Evaluation Of Signal Intensity For Differential Diagnosis Of Brain Lesions In Magnetic Resonance Imaging

Smitha. H, Meena Devi V.N, Vinoo Jacob, Sreekanth.K.S

Abstract : Brain lesions leads to functional disturbances of brain systems. For differential diagnosis as well as for planning a treatment, the differentiation between tumors and tumor like lesions are essential. Since Magnetic Resonance Imaging (MRI) is highly sensitive in detecting abnormalities, the identification of specific characteristics of brain lesions can be detected with the help of MRI for the differential diagnosis. The objective of this study is to compare the MR signal intensity patterns and enhancement patterns of brain lesions in patients which helps for early detection and management of brain lesions. For this 41 patients suspecting brain lesions were underwent for both T1wt images and T2 wt MRI images. Imaging was performed with a 1.5-T scanner by using different pulse sequences and a two-dimensional Fourier transform image reconstruction. Results obtained were compared and statistical analysis was done by SPSS version 16. Comparison was done by chisquare test. P-value <0.0001 was considered to be statistically significant. Qualitative variables where expressed in frequency, for comparing T1 wt images and T2 wt images. It was found that most of the brain lesions like tumors were appeared as hyperintense in T2 wt images compared with T1 wt images. But the tumor like Tuberculoma was appeared as hyperintense in T1 wt images and T2 wt images. Similarly Sub Dural Hematoma (SDH) and Sub Arachnoid Hematoma (SAH) were found as hypointense in T2 wt images compared to T1 wt images. The evaluation of signal intensities of brain lesions can predict better diagnosis which helps the clinicians for early detection and further treatment of lesions.

Key words: Brain lesions; differential diagnosis**;** hypointense; hyperintense; Magnetic Resonance Imaging.

1. Introduction

Brain lesions include brain abscess, tuberculoma, neurocysticercosis, tumors and sarcoidosis[1]. An “Intra-cranial space occupying lesion” (ICSOL) is defined as a mass lesion in the cranial cavity with a diverse aetiology like benign or malignant neoplasm, inflammatory or parasitic lesion, haematoma, or arterio-venous malformation. The studies revealed that per year the incidence of Central Nervous System (CNS) tumors varies from 10-17 per lakh persons per year for intracranial and 1-2 per lakh persons for intraspinal tumors and of these, about half are primary tumours and the rest are metastatic tumors like astrocytoma[2]. Malignancy grade II tumours have a peak incidence between 25 and 50 years and the glioblastomas have a peak incidence between 45 and 70 [3,4]. Brain lesions result in the functional disturbances of brain systems [5] .For planning treatment also the differentiation between tumors and tumor like lesions of the central nervous system is essential .The differentiation can be done by anatomic imaging studies like Ultrasound (US) Computed Tomography (CT) or Magnetic Resonance Imaging (MRI)[6] .Since MRI is highly sensitive in detecting abnormalities, the identification of specific characteristics of brain lesions can be done with the help of MRI for the differential diagnosis [7]. Magnetic Resonance Imaging (MRI) is a well-established tool for examining intracranial lesions[8]. The first clinical magnetic resonance image was produced in 1980 in Nottingham and Aberdeen[9].Depending on the tissue content, the MRI images produce different image contrast. The contrast in the MRI images are due to the varying signal intensity [10].MR imaging (MRI) provides a powerful tool for diagnosis with excellent soft tissue contrast. MR imaging has tissue variables like spin density, T1 and T2 relaxation times, flow and spectral shifts to construct its images. By selecting pulse sequences and pulse times, these variables can be combined in various ways to emphasize any desired combination of tissue characteristics in the images[11]. Further for the evaluation of brain lesions gadolinium enhancement plays an important role. An enhancing lesion is defined as an area of at least 3mm with a clear area of hyperintensity on MRI images obtained at least 5 min after administration of the contrast agent. By gadolinium enhancement, abnormality on T2 or T2 FLAIR images can be confirmed. In the case of larger lesions particularly about the ventricles or the cortex , an open ring enhancement will be shown which helps in the differentiation from neoplatic lesions or abscesses[7]. The two main mechanism of contrast enhancement are due to increased vascularisation within pathological lesion or due to the diffusion of contrast through blood brain barrier. With contrast, MRI examination can be performed for precise imaging of tumors, inflammatory lesions, ischemic changes or demyelination[8].With respect to contrast mechanism, images can be weighted .Weighted images like T1 weighted (T1wt), T2 weighted (T2wt) and Proton Density weighted (PD wt) are different in their signal intensity[12].By carefully selecting the MR parameters, the signal intensity can noninvasively diagnose both in T1 wt images and T2 wt images. The purpose of this study is to compare the MR signal intensity patterns and enhancement patterns for differential diagnosis of brain lesions in patients

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based on signal intensity for early detection and management.

2. Materials and Methods

This study was conducted in the Radiology Department of one of the major tertiary health care centres in South Kerala. Patients suspected of brain lesions and who underwent MRI for diagnosis were included in this study. The study was approved by the Institutional Ethics Committee. Both males and females were included in the study. Patients with the proven MRI diagnosis were only included as study subjects. We did MR imaging of 41 patients with different brain lesions. Imaging was performed with a 1.5-T scanner. With a head coil of diameter, 30 cm, all images were obtained by using spin-echo pulse sequences, gradient echo sequences, FLAIR and a two dimensional Fourier transform image reconstruction. As hydrogen nucleus (^{1}H) possess a property known as "spin", the hydrogen proton acts like a tiny magnet in our body[9,13] .The hydrogen nuclei could generate their own magnetic moment and so have an inherent interaction with external magnetic field[14]. The magnetic fields of hydrogen protons did not sum as the protons oriented randomly, but cancelled out[13].The nucleus were placed in a strong external magnetic field (B_0) to align either in parallel or perpendicular to the external field [9].The mechanism that gave signal contrast among different tissue types was nuclear magnetic relaxation[15]. Depending on the specific time constant, there were two relaxation process[14].The process of longitudinal magnetization recovery and transverse decay. The longitudinal radiofrequency pulse or excitation, to invert the magnetization vector is T1 (spin lattice) relaxation and is the time required to recover approximately 63% of their pre excitation magnetization (Figure.1). Substance having shorter T1 relaxation time gave higher signal intensity atT1wtimages[16] T1 wt images were depended on TR (Time of Relaxation) between slice selection and RF pulses ([11]. As T1 is an exponential growth time constant , a tissue with short T1 could give a hyperintense signal and a tissue with long T1 could appear dark (hypointense) in MR image[17] . T2 or Transverse relaxation is the measure for the decay of transverse magnetization [15].T2 is the time taken for the transverse magnetization to decay to 37% of its original value (Figure 2)[13].T2 wt images depends on TE (time of Echo) in milliseconds[11]. Naturally present signal contrast mechanisms are T1 and T2 relaxation. It was used to visualize the normal anatomy and pathological changes. The intrinsic changes in T1 and T2 relaxation due to disease process could be achieved by using contrast agents in MRI images [15]. Substance having longer T2 relaxation time appeared as hyperintense on T2 wt images and with short T2 relaxation time appeared as hypointense on T2 wt images[8].To detect anatomical structures T1 wt images are best but if contrast material is used pathological entities can be observed. T2 wt images gives the depiction of disease as the pathological process have more water content and appears as bright in T2 wt images[18]. From all patients we obtained T1-wt spin-echo images (500–600/ 20–30/2-4 repetition time/echo time/excitations) and T2-wt spin-echo, FLAIR, gradient echo (2500–3000/30, 80/1), and post contrast T1-weighted images after intravenous injection of gadolinium (0.1 mmol/kg body weight). The images were acquired on a 256 x 256 matrix, with a field of view of 23 cm. The MR studies were evaluated for the signal intensity compared with brain lesions on T1 and T2wt images and the extent of enhancement. The variations in the anatomical structures as a measurement of signal intensity were compared both in T1 and T2 wt images. Statistical Analysis was done by SPSS version 16 software. Comparison was done by chisquare test. P-value <0.0001 was considered to be statistically significant. Qualitative variables where expressed in frequency, for comparing T1 wt images and T2 wt images (Figures 1 & 2).

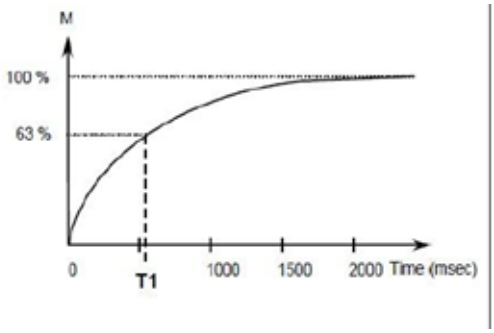

Fig.1.T1 RecoveryCurve

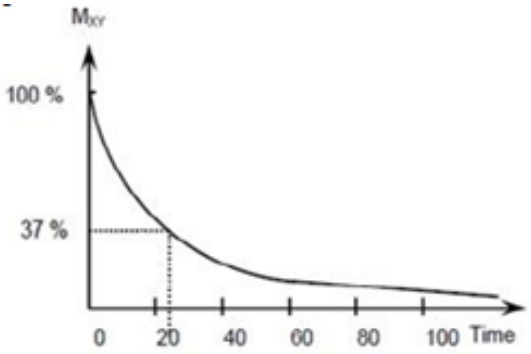

Fig. 2 . T2 Decay

3. Results and discussion

Out of 41 brain lesions cases studied, both T1 wt and T2 wt images were compared for their intensity and percentage. Table 1. shows the comparison between T1 wt images and T2 wt images. It was found that in T1wt images, the brain lesions like lymphoma, meningioma, neurocysticercosis, fungalabscess, granuloma, glioblastoma, glioma, oligodentroglioma, subdural haematoma, subarachnoid haematoma, epidural hematoma, left craniopontine angle tumor, subependymoma, epidermoid cyst,macroadenoma, right pontine lesion, multiple sclerosis, granulomatus and metastatis were appeared as hypointense.Where as the tuberculoma were observed as hyperintense in T1wt images. It was also found that in T2wt images the brain lesions like subdural haematoma and subarachnoid haematoma were appeared as hypointense. But the other brain lesions like lymphoma, meningioma,

neurocysticercosis, fungal abscess, granuloma, glioblastoma, glioma, oligodentroglioma, epidural hematoma, left craniopontine angle tumor, subependymoma, epidermoid cyst, macroadenoma, right pontine lesion, multiple sclerosis, granulomatus and metastatis were appeared as hyperintense in MRI.

Table 1. Comparison between T1wt hypointense , hyperintense images and T2 wt hypointense and hyperintense images in different lesions

T1 wt images	T1 wt images	T2 wt Images	T2 wt images
Hypointense	**Hyperintense**	**Hypointense**	**Hyperintense**
Lymphoma	--	--	Lymphoma
	Tuberculoma	---	Tuberculoma
Meningioma	---	---	Meningioma
Neurocysticercosis	---	--	Neurocysticercosis
Fungal Abscess	---	---	Fungal Abscess
Granuloma	---	---	Granuloma
Glioblastoma	---	--	Glioblastoma
Glioma	---	---	Glioma
Oligodentroglioma	---	---	Oligodentroglioma
SDH	--	SDH	--
SAH	---	SAH	---
EDH	---	--	EDH
Left CP Angle	--	---	Left CP Angle
Subependymoma	---	---	Subependymoma
Epidermoid Cyst	---	--	Epidermoid Cyst
Macroadenoma	---	---	Macroadenoma
Right Pontine Lesion	---	---	Right Pontine Lesion
Multiple Sclerosis	---	--	Multiple Sclerosis
Granulomatus	--	---	Granulomatus
Metastatis	---	---	Metastatis

Table 2 shows frequency and percentage corresponding to the T1 wt images. In isointense, frequency was one while the corresponding percentage was 2.4. In Hyperintense, the frequency was 6 and percentage was 14.3. While in hypointense the frequency was 31 and percentage was 73.8. T1 wt images showed a frequency of one and were 2.4%.

Table 2. Frequency corresponding to T1 wt images and Percentage

		Frequency	Percent(%)
	Isointense	1	2.4
	Hyperintense	6	14.3
	Hypointense	31	73.8
	Isointense	3	7.1
	T1wtimages	1	2.4
	Total	42	100

In Table 3 there is representation of T2 wt images in frequency and percentage. In Hyperintense images the frequency and percentage were 34 and 81 respectively where as in hypointense the frequency was 7 and percent was 16.7% . Similarly in T2 wt images were observed as 1 and 2.4 %

Table 3. Frequency corresponding to T2 wt images and percentage

		Frequency	Percentage(%)
	Hyperintense	34	81
	Hypointense	7	16.7
	T2 wt images	1	2.4
	Total	42	100

Table 4 shows the Cross tabulation between T1 wt images and T2 wt images which gave 8.8% hyperintense and 100% hypointense and 91.2% and 0.0% respectively.

			T2 wt images		Total
			Hyperintense	Hypointense	
T1 wt images	Hyperintense	Count	3	3	6
		% within T2 wt images	8.8%	100.0%	16.2%
	Hypointense	Count	31	0	31
		% within T2 wt images	91.2%	0.0%	83.8%
Total		Count	34	3	37
		% within T2 wt images	100.0%	100.0%	100.0%

McNemar's chisquare value was found to be 21.44 with a p-value < 0.0001. Since p-value was significant, there is association between the T1wt images and T2wt images. These information was helpful to predict which type of signal intensity was helpful in the differential diagnosis based on the frequency and percentage for an early treatment and timely intervention. This was a hospital based study and through the study we investigated and analyzed the types of brain lesions having different signal intensity in T1 wt and T2 wt MRI images in patients .Our data shows interesting findings which are different from the data obtained from the studies conducted in other parts of the world. It was found that in T1wt images, the brain lesions like lymphoma , meningioma, neurocysticercosis, fungal abscess, granuloma, glioblastoma, glioma, oligodentroglioma, subdural haematoma, subarachnoid haematoma, epidural hematoma, left craniopontine angle tumor, subependymoma, epidermoid cyst, macroadenoma, right pontine lesion, multiple sclerosis, granulomatus and metastatis were appeared as hypointense. Whereas the tuberculoma were observed as hyperintense in T1wt images. In our studies the glioblastoma were appeared as hypointense in T1wt images and hyperintense on T2wt images . In recent studies also it was found that the lesion glioblastoma appears hyperintense on T2-FLAIR sequences [19]. We obtained the glioma as hyperintense on T2wt images . In early studies also it was observed that malignant glioma were observed as hyperintense areas in T2 wt images[20]. In the case of meningiomas, in the present study, were appeared as hypointense in T1wt images and hyperintense in T2wt images .In one of the studies also it was found that microcystic meningiomas are demonstrated as hypointense in T1wt images and hyperintense in T2wt images.Similarly it was confirmed that the angiomatous meningioma and secretory meningioma were seen as hypointense in T1 wt images and hyperintense on T2 wt images[21].Early studies also revealed that the soft meningiomas were observerd as hyperintense on T2 and hypointense on T1 wt images, but the firm meningiomas were found as hypointense on T2 and isointense on T1 wt images [22] . It was also reported that the meningioma were hyper or isointense in T2 wt and hypointense or isointense in T1 wt images[23]. Our MRI findings in the case of lymphoma showed that the signal intensity as hypointense in T1wt mages and hyperintense appeared in T2wt images. The primary CNS lymphoma was also demonstrated as iso or hyperintense in T2 wt images and hypointense or isointense lesions in T1wt images in one of the study [24] . Another findings in our study showed that the lesion like metastatis appeared as hypointense in T1 wt and hyperintense on T2wt images. It was also confirmed that in previous studies the metastatic lesion appeared as hypointense on T1wt and as hyperintense on T2 wt imaging) [8]. Earlier studies also revealed that intraparenchymal metastasis were commonly seen and it was appeared as hypointense on T1 wt images and hyperintense on T2 / FLAIR images, which also showed as nodular enhancement [25] We observed macroadenoma in T1 wt images as hypointense and T2 wt images as hyperintense image. One of the studies also reported that the lesion, adenoma was appeared as hyper or isointense in T2wt images and hypointense or isointense in T1 wt images[23]. Here we observed that the brain lesion like neurocysticercosis appeared as hypointense in T1wtimages and hyperintense in T2 wt images. But the studies revealed that the appearance of neurocysticercosis on MRI as hypointense to isointense in T1 wt and hyperintense as T2 wt images[26]. However in another study it was found that neurocysticercosis , T1 appeared as hypointense and T2as In our study it was found that in the lesions like subdural hematoma (SDH), T2 wt and T1wt images appeared as hypointense. In earlier studies also it was seen that acute subdural hematomas (SDH) with long TR and long TE appeared as hypo intense [27].

4. Conclusion

Awareness of signal intensities of brain lesions is essential for the proper diagnosis as the incidence of brain lesions are very common now a days. Imaging modalities like MRI have complimentary roles in the evaluation of brain lesions. MRI is one of the best methods for assessing soft tissue involvement. The imaging of signal intensities from MRI plays a fundamental role not only in diagnosis but also in treatment planning. From this study we could conclude that most of the brain lesions like tumors were appeared as hyperintense in T2 wt images compared with T1 wt images . But the tumour like Tuberculoma was appeared as hyperintense in T1 wt images and T2 wt images. Similarly Sub Dural Hematoma (SDH) and Sub Arachnoid Hematoma (SAH) were found as hypointense in T2 wt images compared to T1 wt images. Diverse categories of brain lesions have characteristic clinical and imaging features that allow definite differential diagnosis based on signal intensity variation.

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