Diagnostic Accuracy of Diffusion Weighted Sequences of Magnetic Resonance Imaging (MRI) in Patients of Acute Brain Infarct

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Abstract:

Stroke is typically the most frequent cause of disability and fifth leading cause of death in the past, early detection of acute brain infarct may be challenging for non-invasive diagnostic imaging, but recent advancement in diagnostic imaging makes it possible.

Objective:

To determine the diagnostic accuracy of diffusion weighted sequences of magnetic resonance imaging in patients of acute brain infarct.

Methods:

In this cross-sectional study, among 70 patients of acute infarct were selected without age and gender discrimination by convenient sampling, at Department of Radiology Children's Hospital, Lahore and Institute of Child Heath Lahore. 1.5-Tesla MRI Philips Ingenia machine was used.

Results:

Out of 38 patients with acute brain infarct, 37 were hyper intense on diffusion weighted imaging (DWI) while one patient was iso-intense on DWI, showing 97.4% sensitivity for acute infarct patients. Similarly for evaluating the specificity of DWI, Out of 32 non-infarcted patients, 2 patients were hyper intense on DWI & 30 patients were iso-intense to brain on DWI.Which showed 93.8 % specificity for acute brain infarct. Out of 38 patients with infarct, 35 were hypo intense and 3 patients were iso-intense on ADC.

Conclusions:

Diffusion weighted sequences of MRI were highly accurate in detection of acute brain infarction. Diffusion weighted imaging (DWI) had superior sensitivity over the apparent diffusion coefficient (ADC) for the detection of acute brain infarction but has same specificity like ADC.

Key Words:

Acute brain infarct, Diffusion Weighted Imaging (DWI), Apparent Diffusion Coefficient (ADC)

Introduction:

Stroke is typically the most frequent cause of disability and the fifth leading cause of death in the United States[1]. Each year almost 795,000 people go through strokes; of these, 87% are ischemic strokes cases[2]. The two paired arteries carry blood supply to brain, the internal carotid arteries and the vertebral arteries[3,4]. Cerebral infarction is occurs instantly when the leading vessels that supply the blood to brain are blocked. Infarct evolves over time, the temporal evolution of an infarct occurs in three stages: Acute, a stroke that is 1day-1week old; Sub acute, 1 week-3 week old and Chronic, more than three week old[5]. The common clinical features of ischemic stroke are: Sudden weakness or numbness in the face, trunk, upper or lower extremity, headache, convulsions and a problem in visual field of one of both eyes[6,7].Magnetic resonance imaging (MRI) is a soft tissue imaging technique used to produce high quality images of the human body. It is based on the fundamental principles of nuclear magnetic resonance (NMR). In MRI images are produced by using the strong magnetic field, radio waves and computer[8]. Cerebral infarction increases the risk of disability and mortality. Timing is very

important to figure out the extent of brain damage and choose the relevant treatment. The advancement in radiological diagnosis not only supports us in judging the timing but also the development of stages of brain infarction. From the past few years, the diffusion weighted imaging (DWI) and apparent diffusion coefficient (ADC) increase the sensitivity in early diagnosis of brain infarction[9]. The molecules in tissue are not in constant position but move randomly. This phenomenon of erratic movement of molecules is known as diffusion. The water molecules can diffuse freely in the extracellular environment but intracellular molecules face restricted diffusions[10,11]. Diffusion weighted imaging is based on quantification of microscopic random motion of water molecules. DWI is the most reliable sequence to detect early ischemic stroke and cellular tumors, abscess and other neurological diseases[12].The implementation of Diffusion-weighted imaging can even be utilized in medical specialist imaging of breast, liver, endocrinegland and furthermore for whole-body imaging[13-15]. DWI sequences are spin echo sequences start with 90 and followed by 180-degree pulses[16]. Echo-planar imaging (EPI) is the currently used technique to obtain DWI images[17].DWI images are in fact inherently T2 weighted. Therefore, any pathology with long T2 relaxation will appear high intensity, even if they do not restrict diffusion. Diffusion coefficient gives us a true idea about restricted diffusion by eliminating T2 effects. As a result of applying different b-value with several DWI series, we can actually count up the apparent diffusion coefficient. We can vary the weighting amount of diffusion weighted images by adjusting the strength of diffusion gradient and time spacing[18]. The ADC value is believed to be low in ischemic brain stroke. In this condition a cytotoxic edema is occurs because of a shift of water from the extracellular to the intracellular compartment due to imbalance of sodium and potassium pump. The imbalance of membrane causes water diffusion restriction and low signal on ADC. We compare DWI images to ADC images to confirm the factual diffusion. Some abnormalities might seem bright on DWI while not diffusion restriction because of T2 shine impact. Therefore, we tend to use ADC map to attest true diffusion restriction[19-21].

A study conducted by Lansberg MG *et al.,* showed that sensitivity of apparent diffusion coefficient (ADC) was 88% and specificity 90% in acute stroke patients[22]. Similarly study conducted by Oppenheim C *et al.,* demonstrated acute ischemic stroke on FLAIR and DWI. Total 91 patients were observed in this study. The results of there study were that sensitivity was 98% and specificity was 100% On DWI[23]. Likewise, Brunser AM *et al.,* studied accuracy of diffusion weighted imaging in patients with suspected cerebral infarcts. They took 712 patients of acute and sub-acute stroke In their study DWI showed a sensitivity of (90%) and a specificity of (97%)[24]. In Similar fashion, the result of a study conducted by Everdingen V *et al.,* highlighted that DWI sensitivity 75% and specificity 100% in acute stroke patients[25].

The aim of this study was to evaluate the diagnostic accuracy of diffusion weighted sequences of MRI in the patients suffering from acute brain infarct.

Methods:

In this cross-sectional study, 70 patients were included from the Department of Radiology Children's Hospital, Lahore & Institute of Child Health Lahore. Seventy patients of acute infarct without age and gender discrimination were selected by convenient sampling. A 1.5- Tesla MRI Philips Ingenia machine was used to collect data. The patients were included in this study if they had clinical evidence of infarct presenting within 6 hours to one week, abrupt onset of focal neurological symptoms compatible with stroke, clinical evidence of arterial territory infarct with corresponding hypo attenuation on CT and patients with transient ischemic attacks. Patients

having any contraindications of MRI, coagulopathy, brain abscess and brain tumor were excluded.

Results:

Out of 70 patients of acute infarct 41 (58.6%) were male patients whereas 29 (41.4%) were female patients. Table 1 shows that minimum age was 1 year and maximum age was 80 year.

Descriptive Statistics						
	N	Range	Minimum	Maximum	Mean	SD
Age in years	70	79	1	80	12.3043	16.35477

Table 1: Frequency distribution of age

Table 2 shows that magnetic resonance imaging (MRI) diagnosed the 34 patients with acute brain infarct and 30 patients were normal cases. 3 patients identified both acute and chronic infarct and 3 patients detected with other ischemic changes.

Diagnosis on MRI	Frequency	Percent
Acute Infarction	34	48.6
Normal brain	30	42.8
Both acute and chronic infarct	3	04.3
Other ischemic changes	3	04.3
Total	70	100.0

Table 2: Frequency distribution of MRI Diagnosis

Out of 70 patients 36 were hyper intense while, 31 were iso-intense and 3 patients were both hyper and hyo-intense on diffusion weighted images.Table 3 shows the signal intensity onDWI and signal intensity on ADC. Out of 70 patients 34 were hypo-intens, 33 were iso-intense and 03 patients were both hyper & hypo intense on apparent diffusion coefficient images.

SI (DWI)	Frequency	Percent	SI (ADC)	Frequency	Percent
Hyper intense	36	51.4	Hypo intense	34	48.6
Iso intense	31	44.3	Iso intense	33	47.1
Both hyper and hypo intense	03	4.3	Both hyper and hypo intense	03	4.3
Total	70	100.0	Total	70	100.0

Table 3: Frequency distribution of signal intensity on DWI and ADC

Table 4 shows the diagnostic accuracy of DWI in diagnosis of acute brain infarct. Out of 38 patients with acute infarct 37 were hyper intense on DWI Images while, 01 patient was iso-intense on DWI showed 97.4% sensitivity for acute infarct patient. It means that DWI was highly sensitive for detection of acute infarct. Similarly for evaluating the specificity of DWI, out of 32 non-infracted patients, 02 patients were hyper intense on DWI & 30 patients were iso-intense to brain on DWI shows 93.8 % specificity for acute infarct which showed that DWI was highly specific for detection of acute infarct. Table 4 also shows the diagnostic accuracy of ADC in diagnosis of infarct. For evaluating the sensitivity of ADC 38 patients with infarct were studied. Out of these 35 were hypo intense and 03 patients were iso-intense on ADC, showing sensitivity of 92.1%. It means that ADC is less sensitive than DWI. Similarly, the specificity of ADC out of 32 non-infracted patients 30 patients were iso intense and 2 patients were hypo intense showed specificity of 93.8%.

DWI test result	Truth		Total
	Non diseased	Diseased	
Negative	30 (93.8%)	01 (2.6%)	31 (44.3%)
Positive	02 (6.3%)	37 (97.4%)	39 (55.7%)
Total	32 (100.0%)	38 (100.0%)	70(100.0%)
ADC test result			
DWI test result	**Truth**		**Total**
	Non diseased	Diseased	
Negative	30 (93.7%)	03 (7.9%)	33 (47.1%)
Positive	02 (6.3%)	35 (92.1%)	37 (52.9%)
Total	32 (100.0%)	38 (100.0%)	70 (100.0%)

Table 4: Diagnostic accuracyof DWI and ADC

Discussion:

Out of 70 patients, 38 patients with acute brain

infarct and 37 diagnosed on DW Iand it showed 97.4% sensitivity and specificity of 93.8% for acute infarct patients. Out of 38 patients, 35 were diagnosed on ADC. It Showed 92.1% sensitivity and 93.8% specificity for acute brain infarct. Lansberg MG *et al.,* conducted a study on evaluation of apparent diffusion coefficient, diffusion weighted imaging and T2 weighted signal intensity of acute stroke. They enrolled 27 patients and they also reported sensitivity 88% and specificity 90 % on ADC[22]. In the same way, study conducted by Oppenheim C *et al.,* demonstrated acute ischemic stroke on FLAIR and DWI. Total 91 patients were observed in their study and result of the study were in accordance with current study showing sensitivity 98% and specificity 100% on DWI[23]. Similarly, Brunser AM, *et al.,* studied accuracy of diffusion weighted imaging in patients with suspected cerebral infarcts. They took 712 patients of acute and sub-acute stroke and reported that DWI showed a sensitivity of 90% and a specificity of 97%[24]. Likewise,Everdingen V *et al.,* conducted a study to evaluate acute stroke on DWI among 42 patients and ischemic lesions on early DWI images predicted that the sensitivity of DWI was 75% and specificity was 100 %[25].

Conclusions:

It was concluded that the high sensitivity and specificity of diffusion weighted imaging (DWI) and apparent diffusion coefficient(ADC) sequences of MRI were accurate in detection of acute cerebral infarct.

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