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ORIGINAL RESEARCH ARTICLE

# A Comparative Study of Carotid Doppler and Magnetic Resonance Angiography Neck Vessels in Stroke Patients

**Girish Magadum[1], Neeraj Prajapati[2*], Vinod Kumar Mogha[3], Divyant Rawal[4#]**

## ABSTRACT

**Introduction:** According to the definition provided by the World Health Organization, stroke is delineated as a clinical syndrome characterized by the rapid onset of observable clinical indicators indicative of either localized or widespread disruption in cerebral function, enduring for a duration exceeding 24 hours. The study aimed to evaluate the positive findings of color Doppler and MRA in neck vessels in stroke patients and to delineate the pitfalls during imaging, interpretations and limitations of color Doppler ultrasound.

**Material and Methods:** A prospective observational study was conducted in the Radiodiagnostic Department of SRMSIMS hospital in Bareilly, India. Over a period of 1.5 years in the Department of Radiodiagnosis. The study included a total of 60 patients with a history of stroke and coming for ultrasound carotid Doppler is further evaluated using MRA to determine stenosis or occlusion of carotid artery and assessed using Acuson Siemens Juniper Ultrasound, 3 Tesla 48 Channel MRI Machine Seimens Magnetom Skyra and 1.5 Tesla 16 Channel MRI Machine Seimens Magnetom Sempra.

**Results:** The study shows that the 60 stroke patients aged 58.43 ± 13.25 years, comprised 78.33% males and 21.67% females. Presenting complaints of 28.33% with right-sided paralysis, 20% with left-sided paralysis and bilateral lower limb weakness (13.33%). About 55% had right-sided strokes and 45% had left-sided strokes. For right-sided strokes, Doppler identified mild stenosis in 11.11% of cases, whereas MRA detected 6.06%. Statistical analysis revealed no significant difference in between Doppler ($p = 0.610$) and MRA ($p = 0.552$) for mild stenosis. MRA detected additional cases of mild to severe stenosis not identified by Doppler ($p > 0.05$). Among left-sided stroke patients, Doppler identified mild stenosis in 12.12%, slightly less than the 15.15% detected by MRA, with a non-significant *p-value* of 0.72 indicating comparable performance in mild stenosis detection. For internal carotid artery (ICA) stenosis, Doppler and MRA demonstrated differing capabilities. Doppler identified mild stenosis in 14.81 and 6.06% of right and left stroke patients, respectively, while MRA detected similar patterns in 14.81 and 7.41% of cases. Both modalities exhibited high agreement in detecting the absence of stenosis ($p$ >0.05). Doppler showed notable differences between right and left stroke patients, whereas MRA depicted more consistent findings across both sides in the assessment of plaque nature. Doppler detected hypoplastic vertebral artery (VA) in 15.15% of right-sided strokes and 6.06% for left-sided strokes, MRA identified higher rates at 21.21 and 18.18%, respectively, with non-significant differences ($p > 0.05$). MRA significantly outperformed Doppler in detecting diffuse VA involvement (22.22 *vs.* 0% in right-sided strokes, $p = 0.005$; and 0 *vs.* 77.78% in left-sided strokes, $p = 0.000$) and in identifying the absence of abnormalities ($p = 0.002$ and $p = 0.000$ for right and left VA, respectively).

**Conclusion:** This study concluded that MRA tended to detect more cases of stenosis across various severity levels compared to Doppler, particularly in severe stenosis among left-sided stroke cases, however, the differences were not statistically significant. MRA significantly outperformed Doppler in detecting diffuse vertebral artery involvement. This shows the complementary roles of Doppler and MRA in assessing CCA and ICA stenosis, MRA tends to offer a marginal advantage due to its superior resolution and ability to detect subtle abnormalities such as minor calcifications.

**Keywords:** Stroke, Magnetic resonance angiography, Color Doppler.

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Junior Resident[1], Professor[2], Assistant Professor[3], Associate Professor[4#], Department of Radiodiagnosis

[#]Department of Neurology

Department of Medicine, Shri Ram Murti Smarak Institute of Medical Science, Bareilly, Uttar Pradesh, India.

***Corresponding Author:** Neeraj Prajapati, Professor, Department of Radiodiagnosis, Shri Ram Murti Smarak Institute of Medical Science, Bareilly, Uttar Pradesh, India, e-mail: drneerajprajapati@rediffmail.com

## INTRODUCTION

Ischemic stroke stands as a paramount contributor to neurological morbidity and mortality on a global scale. This encompasses various subtypes, delineated by the Trial of Org 10172 in acute stroke treatment (TOAST), including large vessel stroke, small vessel or lacunar stroke, and cardioembolic stroke. It is etiology is multifaceted, stemming from diverse precipitating factors such as embolism originating from the heart, occlusion of cerebral small vessels, and the impact of atherosclerosis on cerebral circulation. Emerging insights underscore the intricate involvement of the immune system in the pathophysiological cascades ensuing post-cerebral ischemic injury.[1]

Stroke is characterized by the emergence of focal neurological signs and symptoms attributed to an underlying vascular cause, persisting for a minimum of 24 hours. Diagnostic investigations typically involve baseline brain MRI or CT scans, with follow-up brain

CT scans utilizing contrast medium after 48 to 72 hours to confirm the presence of ischemic lesions. Globally, stroke ranks as the third leading cause of mortality and the primary cause of disability in Western countries. Available data indicates that approximately 15 million individuals worldwide are diagnosed with stroke annually, with 5 million resulting in fatalities and an additional 5 million experiencing permanent physical impairments. Moreover, the incidence of stroke exhibits a correlation with ethnicity, with data from the United States highlighting a higher risk among Black and Hispanic populations compared to Caucasians.[2]

## MATERIAL AND METHODS

The present study was conducted over a period of 1.5 years in the Department of Radiodiagnosis (1st Aug. 2022 to 31st Jan. 2024) with study design: a prospective observational study and sample size of 60 conducted in the Department of Radiodiagnosis at SRMSIMS hospital, Bareilly, India. Before commencing the study, informed written consent was taken from all patients. All patients were consulted by the same Radiologist to minimize bias. Inclusion criteria are patients coming with a history of stroke and patients coming for ultrasound carotid Doppler are further evaluated using MRA to determine stenosis or occlusion of the carotid artery.

### Method of Data Compilation

Informed consent was taken from the patient, detailed history, examination and biochemical investigations were done. Carotid Doppler of neck vessels was done. MRA of neck vessels was performed by giving IV contrast through a pressure injector. Preformed proforma was filled for every patient.

### Plan for Data Analysis

Data is analyzed using statistical software SPSS version 22 and Microsoft Excel. Descriptive statistics including mean ± standard deviation (SD), minimum (Min), and maximum (Max) values were calculated for continuous variables. Categorical data, including proportions and percentages, were analyzed to assess the distribution of demographic characteristics and clinical presentations among the study population. Data was tabulated in visual representational form using various charts and graphs. To compare proportions between Doppler and MRA findings, a Z test for two proportions was used. A *p-value* greater than 0.05 was considered a significant value.

## RESULTS

Data contains measurements on 60 subjects whose ages ranged from 25 to 83 years with a mean age of 58.43 ± 13.25 years. Table 1 gives the distribution of subjects according to demographic details. Out of 60 subjects, 13 (21.67%) were females and 47 (78.33%) were males. On analysis for right-sided stroke patients (Table 2), Doppler identified mild stenosis in 11.11% compared to 6.06% detected by MRA. Statistical analysis showed no significant difference between Doppler ($p$ = 0.610) and MRA ($p$ = 0.552) in detecting mild stenosis, suggesting comparable sensitivity. MRA additionally detected mild to severe stenosis categories that Doppler missed, although these differences were not statistically significant ($p > 0.05$).

Turning to left-sided stroke patients, Doppler detected mild stenosis in 12.12%, slightly less than the 15.15% identified by MRA, with a non-significant *p-value* of 0.72 indicating similar performance in mild stenosis detection. Both methods showed agreement in detecting the absence of stenosis (100% agreement, $p$ = 1.00).

The nature of the plaque observed as per Doppler showed calcified obstruction of the right CCA (Table 3) among one patient with right and left-sided stroke and the non-calcified obstruction observed was found among two patients with left-sided stroke and one patient with right-sided stroke. Two patients each had a right-sided stroke and had a calcified and non-calcified block of left CCA.

Table 4 shows on MRA, two patients each diagnosed with left-sided stroke were observed with focal and diffuse obstruction of right CCA, respectively. Over 2 (6.06%) patients had focal obstruction with no diffuse obstruction as per MRA observation. In 3 (9.09%) and 2 (6.06%) of the patients with right-sided stroke had found to have diffuse and focal obstruction of left CCA. Table 5 shows that Doppler identified mild stenosis in 14.81% of cases, while MRA detected the same percentage, though the difference was not statistically significant ($p$ = 1.00) in right-sided stroke patients. In terms of moderate and severe stenosis categories, Doppler showed 3.7 and 7.41%, respectively, whereas MRA identified higher percentages at 11.11% for both, with non-significant *p-values* ($p$ = 0.294 and $p$ = 0.638, respectively). Both methods showed agreement in detecting the absence of stenosis in right-sided ICA ($p$ = 1.00). For left-sided stroke patients, Doppler detected mild stenosis in 6.06%, slightly lower than the 7.41% identified by MRA, with a non-significant *p-value* of

**Table 1:** Distribution of subjects according to demographic details

| *Variables* | *Sub category* | *Number of subjects (%)* |
|---|---|---|
| Age (years) | Mean ± SD | 58.43 ± 13.25 |
| | Median (Min, Max) | 57 (25, 83) |
| Sex | Female | 13 (21.67%) |
| | Male | 47 (78.33%) |

**Table 2:** Distribution of patients based on stenosis

| *Investigation* | | | *Doppler* | | *MRA* | | *p-value* | |
|---|---|---|---|---|---|---|---|---|
| *Variables* | *Sub-category* | | *Left-sided stroke* | *Right-sided stroke* | *Left-sided stroke* | *Right-sided stroke* | *Left vs. Left* | *Right vs. Right* |
| CCA - Stenosis | Right | Mild | 3 (11.11%) | 2 (6.06%) | 1 (3.7%) | 1 (3.03%) | 0.610 | 0.552 |
| | | Mild-moderate | 0 | 0 | 1 (3.7%) | 0 | 0.308 | NA |
| | | Moderate | 0 | 0 | 1 (3.7%) | 1 (3.03%) | 0.308 | 0.31 |
| | | Severe | 0 | 0 | 1 (3.7%) | 0 | 0.308 | NA |
| | | Nil | 24 (88.89%) | 31 (93.94%) | 23 (85.19%) | 31 (93.94%) | 0.69 | 1 |
| | Left | Mild | 0.00 | 4 (12.12%) | 0.00 | 5 (15.15%) | NA | 0.72 |
| | | Nil | 27 (100%) | 29 (87.88%) | 27 (100%) | 28 (84.85%) | 1.00 | 0.72 |

Test: Z test for two proportion, NA: Not applicable due to zero counts in both groups

**Table 3:** Distribution based on nature of plaque on Doppler

| *Investigation* | | | *Doppler* | |
|---|---|---|---|---|
| *Variables* | *Sub-category* | | *Left-sided stroke* | *Right-sided stroke* |
| CCA - Nature of plaque | Right | Calcified | 1 (3.7%) | 1 (3.03%) |
| | | Non-calcified | 2 (7.41%) | 1 (3.03%) |
| | | Nil | 24 (88.89%) | 31 (93.94%) |
| | Left | Calcified | 0 | 2 (6.06%) |
| | | Non-calcified | 0 | 2 (6.06%) |
| | | Nil | 27 (100%) | 29 (87.88%) |

0.142. In moderate and severe stenosis categories, Doppler identified fewer cases compared to MRA, though the differences were not statistically significant ($p > 0.05$). Both methods demonstrated high agreement in detecting the absence of stenosis in the left ICA ($p = 1.00$).

Table 6 signifies that 1 (3.7%) and 6 (22.22%) patients with left-sided stroke had observed calcified and non-calcified lesions of right ICA on Doppler and none among the patients with right-sided stroke. 2 (6.06%) and 11 (33.33%) patients with right-sided stroke had calcified and non-calcified of left ICA, respectively and none among left-sided stroke had obstruction of left ICA. Table 7 shows that on MRA, 5 (18.52%) of the patients with left-sided stroke had diffuse and focal obstruction of right ICA 1 (3.7%) had focal and diffuse obstruction of left ICA. 6 (18.18%) and 11 (33.33%) had obstruction of left ICA among the patients with right-sided stroke. Table 8 shows MRA detected diffuse involvement in 22.22% of cases, significantly higher than Doppler which showed no detection ($p = 0.005$) for right-sided strokes. Similarly, in cases of focal involvement, MRA identified 3.7% compared to Doppler's 0%, though this difference was not statistically significant ($p = 0.308$). Doppler and MRA also differed significantly in detecting an absence of abnormalities (Nil) in the right VA ($p = 0.002$).

On the left-side, both Doppler and MRA showed no diffuse involvement. However, MRA identified focal involvement in 77.78% compared to 0% detected by

**Table 4:** Obstruction of CCA on MRA

| *CCA* | | *Left-sided stroke* | *Right-sided stroke* |
|---|---|---|---|
| Right | Diffuse | 2 (7.41%) | 0 |
| | Focal | 2 (7.41%) | 2 (6.06%) |
| | Nil | 23 (85.19%) | 31 (93.94%) |
| Left | Diffuse | 0 | 3 (9.09%) |
| | Focal | 0 | 2 (6.06%) |
| | Nil | 27 (100%) | 28 (84.85%) |

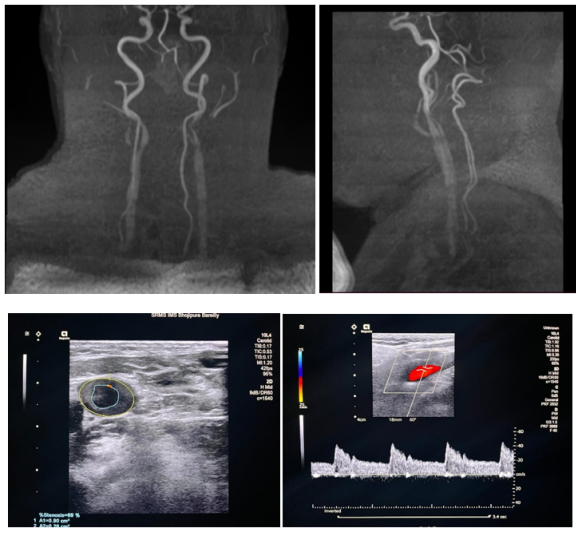

**Figure 1:** Case 1- MR angio neck vessels revealing short segment luminal narrowing (upto 50–60% approx) in visualized left internal carotid artery just after its origin from common carotid artery for a length of 1.6 cm approx and USG doppler neck vessels reveal short segment proximal left ICA stenosis (69%) however normal spectral doppler waveform

**Table 5:** Distribution based on grade of ICA stenosis

| *Investigation* | | | *Doppler* | | *MRA* | | *p-value* | |
|---|---|---|---|---|---|---|---|---|
| *Variables* | *Sub-category* | | *Left-sided stroke* | *Right-sided stroke* | *Left-sided stroke* | *Right-sided stroke* | Left *vs.* Left | Right *vs.* Right |
| ICA | Right | Mild | 4 (14.81%) | 0 | 4 (14.81%) | 0 | 1 | NA |
| | | Moderate | 1 (3.7%) | 0 | 3 (11.11%) | 0 | 0.294 | NA |
| | | Severe | 2 (7.41%) | 0 | 3 (11.11%) | 0 | 0.638 | NA |
| | | Nil | 20 (74.07%) | 33 (100%) | 17 (62.96%) | 33 (100%) | 0.376 | 1.00 |
| | Left | Mild | 0 | 2 (6.06%) | 2 (7.41%) | 2 (6.06%) | 0.142 | 1 |
| | | Moderate | 0 | 2 (6.06%) | 0 | 3 (9.09%) | NA | 0.632 |
| | | Severe | 0 | 9 (27.27%) | 0 | 12 (36.36%) | NA | 0.337 |
| | | Nil | 27 (100%) | 20 (60.61%) | 25 (92.59%) | 16 (48.48%) | 0.142 | 0.106 |

*Test: Z test For two proportions, NA: Not applicable due to zero counts in both groups*

**Table 6:** Distribution of ICA status based on nature of plaque

| *Investigation* | | | *Doppler* | |
|---|---|---|---|---|
| *Variables* | *Sub category* | | *Left-sided stroke* | *Right-sided stroke* |
| ICA | Right | Calcified | 1 (3.7%) | 0 |
| | | Non-calcified | 6 (22.22%) | 0 |
| | | Nil | 20 (74.07%) | 33 (100%) |
| | Left | Calcified | 0 | 2 (6.06%) |
| | | Non-calcified | 0 | 11 (33.33%) |
| | | Nil | 27 (100%) | 20 (60.61%) |

**Table 7:** Nature of obstruction observed on MRA

| *ICA* | *Nature of obstruction* | *Left-sided stroke* | *Right-sided stroke* |
|---|---|---|---|
| Right | Diffuse | 5 (18.52%) | 0 |
| | Focal | 5 (18.52%) | 0 |
| | Nil | 17 (62.96%) | 33 (100%) |
| Left | Focal | 1 (3.7%) | 6 (18.18%) |
| | Diffuse | 1 (3.7%) | 11 (33.33%) |
| | Nil | 25 (92.59%) | 16 (48.48%) |

**Table 8:** Distribution based on vertebral artery obstruction

| *Investigation* | | | *Doppler* | | *MRA* | | *p-value* | |
|---|---|---|---|---|---|---|---|---|
| *Variables* | *Sub-category* | | *Left-sided stroke* | *Right-sided stroke* | *Left-sided stroke* | *Right-sided stroke* | *Left vs. Left* | *Right vs. Right* |
| Vertebral artery (VA) | Right | Diffuse | 0 | 0 | 6 (22.22%) | 6 (18.18%) | 0.005 | 0.007 |
| | | Focal | 0 | 0 | 1 (3.7%) | 1 (3.03%) | 0.308 | 0.31 |
| | | Nil | 27 (100%) | 33 (100%) | 20 (74.07%) | 26 (78.79%) | 0.002 | 0.003 |
| | Left | Diffuse | 0 | 0 | 6 (22.22%) | 6 (18.18%) | 0.005 | 0.007 |
| | | Focal | 0 | 0 | 21 (77.78%) | 27 (81.82%) | 0.000 | 0.000 |
| | | Nil | 27 (100%) | 33 (100%) | 6 (22.22%) | 6 (18.18%) | 0.000 | 0.000 |

Doppler, with a highly significant difference ($p = 0.000$). Additionally, Doppler and MRA significantly differed in detecting an absence of abnormalities (Nil) in the left VA ($p = 0.000$). Figs 1 to 4 represent the different case scenarios

## DISCUSSION

Ours is a unique study as we have compared the Doppler and MRA in stroke with subgroup analysis of right and left-sided stroke, which is not been found in any other published clinical studies.

Stenosis of the CCA reported that 3 (11.11%) and 2 (6.06%) patients with right and left-sided stroke had developed mild stenosis of the right CCA as per the Doppler. Whereas on MRA, we observed that one each among left and right-sided strokes had mild stenosis of right CCA. One each among left-sided stroke has been

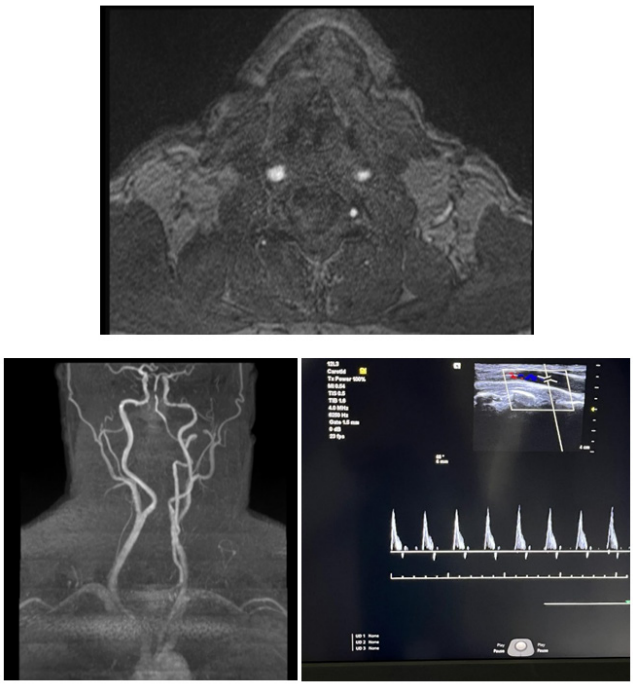

**Figure 2:** Case 2- MR angio neck vessels revealing hypoplastic right vertebral artery. However, USG doppler appears normal

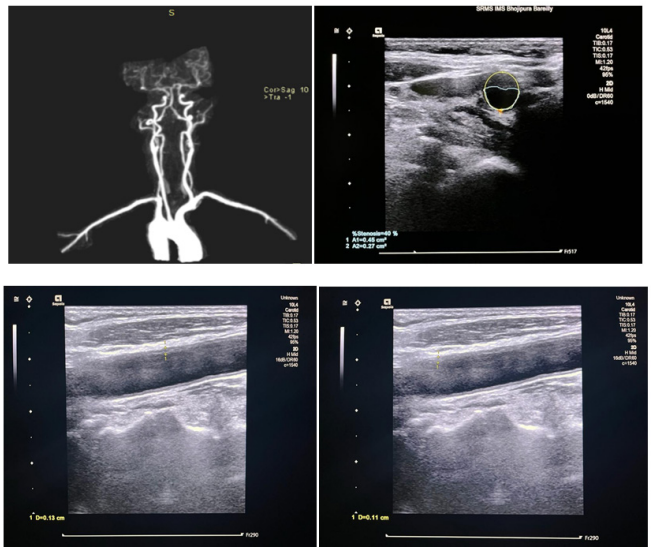

**Figure 3:** Case 3- MR angio neck vessels revealing mild diffuse intimal thickening of bilateral common carotid arteries and focal short segment mild to moderate (35–40%) narrowing of right internal carotid artery in its proximal part just after origin and usg doppler neck vessel revealing mild diffuse intimal thickening of bilateral common carotid arteries, focal short segment 40% narrowing of proximal right internal carotid artery

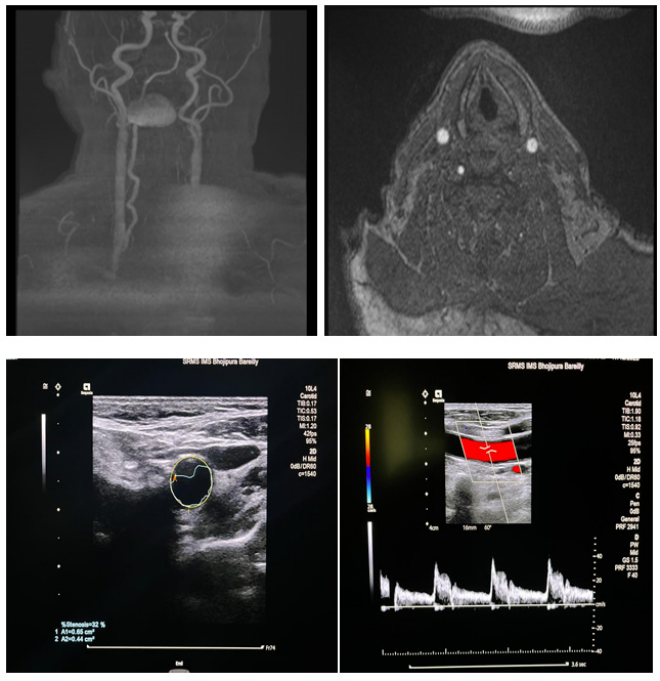

**Figure 4:** Case 4- MR angio neck vessels revealing focal short segment mild narrowing of left internal carotid artery almost 15 mm away from the bifurcation and hypoplastic left vertebral artery, USG doppler neck vessel reveals 32% stenosis of left inernal carotid artery however shows normal spectral doppler

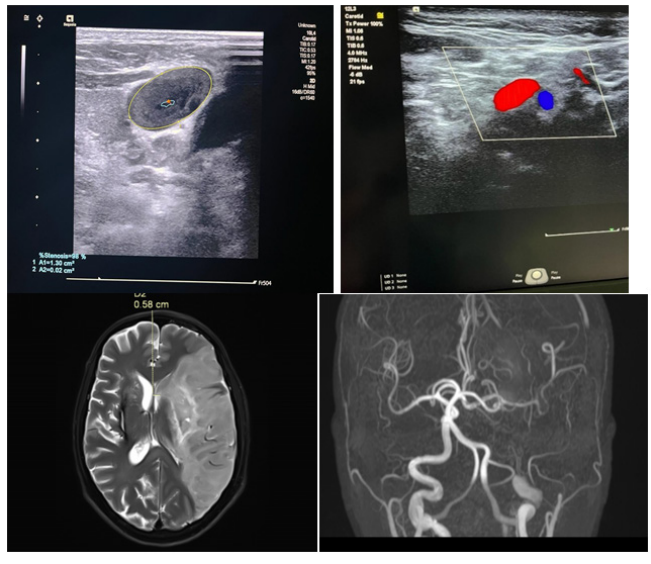

**Figure 5:** Case 5- MR angio neck vessels reveals the study reveals evidence of near complete non visualization of the left internal carotid artery in its cervical and intracranial course baring a terminal part near bifurcation and MRI brain reveals acute ischemic infarcts in left MCA territory. USG doppler neck vessel reveals 100% stenosis of left inernal carotid artery and no waveforms. On spectral doppler

observed to have mild to moderate, moderate, and severe stenosis of right CCA. One patient with a right-sided stroke had observed moderate stenosis of the right CCA. Of the patients observed with stenosis of left CCA, 4 (12.12%) and 5 (15.15%) had been observed with a mild degree of stenosis on Doppler and MRA. Ismail A *et al.* also reported that carotid stenosis has been one of the major findings on USG of neck vessels among patients with stroke. According to their review data, the estimated prevalence of severe CS which is ≥70% of the stenosis as such is 0.1 to 3.1%, which is directly proportional to age, with an attributable stroke risk of 0.7%.[3] Whereas Das PJ *et al.* have noticed that 8.92% of patients had significant extracranial carotid artery stenosis among the cases of ischemic stroke.[4]

Nature of the plaque observed as per Doppler showed calcified obstruction of the right CCA among one each patient with right and left-sided stroke and the non-calcified obstruction observed was found among two patients with left-sided stroke and one patient with right-sided stroke. None had calcification of left CCA among the patients with left-sided stroke whereas two patients each had right-sided stroke.

We observed that, on MRA, two patients each diagnosed with left-sided stroke had been observed with focal and diffuse obstruction of right CCA, respectively. Two patients had focal obstruction with no diffuse obstruction as per MRA observation. None among the left-sided stroke cases has been observed with either focal or diffuse obstruction of left CCA. Whereas 3 (9.09%) and 2 (6.06%) of the patients with right-sided stroke had been found to have diffuse and focal obstruction of left CCA.

As per our findings, none among right-sided stroke patients had stenosis of the right ICA, either on Doppler or on MRA. Whereas 4 (14.81%), 1 (3.7%) and 2 (7.41%) patients with left-sided stroke had mild, moderate and severe stenosis of right ICA on Doppler. On MRA 4 (14.81%) had mild stenosis of the right ICA and three patients had moderate and severe stenosis.

None among the patients with left-sided stroke had stenosis of the left ICA on Doppler. In 2 (6.06%) each with right-sided stroke had mild and moderate stenosis of left ICA. 9 (27.27%) had severe stenosis of left ICA. On MRA, we observed that mild stenosis of left CCA was observed among two each with right and left stroke, respectively. Whereas 3 (9.09%) and 12 (36.36%) had moderate and severe stenosis among the patients diagnosed with right-sided stroke. A study comparing Doppler ultrasound (DUS) with computed tomography angiography (CTA), conducted by Simaan N *et al*., reported significant discrepancies in the assessment of carotid artery stenosis. Specifically, among patients diagnosed with 50 to 69% stenosis by DUS, 45.5% exhibited a different percentage of stenosis when evaluated by CTA. This disparity suggests that the choice of imaging modality can influence the determination of the severity of carotid artery narrowing in clinical practice.[5]

One (3.7%) and 6 (22.22%) patients with left-sided stroke were observed with calcified and non-calcified lesions of right ICA on Doppler and none among the patients with right-sided stroke. About 2 (6.06%) and 11 (33.33%) patients with right-sided stroke had calcified and non-calcified of left ICA, respectively and none among left-sided stroke had obstruction of left ICA. As per Simaan N *et al*., when assessing the degree of stenosis in the vertebral artery, only 47.1% of patients identified with more than 50% stenosis by DUS had concordant results with CTA. The majority of these patients either showed normal or less than 50% stenosis according to CTA. This underscores that CTA is considered more precise than DUS for evaluating stenosis in cervical arteries, encompassing both the internal carotid and vertebral arteries.[5] Vijaywargiya R *et al.,* in their Doppler study also reported that 2 (3.7%), 5 (9.2%) and 10 (18.5%) patients with right, left and bilateral stroke, respectively had plaque formation in CCA. 5 (9.2%), 7 (12.9%) and 2 (3.7%) with right, left and bilateral stroke, respectively had plaque formation in ICA. Carotid bulb plaque was observed among 3 (5.5%), (12.9%) and 13 (24.07%) of those with right, left and bilateral stroke, respectively.[6]

In contrast to our study, Fernandes M *et al.* did not conduct a subgroup analysis to differentiate between the involvement of arteries in right-sided and left-sided strokes separately. They reported that out of 12 patients with significant stenosis, none exhibited bilateral involvement. Among these patients, 8 (66.6%) had right-sided involvement, while 4 (33.3%) had left-sided involvement. Additionally, they observed that 7 patients had stenosis ranging from 60 to 79%, 3 patients had stenosis from 80 to 89%, and 2 patients had complete occlusion of their arteries. The internal carotid artery (ICA) was identified as the most commonly affected site in their patient cohort.

In contrast, our findings indicated that the common carotid artery (CCA) was the most frequently affected site among the patients we studied. This discrepancy highlights variations in the distribution and severity of arterial involvement observed in different patient populations and studies.[7]

In our current study, we utilized magnetic resonance angiography (MRA) to examine carotid artery involvement among patients with ischemic stroke. Specifically, among those with left-sided strokes, 18.52% (5 patients) showed diffuse and focal obstruction of the right internal carotid artery (ICA), while 3.7% (1 patient) exhibited focal and diffuse obstruction of the left ICA. Among patients with right-sided strokes, 18.18% (6 patients) had obstruction of the left ICA, and 33.33% (11 patients) had obstruction of the right ICA.

We found that significant carotid stenosis was present in 12.5% (8 out of 64) of our ischemic stroke patients. Additionally, we observed that 31.6% (30 out of 95) of patients had high carotid intima-media thickness (CIMT), which is indicative of thickened artery walls associated with atherosclerosis. Furthermore, atherosclerotic plaques were detected in 26.3% (25 out of 95) of patients, with a majority of these plaques being echogenic based on Doppler ultrasound findings as reported by Walubembe J *et al.*[8] Seth *et al.* had found that 100% of their patients

with >40% stenosis having a cortical infarct.[9] Fernandes M *et al.* have also discussed the soft plaque in left ICA with 58.9% diameter stenosis and soft plaque in left ICA with 31% diameter stenosis in one of their reference study. Even carotid artery stenosis of 70% or more was diagnosed reliably with the following duplex ultrasound among the patients with ischemic stroke. Unlike all these studies, Khaladkar SM *et al.* had even observed a unilateral web of the carotid artery. Right MCA was not visualized along its entire length on the MRA of their patient which was indicating likely thrombosis. Also, there was a curvilinear filling defect detected along the posterior wall of the right ICA, distal to the carotid bifurcation, in a single transverse section of MRA which was one of the rarest findings.[10] Szabo K *et al.* reported that territorial stroke occurred in 47.6% of patients with ICA occlusion on MRA in their study which is nearer finding to ours.[11]

## CONCLUSION

This study concluded that intimal thickness of the arteries and stenosis were well established in both Doppler and MRA, MRA tended to detect more cases of stenosis across various severity levels compared to Doppler, particularly in severe stenosis among left-sided stroke cases, however, the differences were not statistically significant. MRA significantly outperformed Doppler in detecting diffuse vertebral artery involvement. Obstruction of CCA was found to be accurately diagnosed on MRA whereas Doppler was quite inconsistent but not negligent because the nature of plaque was the factor associated with obstruction. This shows the complementary roles of Doppler and MRA in assessing CCA and ICA stenosis. For assessing VA obstruction, MRA identified obstruction while Doppler flow showed no cases of obstruction, potentially due to minor calcification not detected in Doppler views. Therefore, while Doppler and MRA demonstrate comparable diagnostic efficacy, MRA tends to offer a marginal advantage due to its superior resolution and ability to detect subtle abnormalities such as minor calcifications. MRA's slight superiority in specifications and diagnostic capability reveals its potential pitfall over Doppler in this context.

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