Section: Radio-Diagnosis

Original Research Article

ROLE OF ARTERIAL SPIN LABELLING (ASL) AND DIFFUSION WEIGHTED IMAGING (DWI) IN EVALUATON OF PENUMBRA IN STROKE PATIENTS

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Received *: 08/07/2026*
Received in revised form *: 06/08/2026*
Accepted *: 18/08/2026*

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DOI: 10.70034/ijmedph.2026.3.707

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (3); 4581-4585

ABSTRACT

Background: Acute ischemic stroke is a major cause of mortality and long-term disability worldwide. Early identification of the ischemic penumbra—the hypoperfused but potentially salvageable brain tissue—is crucial for selecting patients who may benefit from reperfusion therapy. Diffusion Weighted Imaging (DWI) accurately identifies the infarct core, while Arterial Spin Labelling (ASL), a non-contrast MRI perfusion technique, assesses cerebral blood flow. The mismatch between ASL perfusion defects and DWI abnormalities serves as an indicator of ischemic penumbra and can guide timely therapeutic interventions. **Aim**: To evaluate the role of Arterial Spin Labelling (ASL) and Diffusion Weighted Imaging (DWI) in evaluation of penumbra in stroke patients

Materials and Methods: It was a cross-sectional, observational study. The current study was conducted in the department of Radiology, NRI Medical College, Chinnakakani, Andhra Pradesh, India during the period from 18 months from October 2020 – April 2022. After getting approval from the Institutional Ethics Committee, stroke patients who got referred from emergency medicine and neurology departments were taken as a study sample.

Results: The current study included 142 patients with ischemic stroke. Most of the patients were aged 69-78 years. Only 41% of patients were females. 68% patients had hypertension. 54% patients were diabetics and 49% were found hyperlipidemias. Most of the patients were found to be involved MCA in 90 patients (63%). DWI-ASL PWI mismatch was found in 92 patients (64%)/. The DWI-ASL PWI mismatch was found even at late presentation at 110hrs of duration. NIHSS and CBF correlation was found with r=-0.5728, P value of <0.00001(P=<0.05 Significant).

Conclusion: DWI has a vital role in accurate localization of the stroke lesions than clinical consideration. Using advanced imaging techniques like ASL-PWI one can reliably obtain important early information about pathophysiology and morphology of a potentially reversible ischemic lesion of brain tissue, simultaneously quantify the brain tissue in terms of CBF (ml/g/min), and provides a predictable insight outcome. This combination represents a valuable alternative to contrast-based perfusion imaging in routine clinical practice.

Keywords: DWI, ASL, Ischemic stroke, NIHSS, CBF.

INTRODUCTION

Ischemic stroke is one of the leading cause of disability and death in world wide. Morbidity, mortality and disability rates of acute ischemic stroke remain high despite the existence of numerous significant achievements in treatment and prevention of stroke. Promotion of appropriate and

timely approach to patient treatment is recommended as one of the potential solutions for this problem. There have been many functional studies to analyse the hemodynamic changes and in understanding the pathophysiology of the brain to ischemia, including xenon-Computed Tomography, positron emission tomography(PET), and single photon emission computed tomography(SPECT)1. However clinical application of these modalities is impossible due the limitations.[1-4]

With the advent of CT technologies like multi-detector row CT(MDCT) has enabled clinicians to identify the vascular and perfusion status within an short imaging time however pitfalls in imaging, MRI is more convenient and reliable modality which provides information on the extent of ischemic injury and the status of perfusion.[5,6,7]

Recent advances in MR imaging techniques like dynamic susceptibility contrast-enhanced perfusion weighted imaging (DSC PWI) and non contrast techniques like arterial spin labelling (ASL) assessment of ischemic process and identification of penumbra is made possible. By definition ischemic penumbra is an area of hypoperfusion without restricted diffusion.[8] The current study was carried out at NRI medical college and general hospital, chinnakakani. It is a tertiary care centre with 1,100 beds and equipped with all imaging techniques. All facilities were available in the Department of Radiodiagnosis to assess the parameters mentioned in this study. The Investigator of this study was well qualified to conduct the study. In the study period of 18 months, around 300-400 stroke patients were referred to the radiology department for MR imaging. From this patient pool, patients were recruited as per the study selection criteria and sample size estimation. Adequate facilities were available in hospital to carry out all necessary laboratory tests required for the study. Medical and Surgical Intensive Care Units (ICU) were available at our tertiary care centre to deal with any emergencies arising among the study participants during the study tenure.

Aim and Objectives

Aim

To evaluate the role of Arterial Spin Labelling (ASL) and Diffusion Weighted Imaging (DWI) in evaluation of penumbra in stroke patients

Objectives

1. Evaluate DWI sequence
2. Evaluate ASL sequence
3. Study the perfusion-diffusion mismatch between ASL and SWI sequences.

MATERIALS AND METHODS

The current study was conducted in the department of Radiology, NRI Medical College, Chinnakakani, Andhra Pradesh, India.

Study period:18 months from October 2020 – April 2022.

Type of study: Cross-sectional, observational study. The study is observational, as no intervention in the form of any therapy was given to any study patients, as a part of the study. The study participant's environment was not changed, as a part of the study-so the study is observational study. Patient's data was collected at a single point of time without forward or backward follow up so the study is a cross-sectional study.

Source of data

After getting approval from the Institutional Ethics Committee, stroke patients who got referred from emergency medicine and neurology departments were taken as a study sample.

Sampling procedure

Convenience Sampling

Convenience sampling is also called grab sampling or accidental sampling, or opportunity sampling.

50 is the minimum sample size.

So, we included 142 patients in the current study.

All 142 patients provided consent for the study.

Inclusion Criteria

1. Stroke patients of less than 5 days duration
2. Stoke patients with age group of 18-80 yrs
3. Patient / patients attenders who given consent

Exclusion Criteria

1. Patients who present with seizure
2. Patients who present with intracranial tumours
3. Patients who present with intracranial haemorrhages
4. Patient who have metallic implants
5. Patients who have pacemakers
6. Patients who have aneurysm clips

Methodology

- ✓ After getting approval from the institutional ethics committee, this study was conducted.
- ✓ Assurance was provided regarding the maintenance of confidentiality.
- ✓ Thorough history was taken from every patient's attendant.
- ✓ Personal and family histories were elicited.
- ✓ Demographics like age and gender were recorded.
- ✓ MRI findings were noted.
- ✓ Data was entered in a case record form designed for the study and it was subjected to statistical analysis.

Material used:

MRI was done using 1.5 Tesla Signa Explorer system. (GE) with a 16-channel neurovascular coil.

Mr safety:

Exclusive MRI screening was done, that is all the patients were screened with metal detector before the procedure to avoid complications due to any implants. Possible contra indications were checked. Metallic jewels, makeup, eyeliner and Kajal were removed before the MRI examination. All the patients were informed that an increase in body temperature, blood pressure, or heart rate could occur.

Patient preparation

- Patients were asked to change to the hospital gown and written consent was obtained.
- Mandatory safety precautions during MRI examinations were followed.
- Patients were informed about the procedure, length of the scan, and any potential side effects prior to the examination to alleviate their fears.

Patient Positioning

Position: Supine

Orientation: Head First

Coil**:** Neurovascular coil

The study included 142 patients with age group of 18-80 yrs fulfilling clinical criteria of Acute ischemic stroke referred to radiology department. All the patients within symptoms duration not more than 5 days, were included in the study. Brain MR Imaging was performed on a 1.5T MRI (GE) with a 16 channel neurovascular coil. The protocol included routine DWI, FLAIR, SWI, 3D ASL, and 3D TOF.

Selection of Protocol

MRI stroke protocol for imaging of brain was selected from protocol library.

Imaging Sequences

- Localiser
- Axial DWI, T2, T1, FLAIR, SWI
- 3D TOF (Neck and Intracranial vessels)
- 3D ASL

Statistical Analysis

The data collected was entered in MS Excel 2019 and analysis was carried out using Microsoft excel and statistical software called Epi info version 7.2.5. The results were expressed in the form of descriptive and inferential statistics. P value <0.05, was considered statistically significant.

Ethical considerations:

The permission from the Institutional ethical committee attached to NRI medical college, Chinnakakani was taken before conducting the study. Every patient was explained the whole process and advantages of availing their data for the study.

The patients were also told that their information will be kept confidential. After he/she accepts, an informed consent form was given in the local language or understandable language and the person was asked to sign it or put a thumb impression. They were assured that their doubts if any to be clarified at any time.

RESULTS

A total of 142 stroke patients were considered and included in the study. It was observed that mean age of occurrence 61.5yrs ± 14.8; median 64 (IQR-20). Most of the patients were aged 69-78 years. 2% patients were aged 19-28 years, 5.6% were aged 29-38years, 11.9% were aged 39-48 years, 14% were aged 49-58 years, 25% were aged 59-78 years and 9% were aged 79-88 years of age group.

Age distribution

Table 1: Age distribution of patients

Age group	Frequency	Percent	Cum. Percent
19-28	4	2%	2.80%
29-38	8	5.60%	8.40%
39-48	17	11.90%	20%
49-58	20	14%	34%
59-68	36	25%	59%
69-78	44	30%	90%
79-88	13	9%	100%
	142		

Gender distribution

Male predominance was found in 83 patients (59%) and 59 (41%) were female.

Table 2: Gender distribution of patients

SEX	Frequency	Percent	Cum. Percent
Female	59	41%	41%
Male	83	59%	100.00%
Total	142	100.00%	100.00%

Comorbidities among patients

Table 3: Comorbidities among patients

Comorbidities	Frequency	Percent
RHD	0	0%
MIGRAINE	8	5%
HYPERLIPIDEMIA	70	49%
DM	77	54%
HTN	97	68%

It was observed that 68% of patients were hypertensive, 54% were diabetics, 49% were hyperlipidemia, and very few were found to be due to migraine (5%).

Distribution of site of occlusion

With the application of 3D TOF angiogram localisation of occlusion site was made out. MCA was found in 90 (63%) patients, ICA in 34 (24%) patients, PCA in 11(8%) patients, ACA in 4(3%) patients, vertebral and Basilar arteries are seen in <1% of patients.

Table:4 Distribution of site of occlusion

Site of occlusion	Frequency	Percent	Cumulative percent
MCA	90	63.3	63.3
ICA	34	2.39	87.3
ACA	4	2.8	90.1
PCA	11	7.7	97.8
BASILAR ARTERY	1	0.7	98.5
VERTEBRAL ARTERY	2	1.4	1

Qualitative assessment of Diffusion-Perfusion Mismatch

With the advent application of 3DASL sequence on pCASL technique, tissue perfusion was quantified with CBF in m/100g/min. It was categorized into, ischemic core, oligemia, and ischemic penumbra. Qualitatively we assessed the volume of infarct in DWI and compared the area of hypo perfusion with PWI on 3D ASL color maps. The areas of hypo perfusion were found in a larger volume than the infarcted areas involved in DWI; i.e., Diffusion-Perfusion mismatch was seen in 92 (64%) patients.

The mismatch was found in patients who presented even at 110hrs duration, 14 patients (15%) were found a mismatch in >48hrs, 11 in 24-48hrs (11%), 22 in 8-24hrs (23%), 14 in 6-8hrs (15%), 9 in 4.5-hrs (9%) and 23 in 0-4.5hrs (25%).

Correlation of NIHSS score with CBF On correlation of NIHSS score at the time of imaging with CBF values (ml/g/min) correlation coefficient r= -0.5728, P value of <0.00001 (P=<0.05 significant).

DISCUSSION

This study was a cross-sectional, observative study conducted at NRI Medical College & General Hospital, Chinnakakani- a tertiary care centre with well-equipped facilities.

The study was conducted for 24 months from October 2020 – October 2022. Patients aged above 18 years with stroke, who signed ICF were included. Patients with incomplete data, ahistory of claustrophobia, cardiac pacemakers, prosthetic heart valves, cochlear implants, or any metallic implants were excluded.142 patients were included as per the sample size.

Age, gender, comorbidities, NIHSS score, qualitative assessment of DWI-PWI mismatch, quantitative assessment of involved segment with CBF, and occlusion site, were assessed for all patients. Numerical parameters were assessed using Mean and SD. Statistical tests were done using epi info software, Microsoft excel 2019.

Comparison of parameters

Age, gender, comorbidities, NIHSS score, DWI-PWI Mismatch, Occlusion site.

Most of the patients were aged 69-78years. 2% patients were aged 19-28years, 5.6% were aged 29-38years, 11.9% were aged 39-48years, 14% were aged 49-58yeras, 25% were aged 59-78years and 9% were aged 79-88years of age group. Only 41% were females. 59% were males.

Comorbidities among patients: It was observed that 68% of patients were hypertensive, 54% were diabetics, 49% were hyperlipidaemia, and very few were found to be due to migraine (5%).

With the application of 3D TOF angiogram localisation of occlusion site was made out. MCA was found in 90 (63%) patients, ICA in 34 (24%) patients, PCA in 11(8%) patients, ACA in 4(3%) patients, vertebral and basilar arteries are seen in <1% of patients. The typical signs and symptoms of posterior circulation stroke are less commonly seen, and it is difficult to differentiate from anterior circulation stroke. Neuroimaging role is vital in localisation of stroke accurately[9].

With the advent application of 3DASL sequence on pCASL technique, tissue perfusion was quantified with CBF in m/100g/min. It was categorised into, ischemic core, oligemia and ischemic penumbra. Qualitatively we assessed the volume of infarct in DWI and compared the area of hypo perfusion with PWI on 3D ASL colour maps. The areas of hypo perfusion wasfound in larger volume than the infarcted areas involved in DWI; i.e., Diffusion-Perfusion mismatch seen in 92 (64%) patients.

The mismatch was found in patients who presented even at 110hrs duration, 14 patients (15%) were found mismatch in >48hrs, 11 in 24-48hrs (11%), 22 in 8-24hrs (23%), 14 in 6-8hrs (15%), 9 in 4.5-hrs (9%) and 23 in 0-4.5hrs (25%). On correlation of NIHSS score at the time of imaging with CBF values (ml/g/min) correlation coefficient r= -0.5728, P value of <0.00001 (P=<0.05 significant).

Greg Zaharchuket, al,[10] retrospective study was done on 51 patients, they Stated 77% of cases were found mismatch on ASL PWI with DWI. Comparison study between ASL-DWI and PWI-DWI mismatch was done with the diagnostic accuracy of 57%.

IngerHavsteenet, al,[11] did a prospective cohort study on 116 patients found, 43% were females, median age of 65years, 79(53%) patients were positive for DWI, 68(46%) patients were ASL positive, both positive in 47(32%) patients, ASL

positive and DWI negative in 21(14%) patients. They confirmed with both the combinations of diffusion and ASL perfusion identifies more lesions than either sequence alone from 40% up to near 60% of patients.

In the study Andrew Bivard et.al,[12] ASL-CBF threshold of 40% showed the highest area under the curve for penumbra identification (AUC 0.76, 95% CI, 0.63-0.85) and found to be accurate in compared with PWI Tmax +6seconds penumbral threshold (AUC 0.79, 95% CI, 73-84) and CTP-Tmax 5.5 seconds penumbral threshold (AUC 0.77, 95% CI, 72-84). Using a perfusion-to-diffusion mismatch ratio of 1.8:1, an ASL-CBF 40% mismatch compared with PWI-Tmax+6 seconds DWI and CTP mismatch showed good SN (0.81) and specificity (0.71).

Limitations of ASL- PWI technique:

As of now, ASL is not as commonly used like CT Perfusion imaging, mainly due to long acquisition time and limitations in spatial and temporal resolution. In order to overcome these challenges.

CONCLUSION

DWI has a vital role in accurate localization of the stroke lesions than clinical consideration. Using advanced imaging techniques like ASL-PWI one can reliably obtain important early information about pathophysiology and morphology of a potentially reversible ischemic lesion of brain tissue, simultaneously quantify the brain tissue in terms of CBF (ml/g/min), and provides a predictable insight outcome.

The study is self-sponsored.

There were no conflicts of interest

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