Susceptibility weighted imaging in acute stroke with co-morbids: Magnetic resonance imaging protocol revisited

Abstract

Introduction:

We aim to investigate penumbra mainly Diffusion weighted imaging- Susceptibility weighted imaging mismatch using Alberta Stroke Program Early Computed tomography Stroke Score scoring in patients with multiple co morbid.

Methods:

From January 2011 to December, 2017; 70 consecutive patients (50 men,20 women; mean age 64.5; range 45-82 years) with acute infarct on Diffusion weighted imaging(DWI) were selected for the study. Stroke protocol performed including DWI and susceptibility weighted imaging(SWI) on first day and repeat within three days. All initial MR images were interpreted by one Neuroradiologist with more than ten years blind to the clinical findings of each patient. The definition of an acute infarct area was high signal intensity on DWI with dark signal intensity on Apparent diffusion weighted imaging (ADC). The infarct extent was scored using the Alberta Stroke Program Early CT Score (ASPECTS) system.Infarct growth was defined as any new or larger lesion on the second DWI.

For correlation with infarct growth, the same topographic system was used to record the extent of the Prominent vessel sign(PVS) on SWI.

Spearman's rank correlation test was used to examine the correlations between PVS score and infarct growth score. Regression was computed, with $P<0.05$ considered significant.

Results:

The MCA territory infarct was on the right side in 9 patients and on the left in 13. The mean ASPECTS score was 4.3 (range 0–9). PVS was detected in 15 patients (mean score 4.1, range 0–10).

The second MRI revealed no infarct growth in 9 patients and infarct growth in 13(ASPECTS mean score 3.95, range 0–9; mean infarct growth score 7.4, range 0–10).

Of 7 patients without PVS on the first MRI, none had infarct growth on the second. Of 15 patients with PVS on the first MRI, 13 (87%) had infarct growth. The PVS score and infarct growth score were well correlated ($r = 0.86, P<0.001$) .

Conclusion:

PVS seen in infarcted territory is related to poor prognosis and this can be reliably used as a surrogate marker of oxygen extraction in penumbra.

SWI can predict tissue at risk and can be a replacement for perfusion scan in clinical scenerio of acute ischaemic infarct.

Keywords stroke, magnetic resonance imaging, diffusion magnetic resonance imaging

Introduction

The estimated annual incidence of stroke in Pakistan is 250/100,000 population which is projected to an estimate of 350,000 new cases each year [1].

The role of imaging in triage of acute stroke is to rule out haemorrhage or ischemic infarction and selection of ischaemic stroke patients for available reperfusion therapies [2]. The imaging modality of choice for stroke triage should enable patient selection for thrombolytic therapy in terms of both safety and efficacy.

Routine IV tissue plasminogen activator(IVTPA) treatment within the 3-hour window is still typically administered according to the protocol of the 1995 National Institute of Neurological Disorders and Stroke (NINDS)trial, which focused on exclusion of hemorrhage with unenhanced CT [3].

However, infarct core and penumbra is desired for selection of reperfusion options as well as to prognosticate [4].Options for penumbra detection currently used and have several controversies are CT or MR with perfusion. These were particularly advised when mechanical thrombectomy is the plan [5].

The mismatch between PWI and DWI predicts a favorable response to thrombolysis after early reperfusion, and so may be a surrogate for ischemic penumbra [6] but for predicting infarct growth or clinical outcome is controversial and has been challenged [7].

In addition, Perfusion studies requires administration of contrast agent, which limits its application in patients with renal insufficiency.

Susceptibility-weighted imaging (SWI) is a potential alternative for predicting infarct growth. In the ischemic brain, the increased oxygen extraction fraction and slow flow contribute to a higher level of deoxyhemoglobin and vein dilatation, which increases the conspicuity of vessels on SWI [8].

Kaya, etal. [9] identified multiple hypointense vessels strictly in the ischemic territory during the hyperacute phase of stroke on 3T and Haccke, et al. [10] on 1.5 T.

The region was larger than the lesion shown on DWI and correlated well with the final infarction area after 72 hours.

SWI/DWI mismatch has also been recommended as a potential indicator of infarct growth in some reports [11].

Using a similar approach, we aim to investigate pneumbra mainly DWI- SWI mismatch using ASPECT scoring. To our knowledge no such study has been conducted so far on national level.

Materials & Methods

We created a data base from retrospective case material from our institution and then searched the data base prospectively as a *hypothesis-driven scientific study.*

Study design was Cross-sectional analytical.

From January 2011 to December,2017; 70 consecutive patients(50 men,20 women; mean age 64.5; range 45-82 years) met the below mentioned criteria in our university hospital and were selected for the study. The review was conducted in accordance with guidelines of the research committee of our institution.

Inclusion criteria:

Acute infarct on DWI in MCA territory.

Stroke protocol performed including DWI and SWI on first day.

Repeat DWI with in three days.

Exclusion criteria:

Tissue plasminogen activator (TPA) given.

Haemorrhagic infarction on initial presentation.

Watershed infarcts/Posterior circulation infarcts

Sampling technique was Non-probability purposive

Imaging techniqueScanners: 1.5 T scanner (Magnetom Avanto; Siemens Medical Solutions, Erlangen, Germany) and 3T (Titan,Toshiba)with a standard 12-channel head coil.

Stroke protocol: After routine axial T2W Only DWI and SWI sequences were performed in first encounter after triage.

For the DWI sequences, (with TR/TE = 3700/109 ms, b = 1000 s/mm2, slice thickness = 5 mm, slice number = 28, and matrix = 128x128) and generated ADC maps.

For the transverse 3-dimensional (3D) SWI sequences, TR/TE = 49/ 40 ms, flip angle = 15°, slice thickness = 2 mm with 60 sections per slab, matrix = 224×256, 64 slices, and (integrated parallel acquisition technique (iPAT) acceleration factor = 2. The phase, magnitude (mag), minIP, and SWI images were uploaded and made available on a picture archiving and communication (PACS) system (Rogan).

The total scan time for stroke protocol was 5-6 mins.

Follow up scan was performed within 3 days with axial T1W,T2W,Coronal FLAIR, DWI, SWI AND Time Of flight MR angiogram of the circle of Willis.

All MRI images were interpreted by one Neuroradiologist with more than ten years of experience and Neuroimaging fellow. All initial MR images were interpreted blind to the clinical findings of each patient.

The definition of an acute infarct area was high signal intensity on DWI with dark signal intensity on ADC.

The infarct extent was scored using the Alberta Stroke Program Early CT Score (ASPECTS) system, a 10-point semiquantitative CT score system developed and tested as a reliable grading system to assess the extent of ischemic change and to predict functional outcome in patients with acute ischemic stroke [12].

This topographic system allots 1 point for each of 10 zones of the MCA territory. A score of 10 is normal while 0 indicates diffuse infarction [13].

The application of ASPECTS to DWI in stroke has been extended and contributes to outcome prediction and quick risk assessment before thrombolytic therapy [14].

Infarct growth was defined as any new or larger lesion on the second DWI.

The infarct growth was scored from 10 (no growth) to 0 (growth in all 10 zones).

The PVS on SWI was defined as a local prominence of hypointense vessels with either increased vessel number or diameter in the target area, when compared with the non-target area.

In this study, the target area was defined as the MCA territory of the infarct side.

For correlation with infarct growth, the same topographic system was used to record the extent of the PVS.

The PVS of the insular cortical vessels was recorded as I, of the lower MCA-territory cortical or medullary vessels (M1, M2, or M3), of the higher MCA-territory cortical or medullary vessels (M4, M5, or M6), and of the thalamostriate vein (C, L, or IC) because this vein drains the caudate nucleus, lentiform nucleus, and internal capsule.

After the two readers had reached a consensus, the extent of the PVS was scored from 10 (no PVS) to 0 (PVS in M1, M2, M3, M4,M5, M6, I, C, L, or IC).

Statistical analysis used SPSS, version 17.0 (SPSS, Chicago, IL, USA). Mean and standard deviation of PVS scores, DWI ASPECTS scores, and infarct growth scores were calculated.

Spearman's rank correlation test was used to examine the correlations between PVS score and infarct growth score. Regression was computed, with $P<0.05$ considered significant.

Results

The study included 12 women and 10 men, (mean age 67.1 years).

First MRI images were all acquired in the acute stage of stroke (mean 12 hours) and second images within 3 days after stroke.

The MCA territory infarct was on the right side in 9 patients and on the left in 13. The mean ASPECTS score was 4.3 (range 0–9). PVS was detected in 15 patients (mean score 4.1, range 0–10).

The second MRI revealed no infarct growth in 9 patients and infarct growth in 13(ASPECTS mean score 3.95, range 0–9; mean infarct growth score 7.4, range 0–10).

Of 7 patients without PVS on the first MRI, none had infarct growth on the second. Of 15 patients with PVS on the first MRI, 13 (87%) had infarct growth. The PVS score and infarct growth score were well correlated ($r = 0.86, P<0.001$) .

Our results were consistent with those of recently published studies on pediatric arterial ischemic stroke Polan,RM, .et al [15] in which we restricted the analytic sample to adults, indicating SWI/DWI mismatch is useful for predicting ischemic stroke progression and study by Chia-YuenChen on adults Chia,Yuen ,.et al. [16].

Discussion

Our study showed that the PVS on SWI is a signature of salvageable ischemic tissue that will become infarcted if blood perfusion cannot be established in time.

This finding is consistent with the results of previous studies KesavadasC, et al.Jneurol [17].KaoHW etal.EuroRadiol [18], HuangP, et al. Neurol [19], Baik etal. CerebrovascDis [20], YamashitaE, etal,ActaRadiol [21].

The PVS had a positive predictive rate of 87% and a negative predictive rate of 100%.

PVS might reflect not only veins but also small arteries with deoxyhemoglobin blood in the penumbra area. Consistent with previous SWI studies , our study of 22 patients showed PVS in 15, microbleed in 6, and intra-arterial thrombus in 9. A lower microbleed rate would be expected, with parenchymal hemorrhage used as an exclusion criterion.

Only two patients (25%) with infarct growth in the lentiform nucleus, internal capsule, or caudate nucleus had PVS, which can be explained by the admixed venous flow in the thalamostriate vein, which drains not only these structures, but also the thalamus

Good spatial correlation between infarct growth and the extent of PVS was also observed. Of 57 zones of infarct growth, all 46 in the insula or M1–M6 zones of the MCA territory matched the extent of PVS, consistent with previous reports that PVS on SWI can predict stroke evolution and spatially correlate with DWI/PWI mismatch.

In Baik's study, clinical outcome improved with the apparent normalization of PVSs in veins after successful recanalization. One case report [22] in the literature described that SWI iso- or hyperintensity of the draining veins might suggest hyperperfusion,which contributed further to an increased risk of developing post-ischemic malignant edema [23-25]. In our study, given that the extent of PVS indicates the extent of penumbra, that patients with more extensive PVS can be expected to have a larger volume of salvageable tissue to be rescued.

- Limitations:

– small patient number.

– did not include performing PWI or arterial spin labeling

– Patients with the worst clinical outcomes or who died were not recruited

– Bias in interpreting the images was possible, because PVS in this study was defined by observation and comparison rather than objective measurement of vessel number or diameter. Using ASPECTS for PVS semiquantification is arguable [26].

– Quantitative susceptibility mapping is a development of SWI that utilizes phase data to obtain information on local susceptibility [27-30]

– Future directions:

It may in future be possible to provide fully quantitative and noninvasive information on oxygen metabolism

Conclusions

Venous congestion seen in infarcted territory is related to poor prognosis and this can be reliably used as a surrogate marker of oxygen extraction in pneumbra.

SWI can predict tissue at risk and can be a replacement for perfusion scan in clinical scenerio of acute ischaemic infarct.

MRI stroke protocol can be a one stop shop with initial first day DWI-SWI sequences to detect core and pneumbra with multiple co-morbids and in settings were reperfusion is planned.

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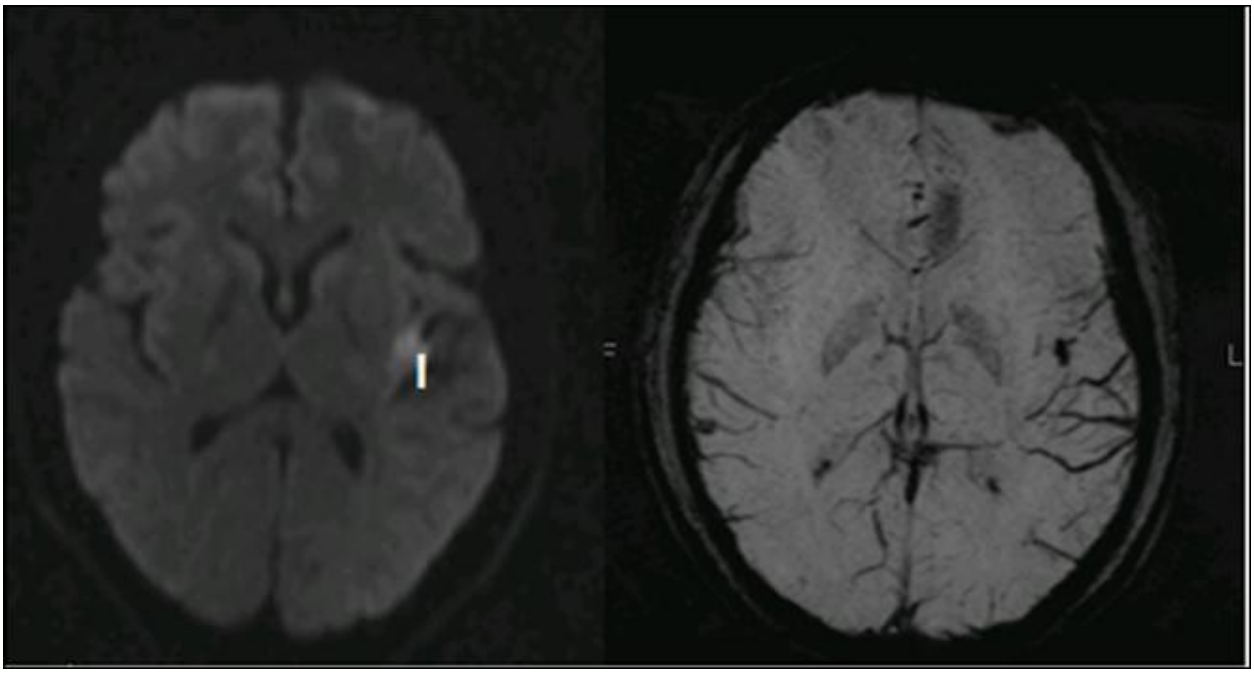

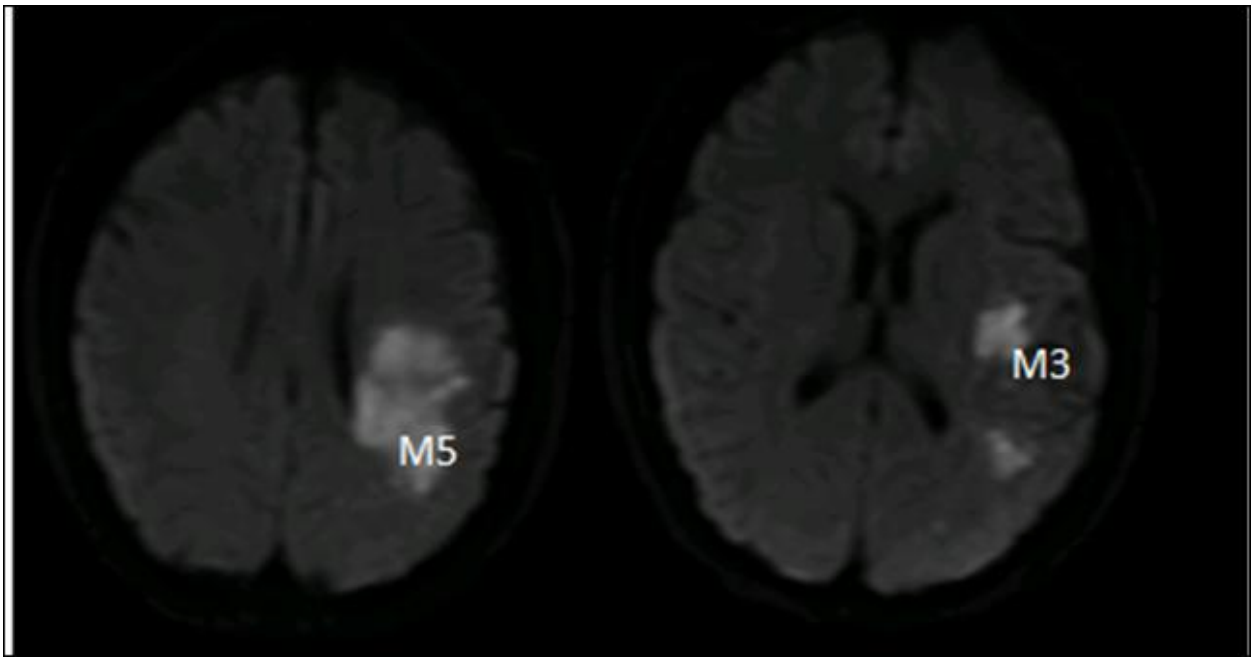

A 63-year-old woman had a diagnosis of LEFT middle cerebral artery territory infarct.

Susceptibility-weighted imaging revealsprominent hypointense cortical and medullary vessels diffusely seen in the insula and M1to M6 zones of the left

Middle cerebral artery territory. Engorged deep veins and thalamostriate artery over the lesions compared with the healthy side were also noted. Involved

M1to M6 zones and insula lost7 points and an engorged thalamostriate vein lost3 points. The prominent vessel sign score was 0 (10–7–3= 0).

Susceptibility-weighted imaging(C,D) at the basalganglia and suprabasal ganglion levels reveal prominent vessel signs in the cortical veins(arrows),
medullary veins(arrows)and thalamostriatevein (arrowhead).