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CORRELATION BETWEEN PERFUSION AND DIFFUSION WEIGHTED MAGNETIC RESONANCE IMAGING IN DIAGNOSIS OF BRAIN TUMORS

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ABSTRACT

Background: Brain tumors are the most aggressive disease, and cancerous brain tumors are a severe life-threatening condition. The tumor growth-induced curvature of the brain (mass impact) can cause serious impairment or death as it develops in the cranium, displaces or replaces the surrounding tissue. Tumors are believed to weaken the blood-brain barrier, contributing in a great diversity vasculature known as the blood tumor barrier. Conventional Magnetic Resonance Imaging has a range of drawbacks in the diagnosis of the most common intracranial brain tumors, including tumor specification and identification of grade tumors. Perfusion-Weighted Magnetic Resonance Imaging and Diffusion-Weighted Magnetic Resonance Imaging introduce a slew of new parameters to conventional Magnetic Resonance Imaging, and they can be used to visualize neovascularization, a characteristic of tumor progression.

Objective : To identify of efficiency and accuracy of perfusion magnetic resonance imaging and evaluation of brain tumors

Material and Methods : One hundred and fifteen patients with histologically proven brain tumors were examined by 1.5 Tesla PHILIPS MR System. For four months, patients who were referred in an MRI assessment were included in this review. Conventional MRIs protocol, (axial T2WI (TSE), Axial T1WI (FSE), axial T2-FLAIR WI, axial T1WI post contrast). Axial Diffusion Weighted Image (DWI) MRI. PW-MRI protocol axial Fast Echo –Echo Planar Image (FE-EPI) Neuro-T2* Perfusion Dynamic Contrast Enhancement agent (DCE-MRI), (Gadolinium(Gd) contrast Magnevist).

Results and discussion: Magnetic Resonance Imaging in (10) patients (8.70%) revealed features consistent with brain tumors (control cases), the brain has been evaluated by conventional (protocol C). (105) patients (91.3%) underwent examination with Perfusion weighted magnetic resonance imaging (p-MRIs) by (FE-EPI) Neuro-T_2^* Perfusion (DCE-MRI) (protocol P), and Diffusion weighted magnetic resonance imaging (d-MRIs) by DWI and ADC value, (18) patients (15.65%) with the anaplastic astrocytoma WHO grade (III), (17) patients (14.78%) with metastatic brain tumors, (15) patients (13.04%) with non-recurrence of post-operative brain tumors, (11) patients (9.57%) with high grade glioma, (10) patients (8.70%) with craniopharyngioma, (9) patients (7.83%) with glioblastoma multiforme WHO grade IV, (9) patients (7.83%) with low grade glioma, (8) patients (6.96 %) with meningioma, the gemistocytic astrocytoma WHO grade(II) was the lowest diagnosed brain tumor (2.61%).

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Conclusions: Perfusion MRI sequence, and Diffusion MRI sequence efficiency and accuracy in evaluation of brain tumors.
Keywords: Diffusion MRI, Perfusion MRI, Brain neoplasms, cerebral blood flow, cerebral blood volume, Vascular Permeability

INTRODUCTION

The most damaging disease is brain tumors, and cancerous brain tumors are not managed. [1]. Cancer is a serious life,-threatening disease. [2]. The tumor growth-induced brain deformation the so called "mass effect" has the power to trigger serious impairment or you'll die as a result tumor is found in the cranium, the underlying tissue must be displaced or substituted. [3]. Neoplasms lead to irregular tissue mass in which growth exceeds and is not synchronized with normal tissues, neoplasms do not comply with normal cell growth rules. [4]. The blood supply of brain tumors through blood-,borne substances and compounds between the blood and the brain is a particular procedure due to the extreme restrictiveness of the blood brain barrier (BBB). [5]. The integrity of the BBB is considered to be affected by tumors, This results in a highly heterogeneous vasculature known as (BTB), which is distinguished by various distinct features, including non-uniform permeability and active molecular efflux. [6].The many different types of brain tumors, each with its own histology, place, age distribution, and prognosis, may be perplexing. More than 100 separate individuals are included in the WHO Classification of Tumors of the Central Nervous System (2007). [7]. At presentation, morphological MRI displays the anatomical tumor site, tumor size, and contrast enhancement, and it is used to assess the individual tumor growth rate by repeated volumetric observations through time.[8] .

Solution of Problem Statement : In this study, more advanced and more accurate techniques and protocols are followed in order to reach an accurate diagnosis, which reflects positively on its treatment methods

In the clinical setting, perfusion and diffusion magnetic resonance imaging sequence (p-MRIs, d-MRIs) are useful diagnostic techniques for evaluating brain tumors. [9]. Perfusion (p-MRIs) and diffusion (d-MRIs) imaging are two types of physiological MRI that provide additional information on tumor vascularity and cellularity. [11-10].

To date, there are no accurate preoperative predictors of tumor grade due to discrepancies in tumor grades and histological subtypes using perfusion and diffusion parameters. This form, on the other hand, However, in the clinical setting, these approaches have proved to be effective medical devices for tumor grads. [7].

Physiology of Cerebral Perfusion: Cerebral blood flow is one of the most fundamental physiological parameters. Maintaining sufficient cerebral blood flow is important for the health of biological tissue. The flow of molecules through the semipermeable network in a given volume of tissue (expressed in mL/min/100 mL tissue), the MTT is the mean time taken by blood to travel through the capillary network (time between arterial inflow and venous outflow), and the permeability—surface area product is the flow of molecules through the capillary membrane in a given volume of tissue (expressed in mL/min/100 mL tissue) (expressed,, in second), MTT to be measured is variable because depends on the value of CBF & CBV.[9].

Physiology of Cellular Diffusion : Brownian motion inside tissues is the basis for DW-MRI, with molecule movement limited by cellular structures in high-density tissue.[13-14]. The movement of water molecules induces signal loss due to spin dephasing, and the signal loss over time can be used to calculate an apparent diffusion coefficient (ADC).[15]. A steep slope of signal loss is characterized by a high ADC-value, and vice versa. It has been shown that cellular density and

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ADC have an inverse relationship, with a high cellular density resulting in a low ADC value due to tissue restriction and thus reduced water movement. [16].

MATERIAL AND METHODS:

The population of patients

The study included one hundred and fifteen patients (57)male, (58) female with age group (10-70 year), the sample was (a non-probability), all patients were referred to the radiology department from the Neurological & Oncology clinic. This study was conducted in Babylon Teaching Hospital in the MRI Department . Imam Al- Sadiq Hospital, and Babylon Center for Treatment of Oncology. The period of collection of these samples from the first of November 2020 to the end of February 2021. A prospective design study was conducted among patients to determine brain tumors by using Conventional, Diffusion weighted image (d-MRIs), perfusion weighted (p-MRIs). Inclusion Criteria, there is a pre-or post –operative background for brain tumor, in patients with new diagnosis brain tumor before treatment with radiotherapy & chemotherapy, for gadolinium chelate, contrast agent, normal renal function test. Exclusion Criteria, patients during treatment radiotherapy & chemotherapy, pregnant woman, patient with a metallic foreign object inside his body.

Magnetic resonance imaging (MRI) Techniques

The MRI unit images were collected using (1.5 Tesla scanner) (Best, Philips Achieva, Netherlands). Morphological sequences (Axial T2WI (TSE), Axial T1WI (FSE), Axial T2WI FLAIR , Axial T1 WI post contrast). As analyzer of the axial T2WI,T1WI,T2WI FLAIR, so that's all slices orientation axial plane are insufficient in clarity of anatomical region of mass, axial T1WI post contrast (Gadolinium contrast agent 0.1mmol/kg body weight, the contrast media was injected intravenously manually) this Conventional MRIs (protocol C)

P-MRIs Axial Fast Echo –Echo Planar Image (FE-EPI) Neuro-T2*Perfusion Dynamic Contrast Enhancement (DCE) agent MRIs. Dynamic scanning the method for acquiring a series of MRIs for 40 dynamic scans. ,(Gadolinium(Gd) contrast Magnevist). Gd. using a standard dose 0.1mmol/kg - 0.2mmol/kg body weight, the injection rate is best performed using an MRI injector with a flow rate of at least 2ml /S with a subsequent flash of 0.9% saline solution. They were additional (protocol P) .

d-MRIs a SE EPI series within the axial or transverse plane survey with the acquisition parameters. DWI b-factor =b 0, b 1000 M s/mm^2, apparent diffusion coefficient ADC value. Mean diffusivity maps were obtained after automatic pixel-by-pixel calculation in the scanner as previously described.[17]. They were additional (protocol D). All parameter of protocols in the (Table 1)

Table 1: Parameters of MRIs 1.5 T Phillips Systems Protocol C, D, & P

Study	**Sequence**	**Slice orientation**	TR ms.	TE ms.	FOV mm	Slice thickness	Gap Mm	Matrix
Routine protocol (Conventional protocol **C**)	T_2WI-TSE	Axial	5285.7	110.0	230x180	5mm	0	256x161
	T_1WI-SE	Axial	650.0	15.0	230x180	5mm	0.5	256x163
	T_2 FLAIR	Axial	6000.0	120.0	230x18	5mm	5	240x14

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					0			4
	T_1 post (Gd.)	Axial	450.0	15.0	230x180	5mm	0.5	256x163
Additional								
Diffusion Weighted Image(DWI) (protocol **D**)	DWI	Axial	5207.2	159.4	230x230	5mm	0	152x109
Perfusion weighted MRIs (Protocol **P**)	FE-EPI	Axial	2485.5	40.0	220x220	5mm	0.5	88x89

MRI Analysis:

To begin, the traditional MRI brain tumor imaging planes (protocol C) were evaluated for each neoplasm, with each neoplasm having a well-defined hypo extreme mass on T1, heterogeneous intensity on T2, and mild & moderate enhancement after comparison, all of which are more consistent with a brain tumor.

Second, (protocol P) MRIs are the best and most versatile imaging method for the brain in all cases of suspected intracranial pathology. The techniques used change as new sequences are created. The temporal differences in attenuation in vessels and tissues was investigated using DCE analysis on a time series of images collected after the contrast material (tracer) is injected. Variations in attenuation in vessels and tissues are studied both spatially and temporally. FE-EPI dynamicT2* hypo-perfusion from hyper-perfusion image analysis. ROI Positioning: The phase involves manually drawing a ROI along the tumor's margins so that the program can correctly measure perfusion values. When placing the ROI, careful care should be taken not to include the great vessels, air, or surrounding fatty tissue, and to ensure that the ROI does not spread beyond the tumor's margins. The ROI must be located at the inner margins of the tumor in all perfusion scan images. For this reason, an accurate assessment of all images must be performed in cine-loop mode. From Gamma Variate Fitting Through maps, to select the map of interest adjust Threshold strong, and select apply spatial smoothing strong and generate parameters (Index= CBF, Navigate Integral (NI)= CBV, Mean Transit Time(MTT)= vascular permeability). It consists of the study of color coded maps, in which each pixel of an MRI is assigned a color. Color-coded maps have a panoramic view of perfusion in the scanned volume when studied qualitatively. With the curve fit algorithm, the device provides numeric values for cerebral blood flow, blood volume, and vascular permeability that are not accessible from conventional approaches, and maps can be shown in either colored or grey-scale. (Protection Protocol P) All patients were divided into two groups based on the severity of their tumors (high grade vs. low grade).

Finally, (protocol D) MRIs This sequence is available on scanners. Most units perform DWI on all patients, the workup of brain tumors, DWI examines the free movement, or Brownian motion, of water molecules at a cellular level. malignant mass tightly packed cells leading to inhibition of effective movement of water molecules restricted diffusion increased signal intensity on DWI, low ADC value versus benign mass decrease signal intensity on DWI, high ADC value . All patients were classified into malignant & benign, restricted & non-restricted

Statistical, analysis:

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Analysis of data was carried out using the available statistical package of SPSS-25 (Statistical Packages for Social Sciences- version 25). Data were presented in simple measures of frequency, percentage, mean, standard deviation, and range (minimum-maximum values). "Statistical package of Social-Sciences (SPSS), and "Microsoft Excel (2016)" to interpret and determine the results of the statistical analysis process for the research application.

RESULTS :

Table 2: The Distribution of studied sample according to Age Group, Age, Gender

		GROUPS						
		Cases(N=105)		Controls(N=10)		Total(N=115)		
		No	%	No	%	No	%	p. value
Age groups	<or =20	11	10.48	0	.00	11	9.57	0.006*
	20-29	31	29.52	0	.00	31	26.96	
	30-39	10	9.52	0	.00	10	8.70	
	40-49	18	17.14	6	60.00	24	20.87	
	50-59	9	8.57	3	30.00	12	10.43	
	60-69	23	21.90	1	10.00	24	20.87	
	≥70	3	2.86	0	.00	3	2.61	
Age		Mean ±SD=39.50±19.42		Mean ±SD=44.5±18.9				
	Total	105	100.00	10	100.00	115	100.00	
Gender	Males	50	47.62	7	70.00	57	49.57	0.176
	Females	55	52.38	3	30.00	58	50.43	

The mean age of study sample for cases M±SD =3.50 ±19.42 while for control groups was M±SD=44.5±18.9. Regarding cases the highest percentage 29.52% in the age groups (20-29) while the lowest percentage in the age groups (≥70) compared to control highest percentage in the age groups (40-49) while the lowest percentage in the age groups (60-69). Regarding the Males percentage (47.62%) cases, while the female percentage (52.38%)cases .

Table 3: The distribution gender according to pattern of the enhancement contrast agent

		Gender					
		males		females		Total	
		No	%	No	%	No	%
pattern of the enhancement contrast agent	mild enhancement	7	12.96	3	5.26	10	9.01
	severe enhancement,	42	77.78	45	78.95	87	78.38
	NO enhancement	5	9.26	9	15.79	14	12.61
	Total	54	100.00	57	100.00	111	100.00

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X^2 =2.767 df=2 p= .251 X= chi square test, df=degree of freedom

Table (3) In the current study, the highest male percentage (77.78%) with severe enhancement contrast agent, while the lowest male percentage(9.26%) with no enhancement contrast agent. Regarding the highest female percentage (78.95%) with severe enhancement contrast agent, while the lowest female percentage (5.26%) with mild enhancement contrast agent.

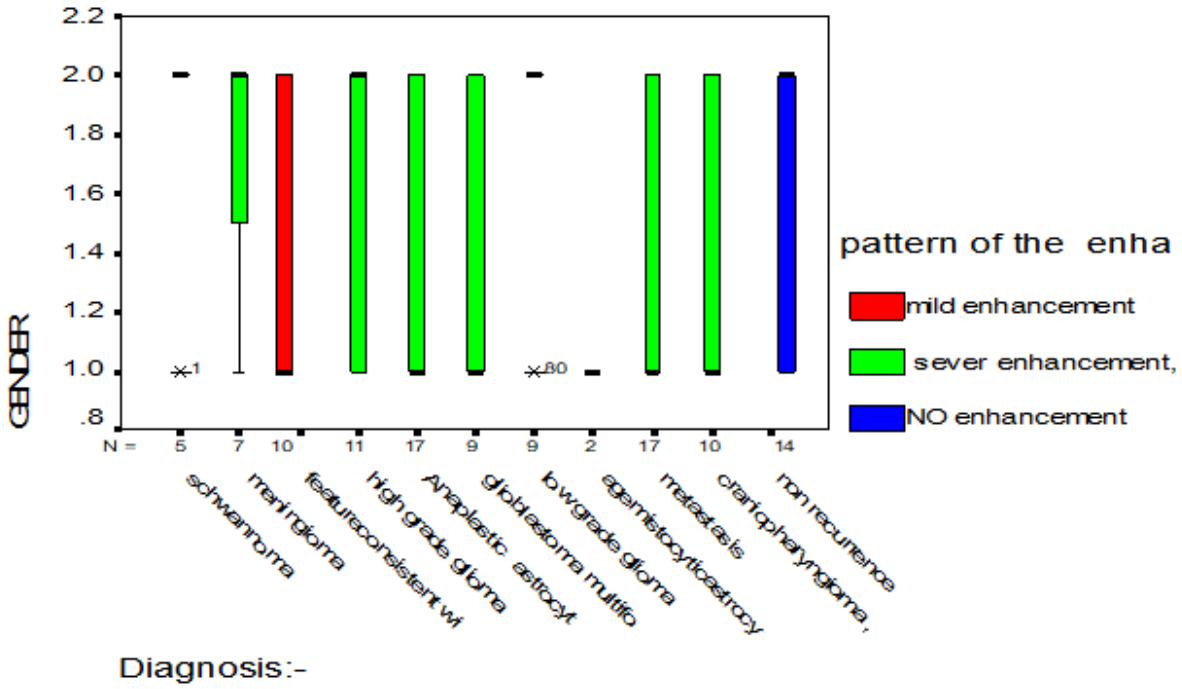

Figure 1: The figure above indicates the classification of all type of brain tumors according to the pattern of the enhancement of contrast media.

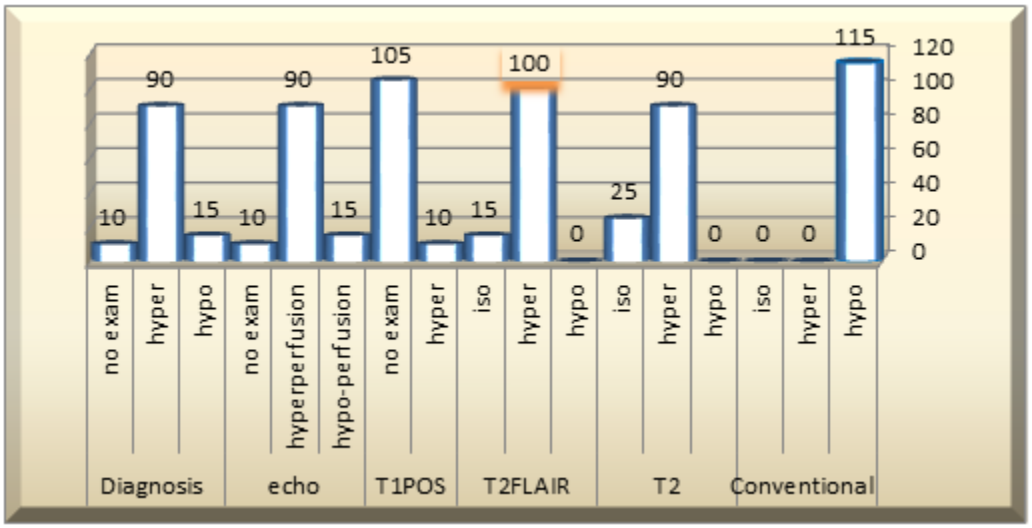

Figure 2: The figure above indicates Conventional protocol diagnosis imaging hyper signal intensity T2 FLAIR (115) cases in the conventional protocol C, while the technique T1 WI-SE post contrasts no exam (105) cases . Regarding technique T2 FLAIR hyper SI(100) cases

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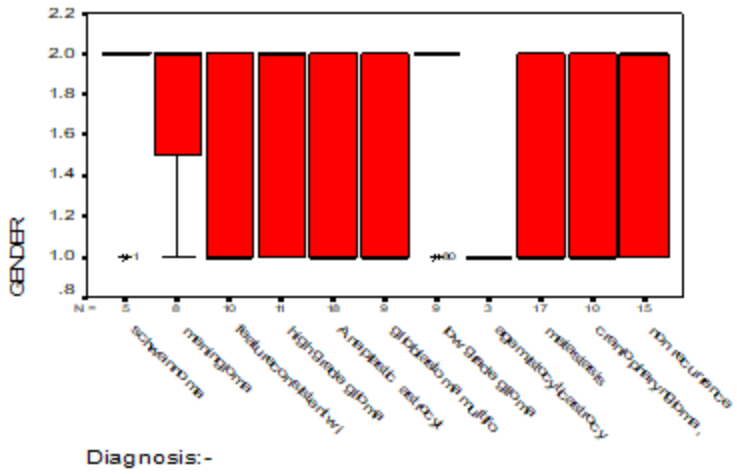

Figure 3: The figure above indicate classification all type of brain tumors according to gender

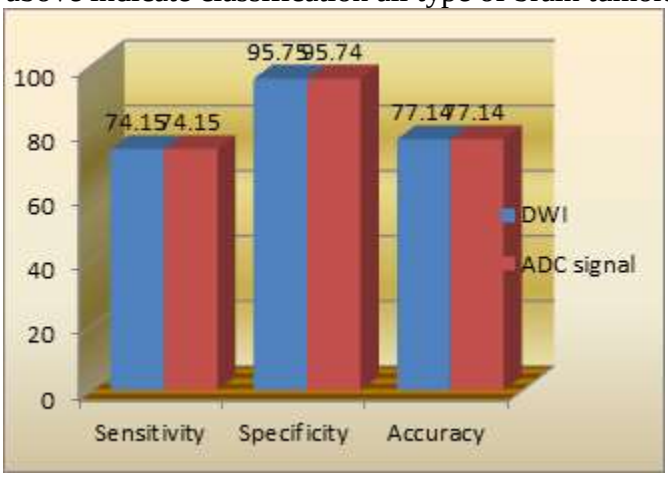

Figure 4: The figure above indicated the sensitivity, specificity, and accuracy of technique diffusion weighted imaging of MRI

Figure 5: The figure above indicated the sensitivity, specificity, and accuracy of technique echo planar imaging of MRI

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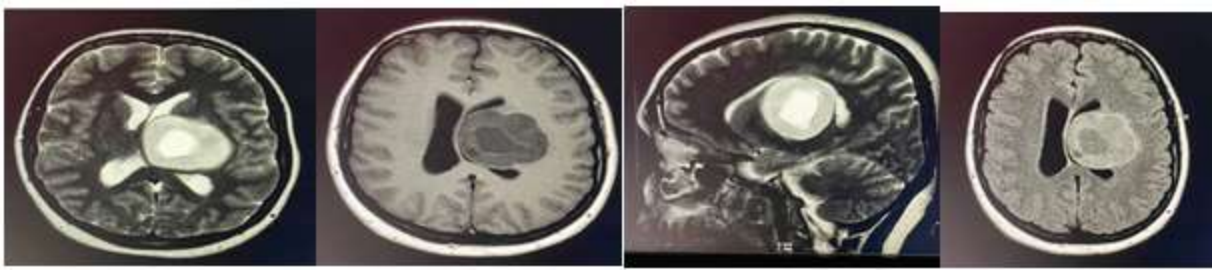
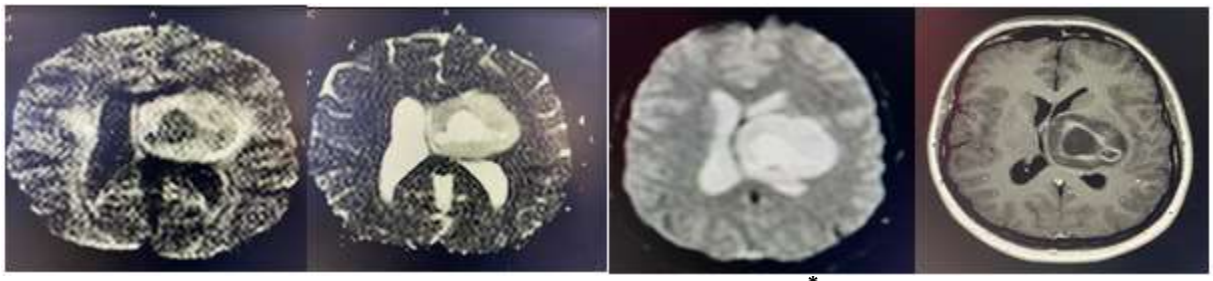
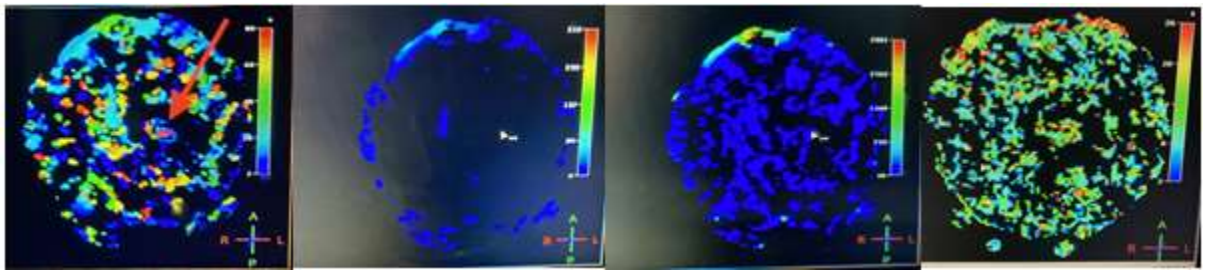


Axial T_2-TSE WI **Axial T_1-SE WI Pre** **Sagittal T_2-TSE WI** **Axial T2-FLAIR**

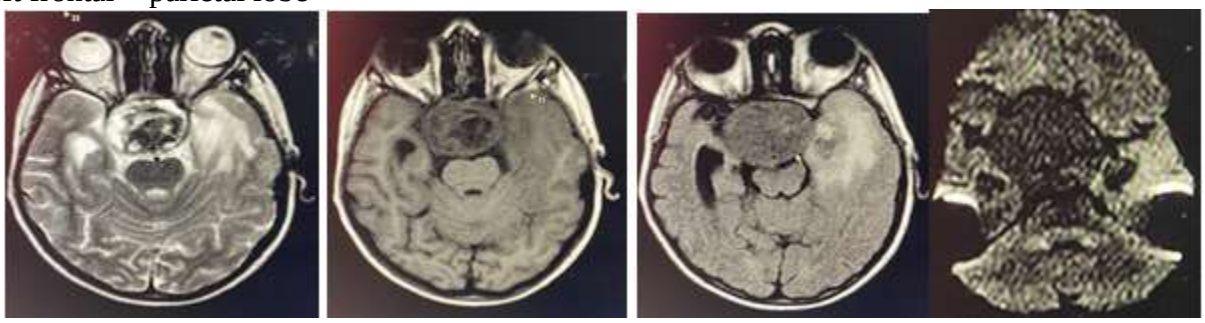


DWI b=1000 **ADC value** **FE-EPI** **Neuro T_2^* Dynamic contrast** **T_1-SE WI Post**



FEPI **Index** **NI** **MTT**

Figure 6: In This Figure as shown, a 23 year old man complaining of headache was referred by a specialist neurologist for MRI Perfusion and Diffusion Weighted Imaging for the brain. It was diagnosed by the radiologist low grade astrocytoma, aggressive large cyst well defined in the left frontal - parietal lobe



Axial T2-TSE WI **Axial T_1-SE WI Pre** **Axial T2-FLAIR** **DWI b=1000**

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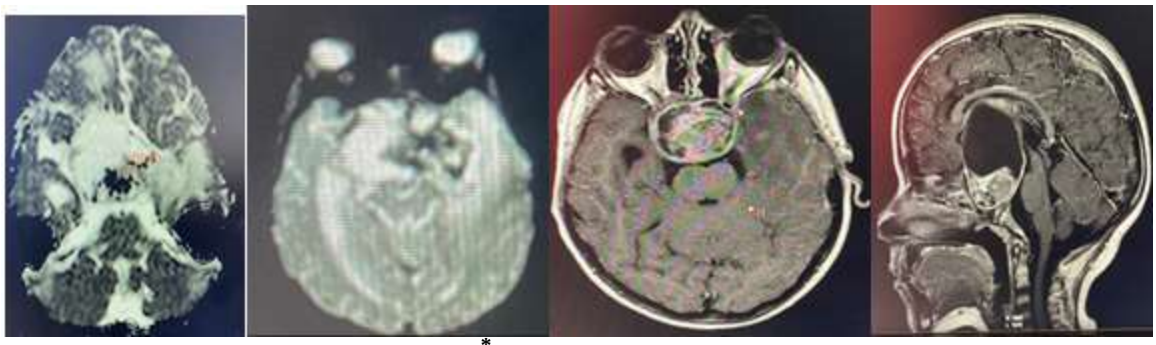
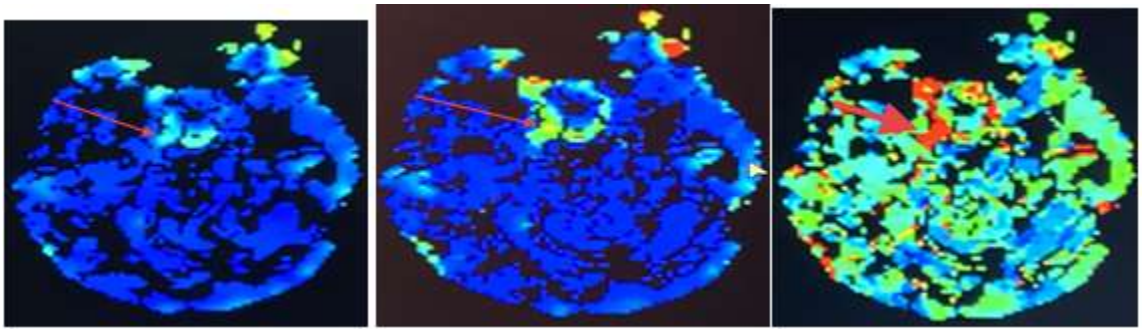


ADC value **FE-EPI** **Neuro T_2^*** **Dynamic** **T_1-SE WI Post contrast** **T_1-SE WI Post contrast**



Index **NI** **MTT**

Figure 7: Image that shows MRI of the brain tumors with craniopharyngioma

DISCUSSION :

According to present study, the most common age groups were (20-29) years (29.52%), Adolescents and young adults are a cancer survivor group that has been understudied. [22]. Regardless of the type of brain tumors and gender. Also a sample in our study the highest females percentage (34.48%) in the age groups (20-29), compared to the highest males percentage (24.56%) in the age groups (40-49), (60-69). The present study indicates the number of patient females is higher (58) cases while the number of patient males (57) cases with all brain tumors, According to study. [23] . For all cancers, people aged 65 and up had a substantial increase in mortality. Despite the fact that cancer remains the leading cause of disease-related death in teens and young adults in high-income countries, overall survival rates continue to rise and now exceed 80% in some countries after five years. Consent with a study [18]. In the current study the number of females was (50.43%) of cases and the males (49.57%) of cases, we note a large number of females examined compared to males.

In the present study, we investigated (10) patients by protocol C. mild enhancement contrast agent with diagnosis feature with consist of brain tumors and from them (7) patients (12.96%) percentage male with mild enhancement contrast agent, (3) patients (5.26%) percentage female with mild enhancement contrast agent. By the conventional protocol C The technique T1-SE WI post the contrast no exam (105) cases, while (10) cases hyper signal intensity(SI). The technique T2 FLAIR hyper SI(100) cases, while the iso SI (15) cases.

Diffusion weighted imaging (DWI) protocol D was first used in tumor diagnosis to determine a tumor's cell density. b-value =1000. In our study, DWI & ADC signal sensitivity and specificity accuracy 100% diagnosis finding neoplasms, DWI & ADC signal($p < 0.558$) classification brain tumors benign brain tumors (36.19%) , while malignant brain tumors (63.81%), which is lower

in highly cellular tumors. This is consistent with a study by.[24]. Diffusion coefficient multiplied by a sensitivity weighted factor that depends on the time and the amplitude of the diffusion gradient. [19].Current study is similar to these studies . Most units perform DWI on all patients, the workup of intracranial tumors, DWI examines the free movement, or Brownian motion, of water molecules at a cellular level. [25]. DWI generates images that are based on the molecular motion of water, which is related by the disease malignant mass tightly packed cells leading to inhibition of effective movement of water molecules restricted diffusion increased SI on DWI, low ADC value. [26] .

Perfusion weighted magnetic resonance imaging protocol P , FE-EPI sensitivity and specificity accuracy (100%) diagnosis hypo-perfusion & hyper-perfusion, the highest hyper-perfusion percentage (78.26%), total time of these sequences less (1:49min). In this sequence we get (1040) images, (10) the cases (8.70%) percentage with no examination by this sequence,(15) cases with no enhancement contrast agent with diagnosis non-recurrence post-operative of brain tumors, and (95) cases sever contrast enhancement contrast agent with diagnosis all type of brain tumors. p-MRIs technique imaging can be used homogeneous techniques use intravenous contrast agents Gd ,the method called EPI Neuro- perfusion T2* Dynamic. Dynamic contrast enhanced (DCE-MRIs) is the preferred in-vivo method .[20]. In this study, stage is the most important determinant of survival .[21]. (WHO) grade II (low-grade) gliomas in adult patients are known to comprise a heterogeneous group of primary brain tumors with highly variable clinical outcome. There are many reasons why improved methods of diagnosis are important, reduce preoperative waiting times, improve surgical success rate, or reduce targeted healthcare usage. In the current study, we used p-MRIs to sequence the new protocol for demonstration (CBF), (CBV), and (vascular permeability). We recommend the use of an FE-EPI Neuro-$T2^*$ Dynamic contrast agents sequence, it is important to determine the site, the type, and the grade of brain tumors .

CONCLUSION :

The important conclusion d-MRIs and p-MRIs have a strong relationship with the sensitivity and specificity of neurologic brain tumors. These results may have a major impact on the use of MRI scanning in the diagnosis and evaluation of brain tumors.The second conclusion Perfusion MRI study (FE-EPI Neuro $T2^*$ Dynamic study) are efficient techniques of mass brain neoplasms in evaluation of parameters Index= cerebral blood flow(CBF), NI=blood volume(CBV) and vascular permeability=(MTT). The third conclusion for patients examination by protocol D using the Diffusion weighting imaging technique(DWI) & apparent diffusion coefficient (ADC) value we found single mass classified into benign and malignant brain tumor and imaging movement restricted or non-restricted. Finally Perfusion & diffusion MRIs together can guide the initial assessment in specifications of stage neoplasms of brain tumor .

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