

# **The Role of Susceptibility Weighted Imaging (SWI) in Evaluation of Acute Stroke**

Thesis

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

# قالوا

لَسْبَدَانِكَ لَا نَعْلَمُ لَنَا  
إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ  
الْعَلِيمُ الْعَظِيمُ

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# *List of Contents*

Title	Page No.
List of Tables .....	i
List of Figures .....	ii
List of Abbreviations .....	v
Introduction .....	1
Aim of the Work.....	3
Review of Literature	
📖 Anatomy of Cerebral Arterial Circulation.....	4
📖 Pathophysiology of Ischemic Stroke .....	38
📖 Physical Principles and Technical Aspects of Susceptibility Weighted MR Imaging.....	63
Patients and Methods .....	78
Results .....	84
Illustrative Cases .....	93
Discussion .....	105
Summary and Conclusion .....	114
References .....	116
Arabic Summary	

## *List of Tables*

Table No.	Title	Page No.
<b>Table (1):</b>	TOAST classification of ischemic stroke.....	40
<b>Table (2):</b>	Comparison between NIG group and IG group regarding the epidemiological data and studied parameters.....	86
<b>Table (3):</b>	Comparison between initial DWI aspects, SWI aspects and FUP aspects in the IG group .....	89
<b>Table (4):</b>	Comparison between initial DWI aspects, SWI aspects and FUP aspects in the NIG group .....	90
<b>Table (5):</b>	Correlation of the studied scores with each other in all patients .....	91

## *List of Figures*

Fig. No.	Title	Page No.
<b>Figure (1):</b>	3T MRA depicting the normal intracranial circulation with its anterior and posterior constituents .....	5
<b>Figure (2):</b>	The C3 (lacerum) ICA segment is a short segment that begins where the petrous carotid canal ends.....	9
<b>Figure (3):</b>	MRA is excellent for depicting the intracranial ICA.....	10
<b>Figure (4):</b>	Submentovertex view shows the relationship of the circle of Willis and its components to the cranial nerves.....	13
<b>Figure (5):</b>	Submentovertex view from 3D TOF MRA shows the right internal carotid artery and its branches.....	14
<b>Figure (6):</b>	The middle cerebral artery (MCA) and its relationship to adjacent structures is depicted on these graphics.....	19
<b>Figure (7):</b>	Three views of 3T MR angiogram are shown from top to bottom. Lateral view is shown on top .....	20
<b>Figure (8):</b>	Typical vascular territories of the three major cerebral arteries are depicted .....	23
<b>Figure (9):</b>	The three major cerebral artery territories fit together like a jigsaw puzzle as they supply the hemispheres.....	24
<b>Figure (10):</b>	Cerebral arterial collateral circulation .....	26
<b>Figure (11):</b>	Schematic rendering of the circle of Willis (COW).....	29

## *List of Figures (Cont...)*

Fig. No.	Title	Page No.
<b>Figure (12):</b>	Anastomoses between ACA and MCA.....	33
<b>Figure (13):</b>	Anastomoses between MCA and PCA.....	33
<b>Figure (14):</b>	Anastomoses between ACA and PCA.....	34
<b>Figure (15):</b>	Anastomoses between ACAs.....	34
<b>Figure (16):</b>	PCA-MCA convexity (leptomeningeal) collaterals.....	34
<b>Figure (17):</b>	A relatively frequent venue of PCA-ACA collateralization, whereby the distal pericalossal artery connects with the posterior pericalossal branch of the PCA. ....	35
<b>Figure (18):</b>	Color overlays on axial T2-weighted magnetic resonance (MR) images of normal cerebrum .....	37
<b>Figure (19):</b>	A schema of the concentric, four- compartment, brain ischemia model .....	48
<b>Figure (20):</b>	Schematic graphs representing the dynamic change of the various hemodynamic or metabolic parameters during the ischemic process of the brain .....	53
<b>Figure (21):</b>	Alberta Stroke Program Early Computed Tomography Score template on non- contrast CT with 10 regions distributed over the MCA territory in ganglionic and supraganglionic levels.....	59
<b>Figure (22):</b>	Shows that as water photons diffuse across magnetically non uniform regions, they lose phase coherence which decreases the signal.....	65

## *List of Figures (Cont...)*

Fig. No.	Title	Page No.
<b>Figure (23):</b>	Magnetic susceptibility .....	67
<b>Figure (24):</b>	Post processing steps.....	74
<b>Figure (25):</b>	Data sets generated during the scan.....	75
<b>Figure (26):</b>	Bar chart showing the mean age of the studied groups. ....	87
<b>Figure (27):</b>	Bar chart showing Gender distribution among the two studied groups. ....	87
<b>Figure (28):</b>	Bar chart showing Infarct side among the two studied groups.....	88
<b>Figure (29):</b>	Bar chart showing Comparison between NIG and IG groups regarding follow up time. ....	88
<b>Figure (30):</b>	Bar chart showing mismatch among the two studied groups.....	89
<b>Figure (31):</b>	Box plot showing comparison between NIG and IG groups regarding initial DWI aspects, SWI aspects and FUP aspects.....	90
<b>Figure (32):</b>	Correlation between initial DWI aspects and FUP aspects. ....	92
<b>Figure (33):</b>	Correlation between SWI aspects and FUP aspects. ....	92
<b>Figure (34):</b>	Case 1.....	95
<b>Figure (35):</b>	Case 2.....	97
<b>Figure (36):</b>	Case 3.....	100
<b>Figure (37):</b>	Case 4.....	101
<b>Figure (38):</b>	Case 5.....	104



## *List of Abbreviations*

<b>Abb.</b>	<b>Full term</b>
<i>ACA</i> .....	<i>Anterior Cerebral Artery</i>
<i>ACoA</i> .....	<i>Anterior Communicating Artery</i>
<i>ACOM</i> .....	<i>Anterior Communicating Artery</i>
<i>AICA</i> .....	<i>Anteriorinferior Cerebellar Artery</i>
<i>AIS</i> .....	<i>Acute Ischemic Stroke</i>
<i>AMPA</i> .....	<i>Amino-3-hydroxy-5-methyl-4-propionate</i>
<i>ASPECTS</i> .....	<i>Alberta Stroke Programme early CT Score</i>
<i>ATP</i> .....	<i>Adenine Triphosphate</i>
<i>BA</i> .....	<i>Basilar Artery</i>
<i>BBB</i> .....	<i>Blood Brain Barrier</i>
<i>BOLD</i> .....	<i>Blood Oxygenation Level-Dependent</i>
<i>Ca<sup>2+</sup></i> .....	<i>Calcium</i>
<i>CBV</i> .....	<i>Cerebral Blood Volume</i>
<i>Cl<sup>-</sup></i> .....	<i>Chloride</i>
<i>CMRO<sub>2</sub></i> .....	<i>Cerebral Metabolic Rate of Oxygen</i>
<i>CPP</i> .....	<i>Cerebral Perfusion Pressure</i>
<i>CT</i> .....	<i>Computed Tomography</i>
<i>DWI</i> .....	<i>Diffusion Weighted Imaging</i>
<i>ECA</i> .....	<i>External Carotid Artery</i>
<i>EVT</i> .....	<i>Endovascular Treatment</i>
<i>FI</i> .....	<i>Final Infarct</i>
<i>FUP</i> .....	<i>Follow Up</i>
<i>HRBV</i> .....	<i>High-Resolution Blood Oxygen Level Dependent Venography'</i>
<i>ICA</i> .....	<i>Internal Carotid Artery</i>
<i>IG</i> .....	<i>Infarct Growth</i>
<i>IJV</i> .....	<i>Internal Jugular Vein</i>
<i>ILT</i> .....	<i>Inferolateral Trunk</i>
<i>IQR</i> .....	<i>Inter-Quartile Range</i>

## *List of Abbreviations (Cont...)*

Abb.	Full term
<i>IVT</i> .....	<i>Intravascular Thrombolysis</i>
<i>K+</i> .....	<i>Potassium</i>
<i>LMA</i> .....	<i>Leptomeningeal Anastomoses</i>
<i>LMC</i> .....	<i>Leptomeningeal Collateral</i>
<i>MCA</i> .....	<i>Middle Cerebral Artery</i>
<i>mIPs</i> .....	<i>Minimum Intensity Projections</i>
<i>MMA</i> .....	<i>Middle Meningeal Artery</i>
<i>MR</i> .....	<i>Magnetic Resonance</i>
<i>MRI</i> .....	<i>Magnetic Resonance Imaging</i>
<i>MTT</i> .....	<i>Mean Transit Time</i>
<i>Na</i> .....	<i>Sodium</i>
<i>NIG</i> .....	<i>Non-Infarct Growth</i>
<i>NMDA</i> .....	<i>N-methyl-d-aspartate</i>
<i>OEF</i> .....	<i>Oxygen Extraction Fraction</i>
<i>PCA</i> .....	<i>Posterior Cerebral Artery</i>
<i>PCoA</i> .....	<i>Posterior Communicating Artery</i>
<i>PCV</i> .....	<i>Prominent Cortical Veins</i>
<i>PICA</i> .....	<i>Posterior Inferior Cerebellar Artery</i>
<i>PWI</i> .....	<i>Perfusion Weighted Imaging</i>
<i>SCA</i> .....	<i>Superior Cerebellar Artery</i>
<i>SPSS</i> .....	<i>Statistical Package for Social Science</i>
<i>SWI</i> .....	<i>Susceptibility Weighted Imaging</i>
<i>VA</i> .....	<i>Vertebral Arteries</i>

## **Abstract**

**Background and Purpose:** SWI provides information about blood oxygenation levels in intracranial vessels. Prior reports have shown that SWI focusing on venous drainage can provide noninvasive information about the degree of brain perfusion in arterial ischemic stroke. We aimed to evaluate the influence of the SWI venous signal pattern in predicting stroke evolution.

**Materials and Methods:** A semiquantitative analysis of venous signal intensity on SWI and diffusion characteristics on DTI was performed in 20 adult patients with acute stroke of MCA vascular territories. The mismatch between areas with SWI-hypointense venous signal and restricted diffusion was correlated with stroke progression on follow-up.

**Results:** We included 20 patients with a confirmed diagnosis of arterial ischemic stroke. Follow-up images were available for. MCA stroke progression on follow-up was observed in 11/20 patient with DWI-SWI mismatch. Initial SWI hypointense venous signal and areas of restricted diffusion on DTI. This mismatch showed a statistically significant association ( $P = 0.00188$ ) for infarct progression.

**Conclusion:** SWI-DWI mismatch predicts stroke progression in arterial ischemic stroke.

**Keywords:** stroke, MRI, Susceptibility weighted imaging (SWI), (PWI), DWI.

# INTRODUCTION

Stroke is caused by the interruption of the blood supply to the brain, usually because a blood vessel bursts or is blocked by a clot. This cuts off the supply of oxygen and nutrients, causing damage to the brain tissue (*Cho et al., 2012*).

The effects of a stroke depend on which part of the brain is injured and how severely it is affected. A very severe stroke can cause sudden death, so predicting the risk of further infarct growth in stroke patients is critical to therapeutic decision making (*Davis et al., 2005*).

Contemporary therapy for acute ischemic stroke is based on the concept of penumbra, which is an area with reduced blood flow but not to such a level that causes irreversible cell membrane failure. Although challenged by several limitations, mismatch between larger abnormal areas on MR perfusion-weighted imaging (PWI) and smaller restricted areas on diffusion-weighted imaging (DWI) is a widely accepted approach to detecting penumbra, predicting stroke evolution and determining patients with the greatest potential to benefit from thrombolytic therapy. However, PWI requires administration of a contrast agent, which is contraindicated in a variety of clinical conditions, such as renal insufficiency and previous reactions to contrast agents (*Haacke et al., 2004*).

Susceptibility-weighted imaging (SWI) which is a high-resolution, three-dimensional, gradient-echo T2\* MR technique with enhanced sensitivity for paramagnetic substances is a potential alternative for detecting ischemic penumbra and thus 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. As a result, SWI can show asymmetric prominent hypointense vessels potentially from different concentrations of deoxyhemoglobin between ischemic and normal brain areas. This potential metabolic information on SWI may help to delineate penumbra without contrast agent administration (*Tsui et al., 2009*).

Recently, a study on pediatric arterial ischemic stroke has reported that SWI/DWI mismatch is useful in detecting penumbra in middle cerebral artery (MCA) infarct, thus predicting progression of infarction on follow-up images (*Moeded et al., 2014*).

## **AIM OF THE WORK**

This study aims to assess the diagnostic value of SWI-DWI mismatch in detecting ischemic penumbra, and predicting early infarct growth in patients with acute MCA territory ischemic stroke.

## Chapter 1

# ANATOMY OF CEREBRAL ARTERIAL CIRCULATION

The brain is rich in blood supply, with a densely branching arterial network. It is supplied by two circulations (**Fig. 1**).

### Anterior Circulation

- Internal carotid artery (ICA) and its branches as well as the anterior communicating artery (ACoA) and the posterior communicating artery (PCoA).

### Posterior Circulation

- Basilar artery (BA) and its branches (*Harnsberger et al., 2006*).

As this thesis discusses middle cerebral artery infarctions, this discussion will focus mainly on the anterior circulation, with a brief description of the posterior circulation.