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# Arterial Spin Labelling Mri For Perfusion Assessment Of Acute Ischemic Stroke And Post-Thrombolysis Recanalization Assessment After 24 Hours

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## 1. INTRODUCTION

- Ischemic stroke is caused by the interruption of blood flow to a part of the brain, leading to tissue infarction. This results in neurological deficits due to the lack of oxygen and nutrients in the affected brain tissue. Stroke is a major cause of mortality and morbidity worldwide.
- Acute Ischemic stroke is within 24 hours of symptom onset. In acute stroke it is no longer sufficient to detect simply ischemia, but also to try to evaluate reperfusion/recanalization status and predict eventual hemorrhagic transformation.
- MRI is best imaging modality to detect the ischemic brain tissue and evaluate the tissue vulnerable for infarction. Perfusion imaging identifies brain tissue that has reduced blood flow, the potential target for reperfusion therapies.
- Diffusion-Weighted Imaging (DWI): is one of the most common MRI techniques used in acute stroke. It is very sensitive in detecting areas of acute ischemia, particularly the core of severe ischemia (irreversible damage) and does not fully capture the ischemic penumbra, the area surrounding the infarct that is still viable but at risk of progressing to infarction if not re-perfused.
- Perfusion Imaging: This is used to assess blood flow to different parts of the brain. It identifies areas with reduced blood flow that might benefit from reperfusion therapies. Perfusion imaging can help detect the ischemic penumbra and is often used in combination with DWI to guide treatment decisions.
- The most important component of the imaging is to determine the penumbra, one of the working definitions of penumbra is brain tissue that is ischemic but not yet infarcted and is at risk of further damage unless the flow is rapidly restored. Hence perfusion - diffusion mismatch gives a realistic target for potential intervention
- Arterial spin labeling (ASL) is a non-ionizing and completely non-invasive MRI technique for measuring tissue perfusion (blood flow), which uses magnetically labeled arterial blood water protons as an endogenous tracer. These benefits make ASL very suitable for perfusion studies in healthy individuals, patients with renal insufficiency and those who need repetitive follow-ups. It is also an impressive method for studying perfusion in pediatric populations in which the use of radioactive tracers or exogenous contrasts agents may be restricted
- The perfusion contrast is given by the difference in magnetization induced by the exchange of these labelled spins at the brain tissue level and a non-labelled control image. Echo plan imaging is used for acquisition of ASL because of its high signal to noise ratio.
- When early arterial re-canalisation occurs after intravenous thrombolysis, focal zones of hyperperfusion, termed luxury perfusion, correspond to the initial hypoperfusion zone and are associated with improved functional outcome at 24 hours.

## 2. OBJECTIVES

1. **To detect Perfusion mismatch**: Identifying the difference between irreversibly damaged tissue and salvageable tissue.
2. **To detect Ischemic penumbra**: Detecting areas of the brain that are at risk of infarction but may still recover with timely intervention.
3. **To detect Luxury perfusion**: Identifying areas with excessive blood flow that may indicate neurovascular dysfunction or maladaptive compensatory mechanisms.

By achieving these objectives, ASL provides critical information for decision-making in acute stroke management and for assessing other conditions related to brain perfusion

## 3. MATERIALS & METHODS

- **Study Design:** Hospital-based observational study.
- **Duration:** 1.5 years.
- **Setting:** KIMS& RF , AMALAPURAM.

**Study Sample:**

- **Inclusion Criteria:**
  1. All patients who presented to the Department of Radiodiagnosis during the study period and were referred for MRI assessment.
  2. Patients who presented within 6 hours of symptom onset and were diagnosed with stroke.
- **Exclusion criteria:**
  1. Patients with ischemic stroke who come to hospital after 24 hours of onset of symptoms.
  2. Patients with hemorrhagic stroke.
- **Study Population:** Patients who underwent MRI stroke protocol (DWI, FLAIR, and ASL sequences) both before and after thrombolysis.

**Methodology:**

1. **Patient Selection:**

   o Inclusion of patients presenting within 6 hours of the onset of symptoms (within the therapeutic window for thrombolysis).

   o MRI stroke protocol sequences (DWI, FLAIR, and ASL) were performed on these patients at both pre- and post-thrombolysis stages to assess the effect of treatment.

2. **MRI Protocols:**

   o **DWI (Diffusion Weighted Imaging):** To detect early ischemic changes and assess tissue viability.

   o **FLAIR (Fluid Attenuated Inversion Recovery):** To visualize acute infarction and differentiate between ischemic and hemorrhagic strokes. o **ASL (Arterial Spin Labelling):** To evaluate cerebral blood flow (CBF), particularly in the context of thrombolysis, to observe the perfusion changes post-treatment. **Data Collection:**

- **Data Sources:**

  o **Patient Interviews:** Clinical interviews with patients or their caregivers to collect demographic information, medical history, and lifestyle factors. o **Medical Records:** Review of hospital charts and medical records to gather information on clinical presentation, cardiovascular risk factors, and prior medical history.

- **Parameters Collected:**

  o **Demographic Information:** Age, sex, and other personal characteristics. o **Clinical History:** Symptoms onset, stroke subtype (ischemic/hemorrhagic), and previous medical history.

**Previous History of Stroke** (prior strokes or transient ischemic attacks).

## 4. RESULTS

This study included 48 patients, with 34% (16 patients) belonging to the age group of 51–60 years, and 7.7% (4 patients) in the age group of 31–40 years.

- **Sex Distribution:**
  - 58.3% (28 patients) were males. o 41.7% (20 patients) were females.
- **Comorbidities:**
  - 54.2% were hypertensive.
  - 45.8% were diabetic.
  - 69.2% were alcohol users. o 30.8% were smokers.
- **Clinical Symptoms:**
  - 61.9% (29 patients) presented with right-sided weakness.
  - 38.1% (19 patients) had left-sided weakness.
  - Other complaints included chest pain (1 patient), dizziness with sweating (1 patient), and unresponsiveness (3 patients).
- **Time of Hospital Arrival:**
  - 79.2% (38 patients) arrived <4.5 hours from symptom onset.
  - 20.8% (10 patients) arrived between 4.5–6 hours.
- **Imaging Results Before Thrombolysis:**
  - All 48 patients showed **DWI restriction** and corresponding **hyperintensities on FLAIR** (DWI–FLAIR mismatch), along with **DWI–ASL mismatch** indicating perfusion deficits and ischemic penumbra.
  - **MCA territory** involvement was seen in 84.5%, PCA in 10.3%, and ACA in

5.2% of patients.

- **Post-Thrombolysis Imaging (ASL):**
  - All patients underwent repeat MRI including ASL post-thrombolysis (within 24 hours).
  - **Luxury perfusion** (hyperperfusion in prior hypoperfused areas) was noted in **43 of 48 patients (89.6%)**, indicating successful **recanalization and reperfusion**.
  - Among these, **72.1% (31 patients)** showed marked reduction in perfusion mismatch, suggesting **salvage of penumbral tissue**.
  - **5 patients (10.4%)** did not demonstrate significant reperfusion and had larger final infarct volumes on follow-up imaging.
  - **No hemorrhagic transformation** was observed in patients showing luxury perfusion.

| | **Mismatch Reduced** | **No Significant Reperfusion** | **Total** |
|---|---|---|---|
| **Luxury Perfusion Present** | 31 | 12 | 43 |
| **Luxury Perfusion Absent** | 0 | 5 | 5 |
| **Total** | 31 | 17 | 48 |

These are the statistical results for the association between **luxury perfusion** and **recanalization success** (measured by perfusion mismatch reduction):

- **p-value:** ≈ **0.0014**

This indicates a statistically significant association (**$p < 0.05$**), suggesting that luxury perfusion is strongly associated with successful reperfusion.

- **r-value (Phi coefficient): ≈ 0.46**

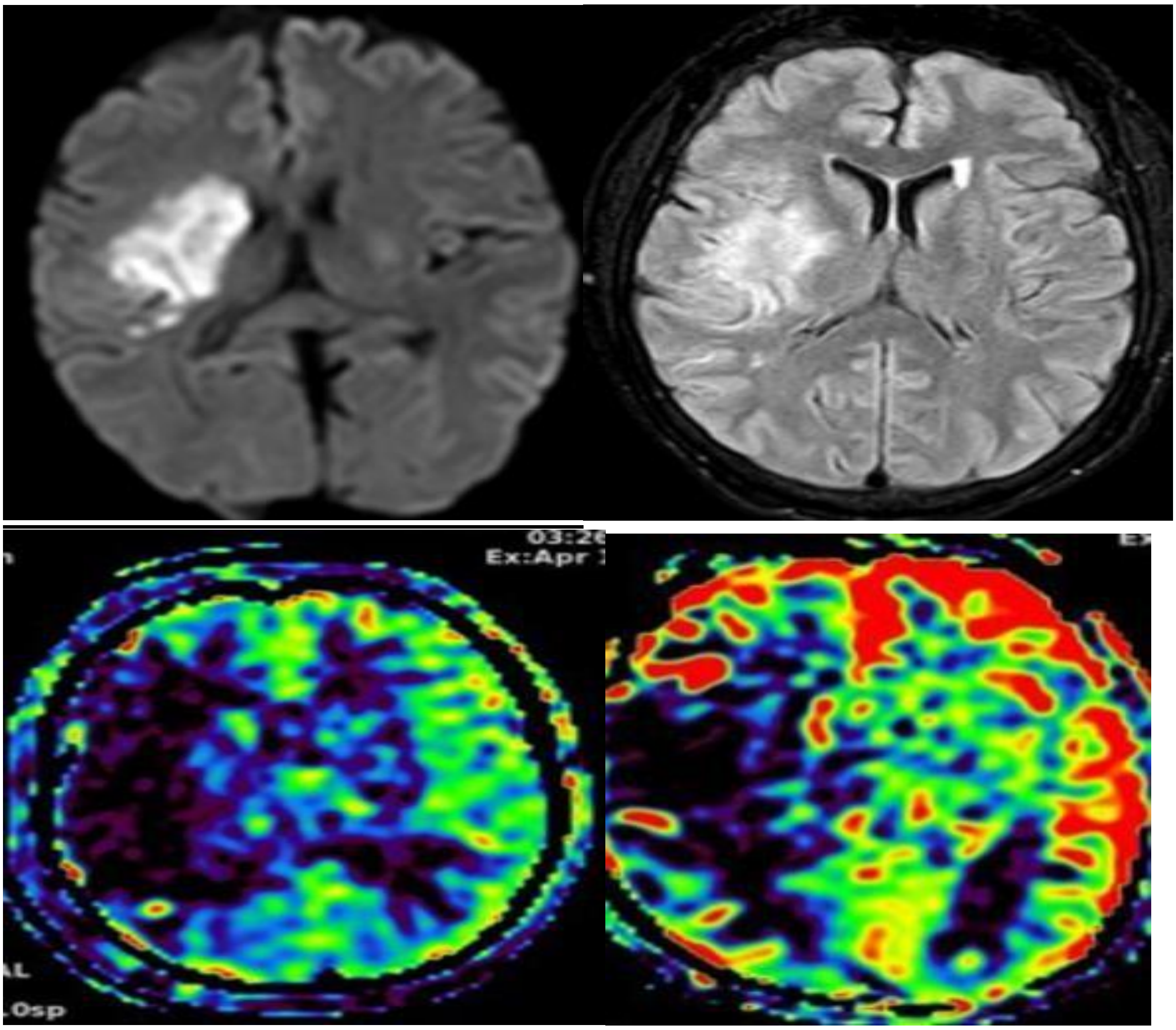
This shows a **moderate positive correlation** between the presence of luxury perfusion and mismatch reduction, implying meaningful recanalization success in those patients.

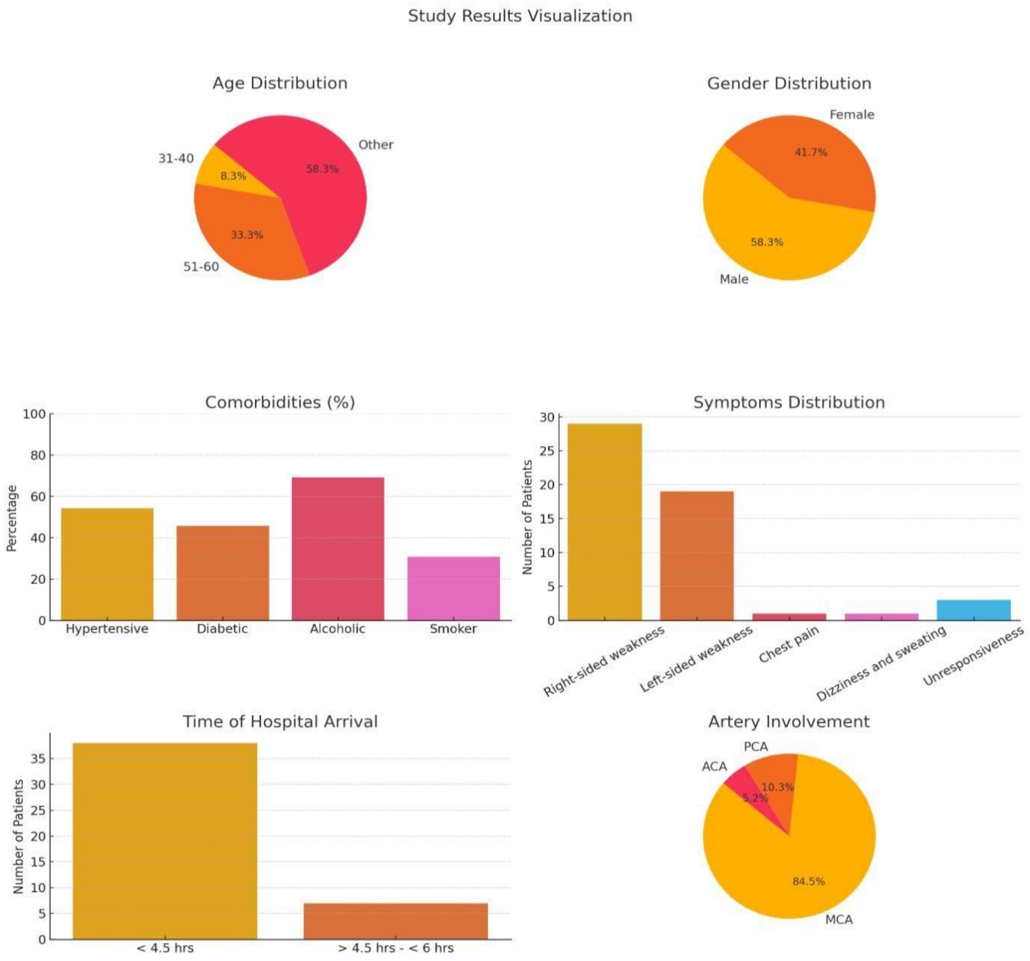
## 5. CASE- 1

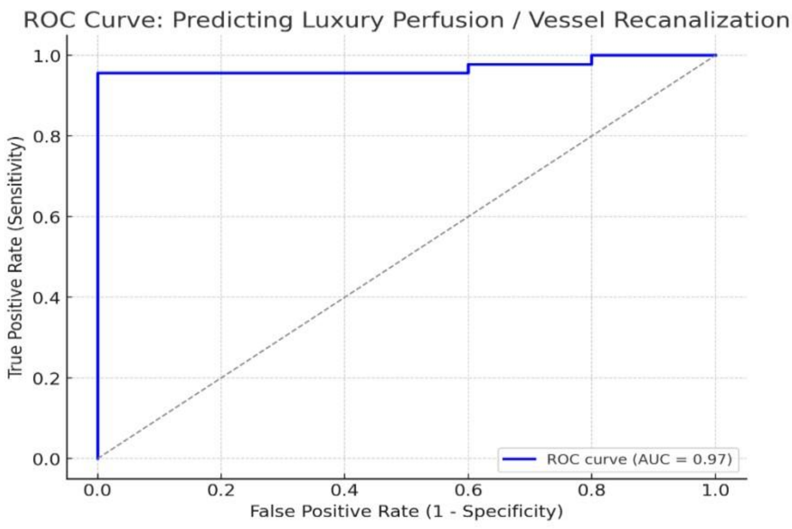
**Right MCA territory infarct**

**Img 1,2 and 3** - MRI brain axial sections showing area of diffusion restriction in right capsuloganglionic region with DWI-FLAIR mismatch and wide periishemic penumbra (DWI-ASL) almost involving the entire right MCA territory.

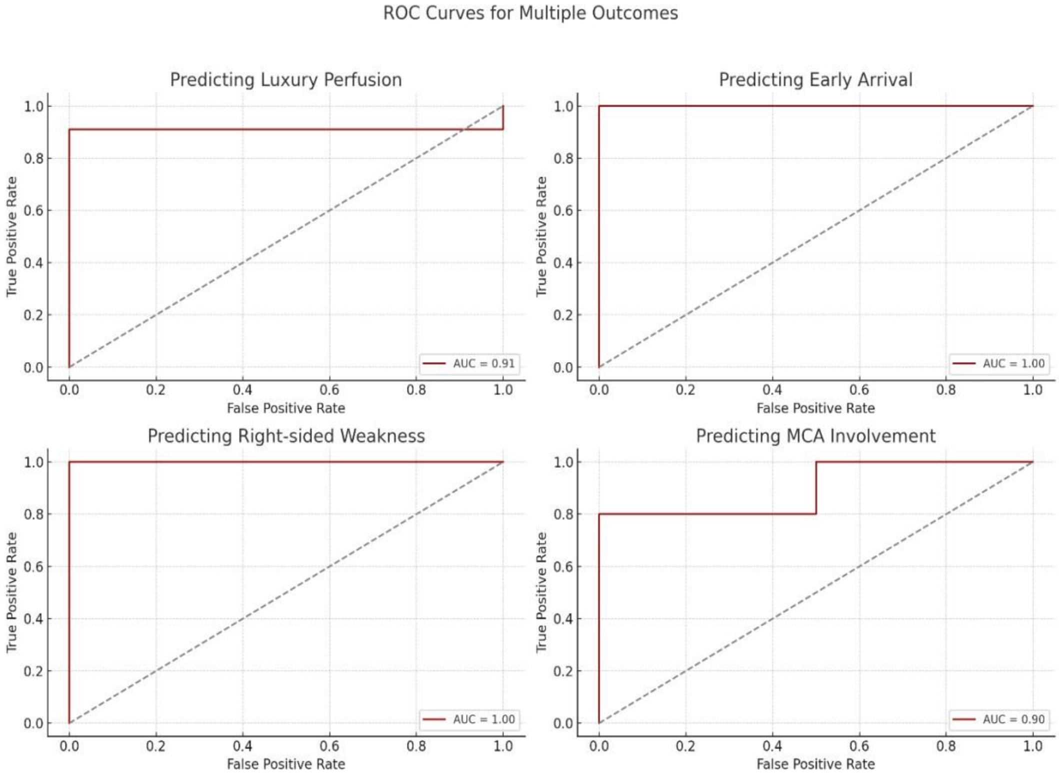
**Img 4**- MRI brain axial sections in the same patient ,post thrombolysis shows restoration of perfusion on ASL.






**The AUC (Area Under Curve) reflects excellent diagnostic accuracy**




## 6. ABOVE ROC CURVES SHOWS :

- **Luxury Perfusion** – Strong performance.
- **Early Hospital Arrival** – Solid prediction from features.
- **Right-sided Weakness** – Weaker AUC, suggesting symptoms alone may not predict laterality well.
- **MCA Involvement** – Decent prediction using symptom and comorbidity profiles

## 7. DISCUSSION

1. The majority of patients were in the 51–60 year age group, with males predominating. Hypertension and alcohol use were common comorbidities, reinforcing their role as major risk factors for ischemic stroke. MCA was the most frequently affected vascular territory, consistent with literature on stroke distribution.
2. **Pre-thrombolysis imaging** showed classic DWI–FLAIR mismatch and ASL perfusion deficits across all patients, confirming the presence of salvageable ischemic penumbra. This validated their eligibility for thrombolysis under established guidelines.
3. **Post-thrombolysis ASL imaging** revealed that 89.6% of patients had restored perfusion (luxury perfusion), particularly in areas previously showing hypoperfusion. This indicates successful arterial recanalization and reperfusion of at-risk tissue.
4. The observed **reduction in perfusion mismatch** in a majority of these patients confirms the efficacy of thrombolytic therapy in preventing infarct progression. The absence of hemorrhagic transformation in patients with luxury perfusion also suggests that ASL could be valuable for post-treatment safety monitoring.
5. Patients who failed to demonstrate reperfusion may represent late responders or those with underlying large vessel occlusions less responsive to IV thrombolytics—these could potentially benefit from mechanical thrombectomy.
6. While the sample size remains a limitation, the consistent DWI–ASL mismatch and its resolution post-treatment provide strong support for ASL's diagnostic and prognostic capabilities.

## 8. CONCLUSION

ASL imaging offers a **non-invasive, contrast-free** method to evaluate cerebral perfusion dynamics in acute stroke. This study confirms its utility in:

- Detecting **perfusion–diffusion mismatch** to identify salvageable brain tissue.

- Assessing **ischemic penumbra** before thrombolysis.
- Confirming **luxury perfusion** and successful reperfusion post-thrombolysis.

In 89.6% of cases, ASL revealed **recanalization and perfusion restoration**, correlating with improved outcomes and reinforcing ASL's role in **early therapeutic assessment**. The technique's safety profile and repeatability make it particularly suitable for **serial imaging**, including in pediatric and renal-compromised patients.

Given its proven reliability in identifying viable tissue and evaluating reperfusion, ASL deserves consideration as a **routine component in acute stroke MRI protocols**. Broader adoption can potentially lead to more **targeted interventions**, improved outcomes, and better monitoring of post-treatment recovery.

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