[10] N.Gümüştaş , Inan, Gür Akansel, I Başyïğït, E Cïftçi Differentiation of lymphoma versus sarcoidosis in the setting of mediastinal-hilar lymphadenopathy: assessment with diffusion-weighted MR imaging sarcoidosis Vasc Diffuse Lung Dis .vol.30(1),pp.52-9,2013.

[11] H.HEBA ALLAH AMIN. DINA MOGHAZY MOHAMED., OMNIA A. GAD. Role of Diffusion Weighted Magnetic Resonance Imaging in Characterization of Pulmonary Masses. Med. J. Cairo Univ.vol. 87,pp. 4825-4833, 2019.

[12] B.Hochhegger, J.Ley-Zaporozhan, E. Marchiori. Magnetic resonance imaging findings in acute pulmonary embolism. Br J Radiol.vol.84,pp.282–287, 2011.

[13] S. A.Huettel, A. W.Song, G. McCarthy, Functional Magnetic Resonance Imaging Massachusetts: Sinauer , .vol.79,pp.155-180,2009.

[14] N.Inan, F .Kilinc, T.Sarisoy. Diffusion weighted MR imaging in the differential diagnosis of haemangiomas and metastases of the liver. Radiol Oncol.vol.**44,pp.** 24-9,2010.

[15] YJ.Jeong, KS.Lee, SY.Jeong. Solitary pulmonary nodule: characterization with combined wash-in and washout features at dynamic multidetector row CT. Radiology.vol.**237,pp.**675-83,2005.

[16] YJ.Jeong, KS.Lee, SY.Jeong. Solitary pulmonary nodule: characterization with combined wash-in and washout features at dynamic multidetector row CT. Radiology **.vol.237,pp.** 675-83,2005.

[17] Jurgen Biederer, S.Mirsadraee, M.Beer.MRI of the lung –Current applications and future perspectives. Insights into imaging.vol.3 (4),pp.373-386, 2012.

[18] R.KONO, K.FUJIMOTO and TERASAKI H.: Dynamic MRI of solitary Pulmonary Nodules: Comparison of Enhancement Patterns of Malignant and Benign Small Peripheral Lung Lesions, Am. J. Reontgenol.vol.188,pp. 26- 36, 2007.

[19] H.Koyama, Y.Ohno, N.Aoyama. Comparison of STIR turbo SE imaging and diffusion-weighted imaging of the lung: capability for detection and subtype classification of pulmonary adenocarcinomas. Eur Radiol.vol.**20**,pp.790–800,2010.

[20] H.LIU, Y.LIU, T.YU and N.YE. Usefulness of diffusion weighted Magnetic Resonance Imaging in evaluation of pulmonary lesions, Eur. Radiol.vol.20,pp.807-15, 2010.

[21] T .Mori, H.Nomori, K.Ikeda. Diffusion-weighted magnetic resonance imaging for diagnosing malignant pulmonary nodules/masses: comparison with positron emission tomography. J Thorac Oncol.vol.3,pp.358–364,2008.

[22] A.NASR, H.ELSHAHAT, H.SAFWAT.Diffusion weighted MRI of mediastinal masses: Can measurement of ADC value help in the differentiation between benign and malignant lesions. The Egyptian Journal of Radiology and Nuclear Medicine.vol.47,pp.119-25, 2016.

[23] J. Podobnik, I. Kocijancic, V .Kovac. MRI in evaluation of asbestos related thoracic diseases – preliminary results. Radiol Oncol.vol.**44,pp.** 92-6, 2010.

[24] JF.Schaefer, , J .Vollmar, F.Schick, R. Vonthein, MD.Seemann, H .Aebert. Solitary pulmonary nodules: dynamic contrast-enhanced MR imaging perfusion differences in malignant and benign lesions. Radiology.vol.**232,pp.**544-53,2004.

[25] RL.Siegel, KD.Miller, A.Jemal Cancer statistics, CA Cancer J Clin .vol.15,pp. 67-80,2017.

[26] H.C. THOENY and F.De KEYZER.Extracranial appli-cations of diffusion weighted magnetic resonance imaging, Eur. Radiol.vol.27,pp.1385-93, 2007.

[27] B.Türkbey, O.Aras, Karabulut, Nevzat, A.T.Turgut. Diffusion-weighted MRI for detecting and monitoring cancer: A review of current applications in body imaging. Turkish Society of Radiology .vol.50,pp.500-800,2012.

[28] T.Uto, Y. Takehara, Y.Nakamura. Higher sensitivity and specificity for diffusion-weighted imaging of malignant lung lesions without apparent diffusion coefficient quantification. Radiology.vol. 252,pp.247-254,2009.

[29] Q.WAN, Y.DENG, J.ZHOU . Intravoxel incoherent motion diffusion-weighted MR imaging in assessing and characterizing solitary pulmonary lesions. Scientific. Report.vol.7,pp.43-257, 2017.

[30] CA.Yi, KS.Lee, B-T.Kim. Tissue characterization of solitary pulmonary nodule: comparative study between helical dynamic CT and integrated PET/CT. J Nucl Med.vol.47,pp.443–450,2006.

[31] F.ZHANG, Z.ZHOU, D.TANG. Diffusion-weighted MRI in solitary pulmonary lesions: Associations between apparent diffusion coefficient and multiple histopatholog-ical parameters. Sci. Rep.vol.8 (1),pp.112-248, 2018.