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Original Article

Investigating the role of susceptibility weighted imaging for assessment of ischemic penumbra with respect to Venus blood flow in ischemic stroke patients

Saeid Sadeghi Joni[1], Reza Gerami[2], Negin Akhondi[3], Ali Etemadi[4], Mahnaz Fosouli[5], Aynaz Foroughi Eghbal[6]

[1]*Department of Radiology, Razi Hospital, Guilan University of Medical Sciences, Rasht, Iran;* [2]*Department of Radiology, Faculty of Medicine, AJA University of Medical Sciences, Tehran, Iran;* [3]*Department of Radiology, Shohadaye Tajrish Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran;* [4]*Faculty of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran;* [5]*Department of Radiology, Isfahan University of Medical Sciences, Isfahan, Iran;* [6]*School of Medicine, Urmia University of Medical Sciences, West Azarbaijan, Iran*

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Abstract: Introduction: Susceptibility weighted imaging can be used to study intracranial venous blood arteries based on the paramagnetic sensitivity of blood discharged by oxygen (SWI). Significant hypotensive drainage channels have been discovered in the ischemic tissue of the brain, which have been recognized by SWI. The compliance or non-compliance between the variation in venous drainage of ischemic brain tissue by SWI and diffusion limitation. Material and methods: This cross-sectional study was conducted in 2019 on 20 patients (15 men and 5 females) who were assigned to the Ghaem Hospital MRI Institute in Rasht, Iran. Results: Infarction has been detected in a total of 20 vascular regions. The caliber of the sulcal and intramedullary veins, on the other hand, was increased in 80 percent and 65 percent of the infarcted regions, respectively. In 45 percent of the vascular regions, a match between SWI and diffusion-weighted magnetic resonance imaging (DWI) was detected, mismatch was detected in two; follow-up revealed infarct progression. Conclusions: Significant data on critically perfused cerebral cortex with possibility of infarction growth was focused on in elevated SWI investigations, contributing to SWI as a worthy MR implies that could be attached as complementary protocols to neuroimaging techniques for acute ischemia, according to the findings of this study.

Keywords: SWI, brain ischemia, ischemic stroke

Introduction

When brain blood supply is considerably diminished, a stroke ensues [1]. If the stroke is caused by a blood clot, medication can help to lessen the damage to the brain [2].

In other words, if a section of the brain's supply of nutrients and oxygen is cut off, the neural function of the affected area will be impaired [3]. In addition, the damaged area's neurological function is harmed [4]. Blood flow abnormalities can also impact the arteries, despite the fact that they are most commonly seen in the arteries [5]. One of the most important tasks is to diagnose a stroke as soon as possible. Because it can cause nerve damage and possibly death in the short term [5].

The use of magnetic resonance imaging (MRI) is one of the most important and necessary procedures for preventing illness progression. The purpose of using this method is to help with accurate and timely diagnosis and follow-up of a medical issue. For stroke testing, T2W, T1W, diffusion-weighted magnetic resonance imaging (DWI), and FLAIR images are common [6]. However, these protocols are insufficient for identifying the Penumbra region, and further complementing contracts are required [7]. It has been shown that penumbra area cannot be determined using such images [8]. The perfusion-weighted imaging (PWI) sequence is presently the gold standard for determining the hemisphere's scope [9].

Although this approach offers distinct advantages, it has been limited in its use due to a variety of problems. 1. Invasion due to the use of intravenous contrast chemicals. 2. A lack of accessibility 3. Adding extra charges to the costs. 4. Restrictions on how this sequence should be performed in children and pregnant people. 5. Cases involving renal function issues or allergies [10].

Susceptibility weighted imaging (SWI) pictures have previously been shown to reveal the hemisphere (Penumbra) region [11]. Furthermore, the complementary SWI sequence has been shown to be beneficial in identifying ischemia for the following reasons: 1) The detection of hemorrhagic components in the infarction area to aid in the diagnosis of ischemia in stroke hemorrhage [12]. 2) An assessment of the risk of minor bleeding before starting thrombolytic treatment [13]. 3) Early identification of hemorrhagic complications after intra-arterial thrombolysis [14].

The goal of this study was to assess the use of magnetic behavioral imaging in assessing hemispheric venous flow in individuals with ischemic stroke. As a result, the following objectives were considered: 1. the severity of the venous signal in the infarct area vs. the intact region in the opposite hemisphere of the brain. 2. the number of brain veins in the infarct area and the intact region in the opposite brain hemisphere. 3. the miss-match between DWI and SWI by comparing the size of the infarct area in SWI and DWI images.

Methods and material

Study design

From March to July 2019, a cross-sectional study was done at the Ghaem Hospital MRI Center in Rasht, Iran. A random sample of people with stroke who were sent to the MRI division for diagnostic purposes and had a final diagnosis from a neurologist was taken. The Ethics Committee of Guilan University of Medical Sciences authorized the study protocol, which was given the code IR.GUMS. REC.1392.481.

The accessible sampling method was used in this investigation. Twenty patients over the age of 15 who had experienced a sudden onset of stroke symptoms in the acute phase, between 6 hours and 3 days, were chosen to provide samples.

Sample size calculation

The sample volume was measured to be 0.05 including the first type error, the second type error was 0.2 and the effect size was 0.35. The effect size was considered according to the similar articles and views of the researcher. The achieved sample size by employing the following formula was 23. In this research, we were capable to investigate 20 patients.

Inclusion criteria

We included patients with less than 72 hours from initiation of the signs, age more than 15 years, and signing the written informed consent by the patient or co-patient. Patients with the following criteria did not enter the study: having cardiac pacemaker, aneurysm clips, and an artificial heart valve in the body, having external objects such as shrapnel or pellets in the body and pregnancy.

Exclusion criteria

1. Initiation of medical treatments. 2. Hemorrhagic stroke. 3. Claustrophobia. 4. Lack of consent.

Then, after completing the MRI questionnaire, each patient received an explanation of the steps to be taken, how to test, and the study's goals so that they could work together consciously.

Data collection tools

The MRI device in this research was the 1.5 Tesla, OPTIMA 360 GE MRI system using a 16 channel HR brain coil.

Data collection

The method was as regards: The routine images of the brain, including the T1W FSE-XL, T2W FSE, and T2 FLAIR sequences, were first taken. Then, the DWI and SWI sequences were produced and PHASE inputs and MAGNITUDE were formed. The supplied images were prepared in multiple cases, and SWI multiple images were named as "MAGNITUDE" (ORIGINAL MAGNITUDE) of the HP FILTERED PHASE of images with SWI magnetic susceptivity and SWI min IP images were renovated. Images were investigated by two neuro RADIOLOGISTS and neurologists who have three years of experience in describing the SWI images.

The patient's position was supine and head first into the device.

Table 1. Chi square test results, the signal intensity of venous region in infarcts compared to the healthy region of the brain hemisphere

Region	Similar (0)	Less (1)	Much less (2)	Test statics	*p*-value
Sulcus	N=6	N=16	N=4	24.26	0.002
Interamedullari	N=8	N=15	N=3	21.26	0.001

Initial analysis of images

Following the evaluation of the required sequence, post-processing was carried out. Final SWI images were created after processing first and additional SWI images (IP, HPF, MAGNITUDE).

After that, a qualitative information analysis of minIP images was performed. The anterior cerebral artery, proximal and distal middle cerebral arteries, and posterior cerebral artery were all split into four vascular zones in each hemisphere of the brain. The extent and signal intensity of draining veins were compared in four SWI locations, and a comparable situation was matched in the opposite hemisphere. The signal intensity of the sulcal vein and intramedullary was scored as similar (0) less (1) is significantly less (2). Another evaluation was done on the veins' extent in contrast to the non-infarcted hemisphere. Similarly, the gradation was (0) somewhat broader (1) significantly wider (2). Additionally, pictures from DWI and SWI were compared.

The SWI images were split into three categories: the same size in both areas, less restricted diffusion than the hypointense signal veins area, and a bigger restricted diffusion region than the hypointense signal veins area. The next MRI test was used to establish the infarct's outcome.

Follow-up pictures of the SWI scan were used to assess brain diagnostic accuracy and perfusion in acute patients. The observations below were classified as necrosis tissue. The acute SWI and follow-up images' matching or non-matching is classified into three models: smaller hypointense region in SWI image compared to area of chronic ischemic changes in following, same size in two regions, and larger region of hypointense veins in acute SWI compared to areas of chronic ischemic changes in following images.

Statistical analysis

We inserted our data into the Statistical Package for Social Sciences (SPSS) (version 24, SPSS Inc., Chicago, IL). Chi-Square, Ratio and Wilcoxon tests were used for data analysis. *P*-value under 0.05 was considered significant.

Results

Study population

In this article, 20 patients were studied by gender. Five and 15 of the them were females and males respectively with an average age of 52.45±11.12 years. In addition, the average duration of MRI after stroke was 40.49±17.62 hours.

Vascular territories

The patients distribution according to vascular territories were involved on SWI images: Left Proximal middle cerebral artery (MCA) (30%) Left distal MCA (20%) left posterior cerebral artery (PCA) (15%), right. Distal MCA (5%) right PCA (5%) right Proximal MCA (15%) right distal MCA (10%).

The whole of 26 vascular regions was involved in SWI. The following results were observed: one vascular region was included in 15 cases (50%), four cases (30%) were diagnosed with two influenced areas and one (20%) residing case had infarction in 3 areas.

Signal intensity

Tables 1-3 indicate analysis of signal intensity and caliber of the intramedullary and sulcal veins within infarcted regions on minIP images. Based on these data, hypointense signals were observed among 80% (21.26) of the intramedullary and 92% (24.26) of the sulcal veins removing the infarcted areas.

Furthermore, increased caliber was observed in 88% (23.26) of the intramedullary and 92% (24.26) of the sulcal dragging vessels.

Table 2. Chi square test results, comparing the extent of the infarction area veins to the healthy region of the brain hemisphere

Region	Similar (0)	Less (1)	Much less (2)	Test statics	*p*-value
Sulcus	N=7	N=14	N=5	24.26	0.002
Interamedullari	N=6	N=17	N=3	23.26	0.001

Table 3. Ratio test results, verify the size of the infarct area in SWI and DWI images

SWI=DWI	SWI>DWI	*P*-Value
14 (53%)	12 (47%)	0.824

SWI: Susceptibility weighted imaging; DWI: diffusion-weighted magnetic resonance imaging.

Follow-up studies

Available follow-up studies involving the infarct area were available to 10 patients (50%). Compliance with chronic ischemic changes in all regions with primary hypertension. There was a venous signal on SWI images.

The present study showed differences in the intensity of the signal in the region of the infarcts in the two measured areas as the non-infarcted region of the cerebral hemisphere. In both measured parts with Sulcus and Intramedullary, the intensity of the venous signal infect regions was less than the healthy area of brain hemisphere, also the extent of the infarct veins region was much larger than the non-infarcted region of the hemisphere.

Discussion

While multimodal MRI is the preferred method for detecting PAIS early, fluid-attenuated (FLAIR) and T2-weighted MRI can detect acute infarction tissue within 24 to 24 hours of injury. The advantage of DWI is that ischemic lesions can be detected even sooner in newborns, within hours of main bleeding, and in older children, within minutes.

SWI is useful in ischemic strokes by: • Identifying constituents in the location to differentiate ischemic and hemorrhagic strokes [15]; • Guiding the use of PWI by displaying hypointense signals [16]; • Identifying occlusive arterial thromboembolism in its early stages [17]; • Measuring microbleeds to predict the risk of hemorrhagic transition and thrombolytic therapy sooner [18]; • After intra-arterial thrombolysis, identifying early hemorrhagic consequences [17].

Following a stroke, ischemia develops in the brain as a result of impaired oxygen metabolism due to the high demand for oxygen in brain tissue [19]. Despite efforts to compensate for the decline in arterial cerebrospinal fluid with oxygen, this state may temporarily sustain the area's oxygen metabolism [20]. This compensatory action, on the other hand, raises the deoxyhemoglobin to oxyhemoglobin ratio in veins, affecting perfusion. Doxyhemoglobin's paramagnetic activity causes a loss of signal or hypointensity in the SWI image, which is linked to tissue vein ischemia [21]. In this study, hypointense SWI signals were found in 80 percent (21.26) of intramedullary and 92 percent (24.26) of sulcal veins draining infarcted vascular areas in the current investigation. In addition, 88 percent (23.26) of the intramedullary and 92 percent (24.26) of the sulcal draining veins had increased caliber [22].

A mismatch like this, according to our view, could suggest brain tissue that is at danger of infarction. These patients were not given reperfusion therapy, and further neuroimaging demonstrated infarct development in the same location as the initial SWI anomaly. These findings [23-26] support the use of SWI. SWI/DWI mismatch, the researchers found, could indicate an ischemic penumbra and predict stroke progression [27].

To generate an estimate of the ischemia penumbra, the DWI/PWI mismatch was incorporated [28-33]. The use of the DWI/PWI mismatch aids in the selection of patients who may benefit from prompt reperfusion therapy.

Given that neuroimaging was performed on nearly all of our patients more than 6 hours after the beginning of symptoms, the DWI/SWI match was unsurprising. One could claim that the infarcted brain tissue at the time of neuroimaging was already infarcted [34].

Two vascular areas inside the ischemic region had hemorrhagic parts. SWI showed higher sensitivity for bleeding related to computed tomography (CT) and gradient-echo sequences [35].

We did a cross-sectional analysis of the documents of the patients here. The study's limitations were restricted study population and lack of prospective data in this filed. We suggest that more prospective studies should be conducted in this regard.

Conclusion

The region of Penumbra in patients with acute ischemia was examined in this study. The PWI image revealed information on the arterial blood supply flow in the affected area. The SWI scans, on the other hand, revealed more details about the injured venous location. This sequence can be used instead of the PWI sequence to determine the non-invasive Penumbra area in patients with a restriction for contrast agent injection, such as babies, nursing women, patients with acute renal difficulties, and persons with severe medication allergies. With an increase in stroke patients and a decrease in their ages, the area of penumbra may be seen rapidly without contaminating the infusion and can be beneficial to patients. With all of these advantages, SWI can be utilized as a complementary sequence in patients with ischemia.

Disclosure of conflict of interest

None.

Address correspondence to: Reza Gerami, Department of Radiology, Faculty of Medicine, AJA University of Medical Sciences, Tehran, Iran. Tel: +989121548869; E-mail: dr.m.meshkatii@gmail.com

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