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Correlation of the degree of carotid stenosis and area of cerebral infarct in ischaemic stroke patients

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Abstract--Context: To evaluate the degree of internal carotid artery stenosis in acute cerebral infarcts and to correlate it with the area of infarct. Aims: A) To calculate the area of acute cerebral infarct by manual tracing and the degree of internal carotid artery stenosis using NASCET score. B) To calculate the ASPECT score of the cerebral infarct. C) To correlate degree of internal carotid artery stenosis, the area of infarct and ASPECT score. Settings and Design: Hospital based retrospective study. Methods and Material: A retrospective study from January 2018 to January 2020 was conducted on 51 patients with acute ischemic infarct involving the internal carotid artery territory (ICA) due to stenosis of the intra or extracranial ICA. In this study we correlated the infarct area as measured by diffusion weighted magnetic resonance (DWI MRI), Alberta Stroke Program Early CT Score (ASPECTS) and degree of carotid stenosis on MR angiography and carotid doppler using North American Symptomatic Carotid Endarterectomy Trial (NASCET) score. Statistical analysis used: Mc Nemar test was used to correlate ICA stenosis by NASCET score with the area of infarct. Pearson's correlation was used to correlate ASPECT score and infarct volume. Results: A significant positive correlation was observed between the degree of internal carotid artery stenosis and area of infarct ($r = .805$, $p < 0.0009$); the correlation was of high strength. There was a strong negative correlation between the ASPECTS and infarct volume ($r = -.868$, $p < 0.0009$). There was significant negative correlation between the ASPECTS and NASCET score ($r = -.838$, $p < 0.0009$). Conclusions: The degree of internal carotid artery stenosis is useful in predicting the area of cerebral infarct.

Keywords---degree of carotid stenosis, area of infarct, ischemic stroke patients, NASCET, ASPECTS.

Introduction

Stroke is a term that describes the abrupt attack of a constant neurological deficit caused by partial or complete obstruction (ischemic stroke) or rupture of a cerebral blood vessel (haemorrhage). Stroke is the second most common cause of morbidity worldwide and is primary cause of acquired disability¹. Of the ischemic strokes, about 75% occur in the area supplied by the internal carotid artery². High-risk carotid plaques and recurrent thromboembolic events are among the leading causes of ischemic cerebrovascular events². Early diagnosis of predisposition to carotid plaques is a key target for preventing cerebrovascular insults². This study was performed to evaluate the degree of internal carotid artery stenosis in acute cerebral infarcts and to correlate it with the area of infarct.

Aims and Objectives

1. To calculate the area of acute cerebral infarct by manual tracing and the degree of internal carotid artery stenosis using North American Symptomatic Carotid Endarterectomy Trial (NASCET) score.
2. To calculate the diffusion weighted imaging Alberta Stroke Program Early CT Score (DWI-ASPECTS) of the cerebral infarct and to correlate degree of internal carotid artery stenosis with the area of infarct and ASPECT score.

Materials and Methods

The study was conducted in the department of radiology, Ramaiah medical college, Bangalore after ethical clearance. The sample consisted of fifty one patients of both sex with age ranging from 38 to 70 years. This study was a two year retrospective study from January 2018 to 2020. All patients with acute anterior circulation infarct on MRI due to stenosis of the intra or extracranial ICA were included. Measurements of the infarct volume was done manually using DW MRI. Lesion volume was calculated by multiplying the area of the infarct by slice thickness.

Carotid doppler was used to evaluate the neck vessels and MR angiogram was used to evaluate the intracranial vessels. The North American Symptomatic Carotid Endarterectomy Trial (NASCET) classification was used in the evaluation of carotid stenosis and grouped according to the degree of stenosis as: Group 1: < 49% stenosis, Group 2: 50–69%, Group 3: 70% to complete occlusion³. Patients with haemorrhagic and embolic stroke were excluded. Suboptimal scans due to artifacts were also excluded.

Radiological measurements

Measurements of the infarct volume in cerebral DW MRI were conducted by a radiologist blinded to the clinical data of the patients. In the DWI sequence, the

hyperintense area with restricted diffusion was measured manually for each slice of the infarct. Lesion volume was calculated by multiplying it by slice thickness (+interslice gap) (Fig 1a, 1b and 2). Grouping by infarct volume was as follows: Group A: $\leq 13 \text{ cm}^2$ and Group B $> 13 \text{ cm}^2$. Diffusion weighted imaging Alberta stroke program early CT score (DWI ASPECTS): It is a 10 point score to estimate infarct in the middle cerebral artery (MCA) vascular territory where one point is deducted from the initial score of 10 for each of the following regions involved (Fig 3a and 3b).

The caudate (C), lentiform (L), internal capsule (IC), insular cortex (I), M1: "anterior MCA cortex" corresponding to the frontal operculum, M2: "MCA cortex lateral to insular ribbon" corresponding to the anterior temporal lobe, M3: "posterior MCA cortex" corresponding to the posterior temporal lobe, M4: "anterior MCA territory immediately superior to M1", M5: "lateral MCA territory immediately superior to M2" and M6: "posterior MCA territory immediately superior to M3"⁴. The North American Symptomatic Carotid Endarterectomy Trial (NASCET) classification was used in the evaluation of carotid stenosis using carotid MRA and grouped according to the degree of stenosis as Group 1: $\leq 49\%$, Group 2: 50–69% and Group 3: 70% to complete occlusion (Fig 4a to 5b and Table 1).

Results

Out of a total of 51 patients (average age, 58 years; range 38 to 70 years, 43 males, 8 females) 28 had right sided infarcts and 23 had left sided infarcts. 50 patients had intracranial ICA stenosis and extracranial ICA stenosis was seen in 38 patients.

A significant positive correlation was observed between the degree of carotid artery stenosis as calculated by NASCET and area of infarct ($r = 0.805$ $p < 0.0009$) in cases with (Fig 6, 9 10):

- Small infarct areas ($\leq 13 \text{ cm}^2$) without basal ganglia involvement.
- Large infarct areas ($> 13 \text{ cm}^2$) with or without basal ganglia involvement (Fig 10).

There was no significant correlation between the degree of stenosis and infarct area in small infarcts with basal ganglia involvement. In these infarcts the degree of stenosis was much greater as compared to the infarct area involved (Fig 9 and 11). Lower stenosis always corresponds to lower Area of infarct but higher stenosis implies a more possibility of higher area of infarct. There was a significant negative correlation between the ASPECTS score and infarct volume ($r = -.826$, $p < 0.0009$). (i.e. lesser the infarct volume higher the ASPECT score) (Fig 7).

There was significant negative correlation between the ASPECTS score and NASCET score in small infarcts (without basal ganglia involvement) and large infarcts. ($r = -.838$, $p < 0.0009$) (Fig 8). Whereas there was significant but moderate strength negative correlation between ASPECTS Score and NASCET Score in infarct areas with basal ganglia involvement alone ($r = -.355$, $p = .038$) (Fig 11).

Discussion

Strokes are the leading cause of disability, death while also the leading preventable cause of disability. Hospital admissions and treatment expenses due to stroke is a financial burden on the patient and their families. Ischemic strokes account for about 80% of all strokes, where the obstruction results most commonly from plaques in arteries, caused by atherosclerosis.

MR angiography (MRA) of the brain is an effective technique for the evaluation of patients with stroke and for the evaluation of intracranial stenosis which further helps in treatment decisions, including whether to initiate more intensive medical therapy for stroke prevention. The advantages of MR angiography are that the study is obtained relatively quickly, often performed along with MR brain. MR imaging does not need ionizing radiation, and can be performed without the need for contrast media injection. Furthermore, the difficulty of separating contrast filled blood vessels from vessel wall calcification and adjacent bone in CT is not encountered on MRA⁵⁻⁶.

Maximum intensity projections (MIPs) from MRA studies simulates the appearance of conventional angiography, thereby allowing measurements to be obtained in the same locations and projections. MRA has a sensitivity and specificity ranging from 80% to 100% and 89% to 95%, respectively, compared with conventional angiography when assessing intracranial stenosis⁷⁻¹⁰.

In our study, the degree of carotid stenosis correlated well with the infarct area. The degree of internal carotid stenosis as calculated on MRA and carotid doppler using NASCET score in the studied population was greater for a larger area of infarct. Among patients with stenosis, the proportion of patients with intracranial ICA stenosis was higher than those with extracranial ICA stenosis (52.6% vs. 27.6%).

The DWI ASPECTS score and the volume of infarct showed a negative correlation, where a low ASPECTS score corresponded to a larger volume of infarct. However small infarcts with basal ganglia involvement did not correlate with the degree of stenosis. That is the area of small infarcts in the basal ganglia did not correlate with the high degree of stenosis in the ICA. This was likely due to pathology involving the penetrating arterioles which supply the basal ganglia directly, which are too small to be visualized on MR angiography.

We concluded that degree of carotid stenosis correlates well with the infarct area and DWI ASPECT score and can be used as an early predictor of infarct volume in patients with stroke. There were some limitations to our study. First, the measurements of area of infarct and degree of stenosis were observer dependent and obtaining measurements on MR angiograms can be subject to error, given the lack of precise spatial resolution. The time-of-flight MR angiography is sensitive to flow disturbances caused by stenosis this may have overestimated the degree of stenosis. Hence both the MIP and axial source images were used to measure the degree of stenosis. Validating our results further in a larger prospective cohort will also be valuable.

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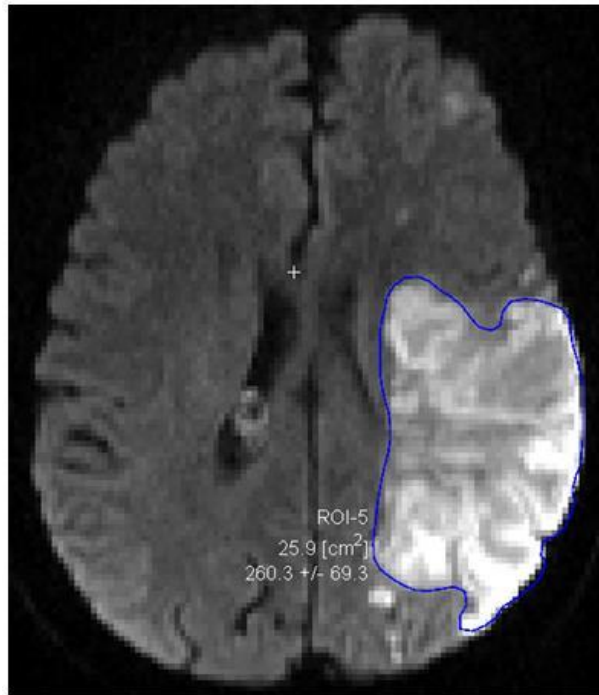


Fig1a.

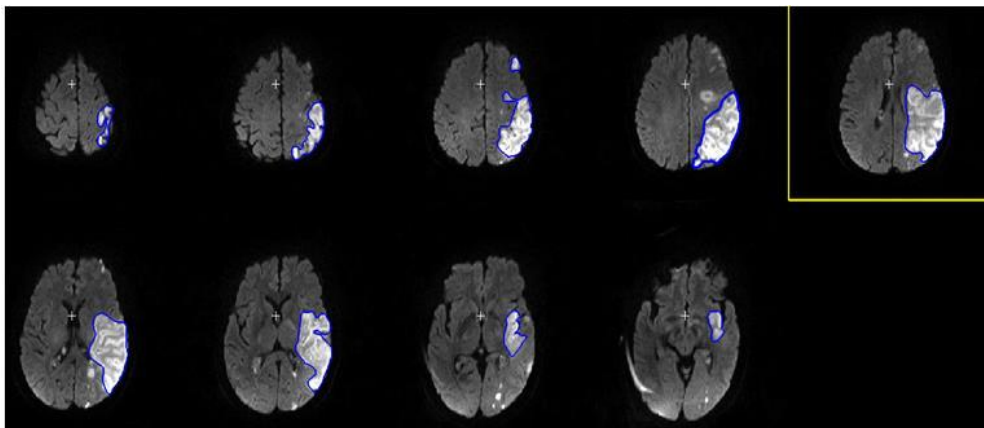


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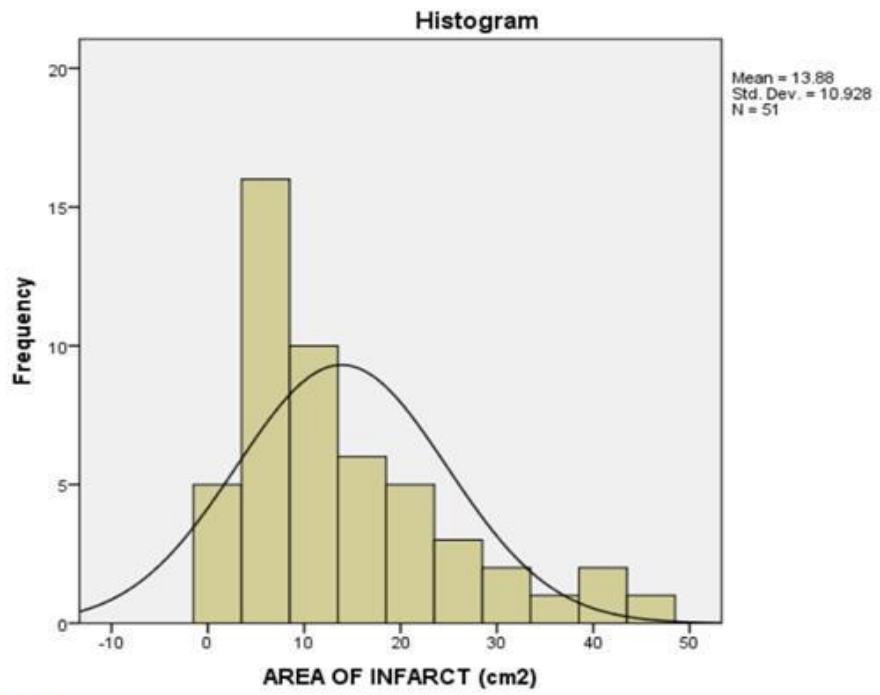


Fig 2.

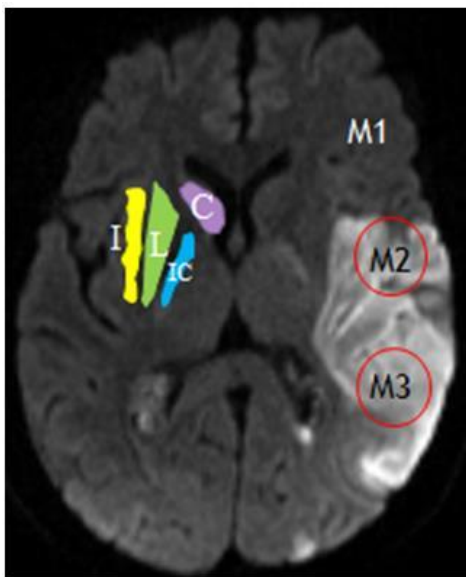


Fig 3a.

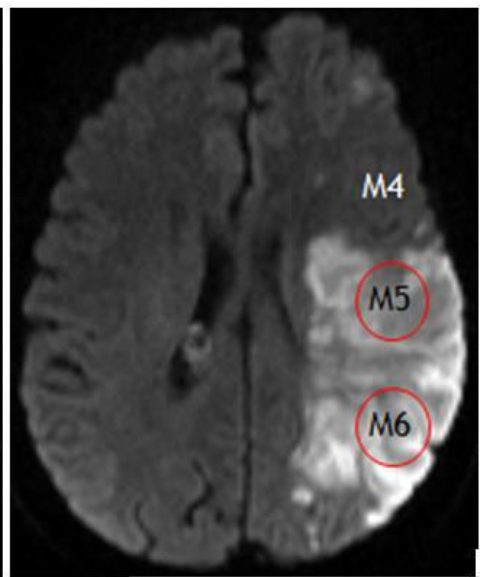


Fig 3b.



Fig 4a.

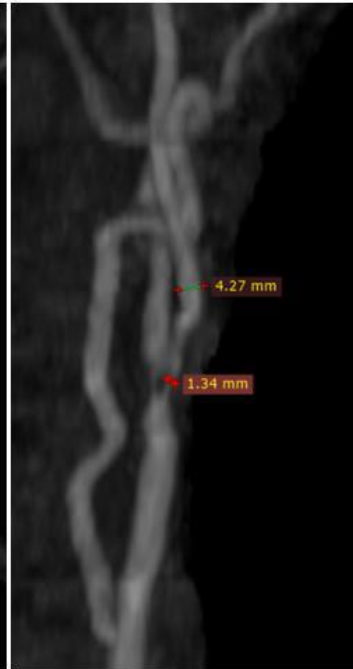


Fig 4b.

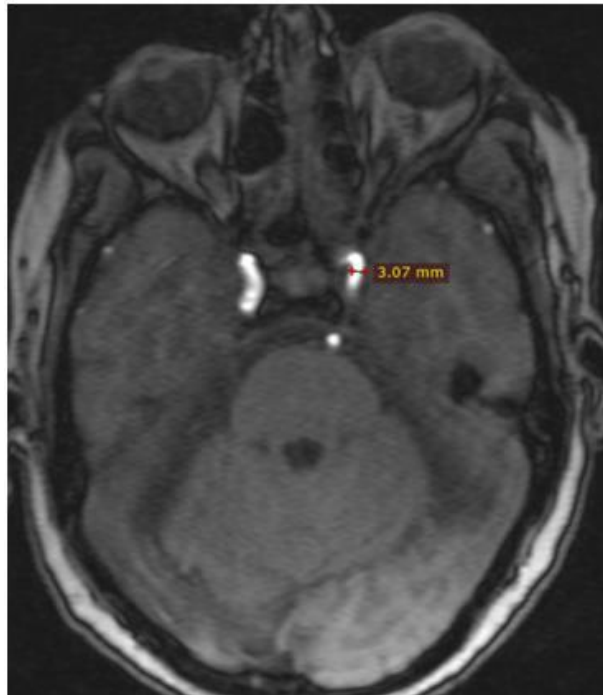


Fig 5a

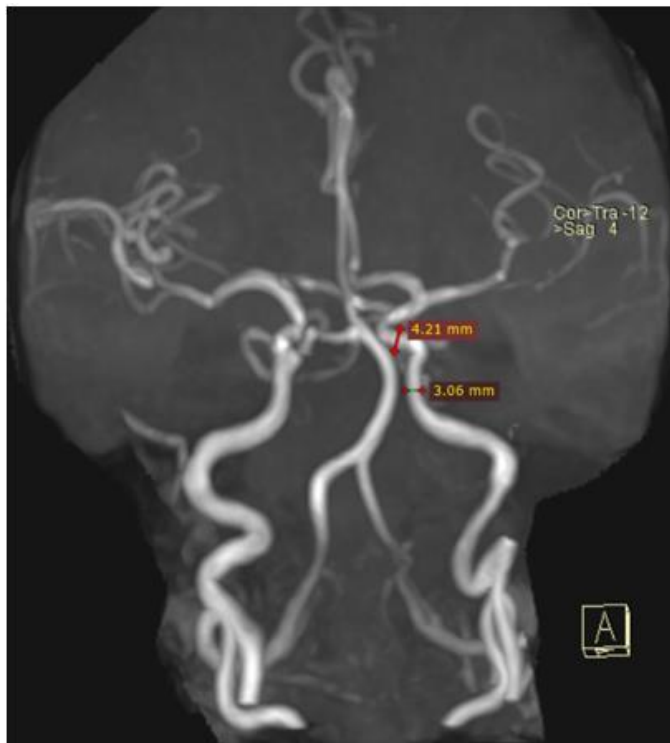


Fig 5b.

Stenosis group	Mean area(cm ²) "x"	N	<u>Std.Deviation</u>
Group 1 (0-49%)	7.18	11	4.285
Group 2 (50-69%)	10.07	14	6.108
Group 3 (70-100%)	18.88	26	12.625
TOTAL	13.8	51	10.928

TABLE1.

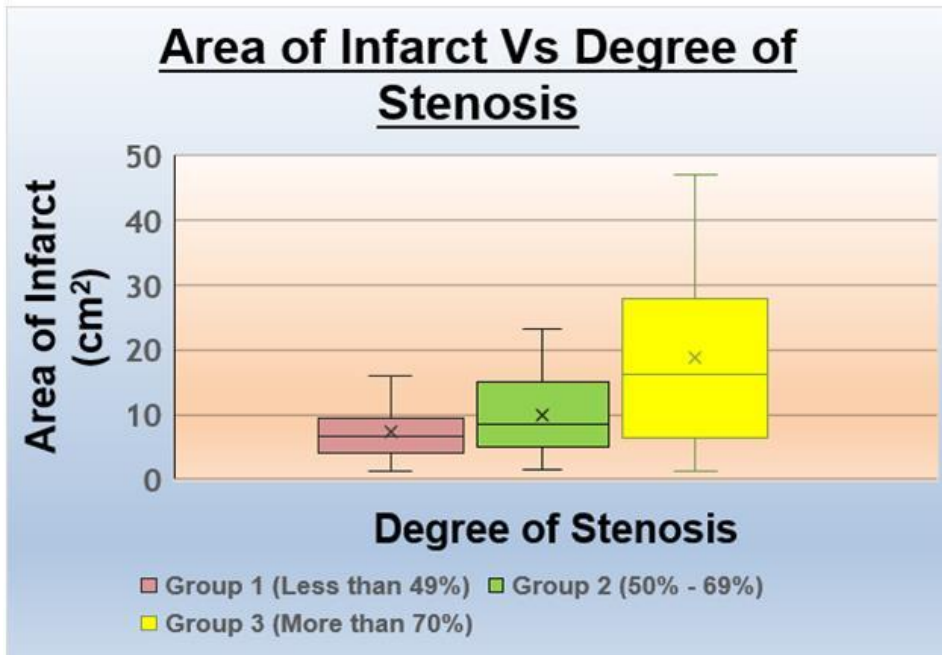


Fig 6.

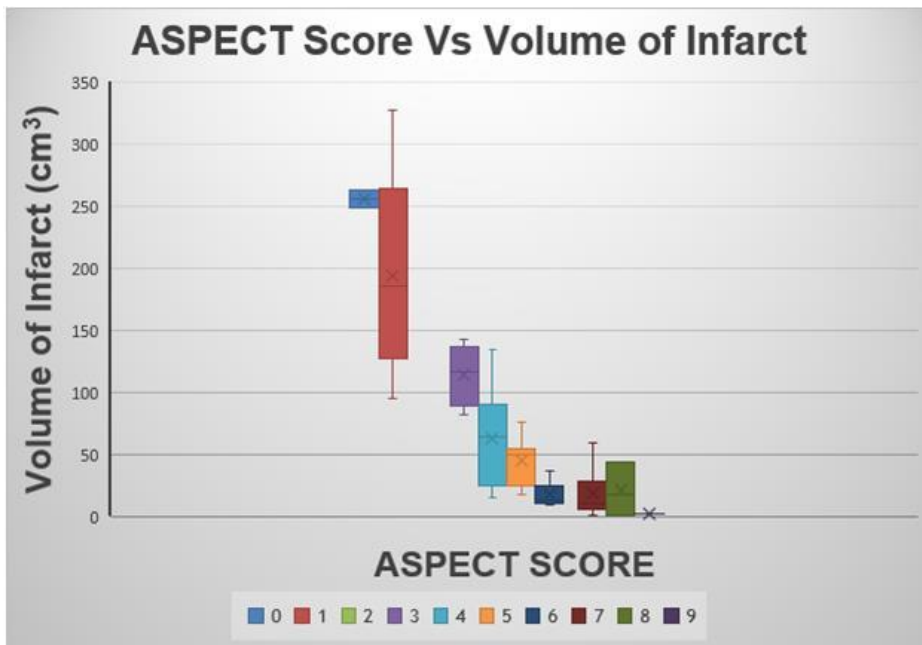


Fig 7.

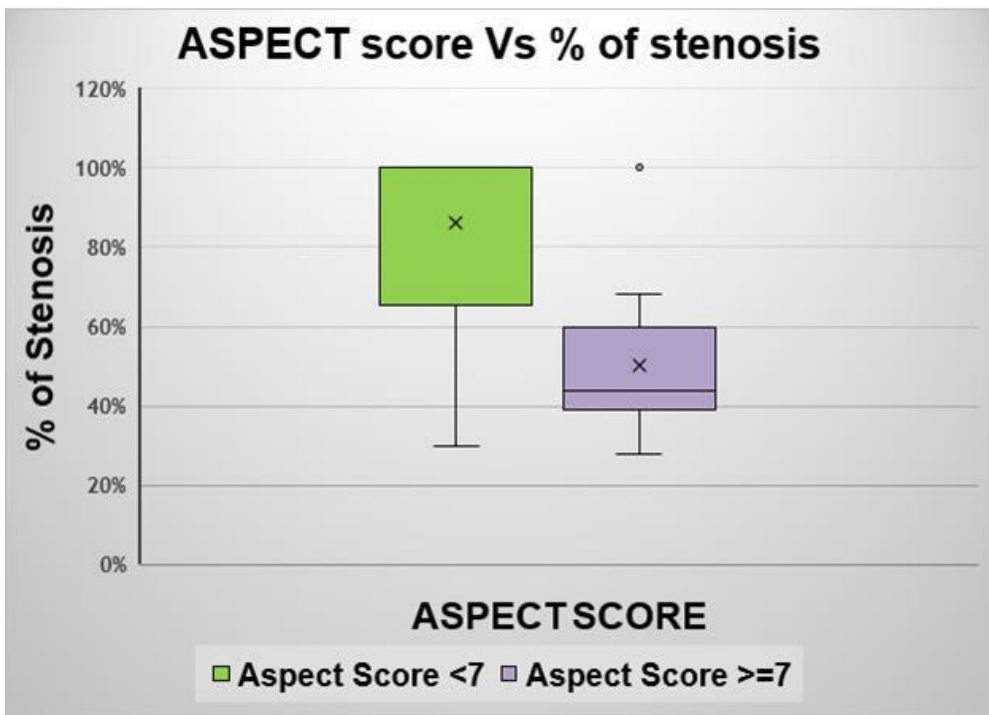


Fig 8.

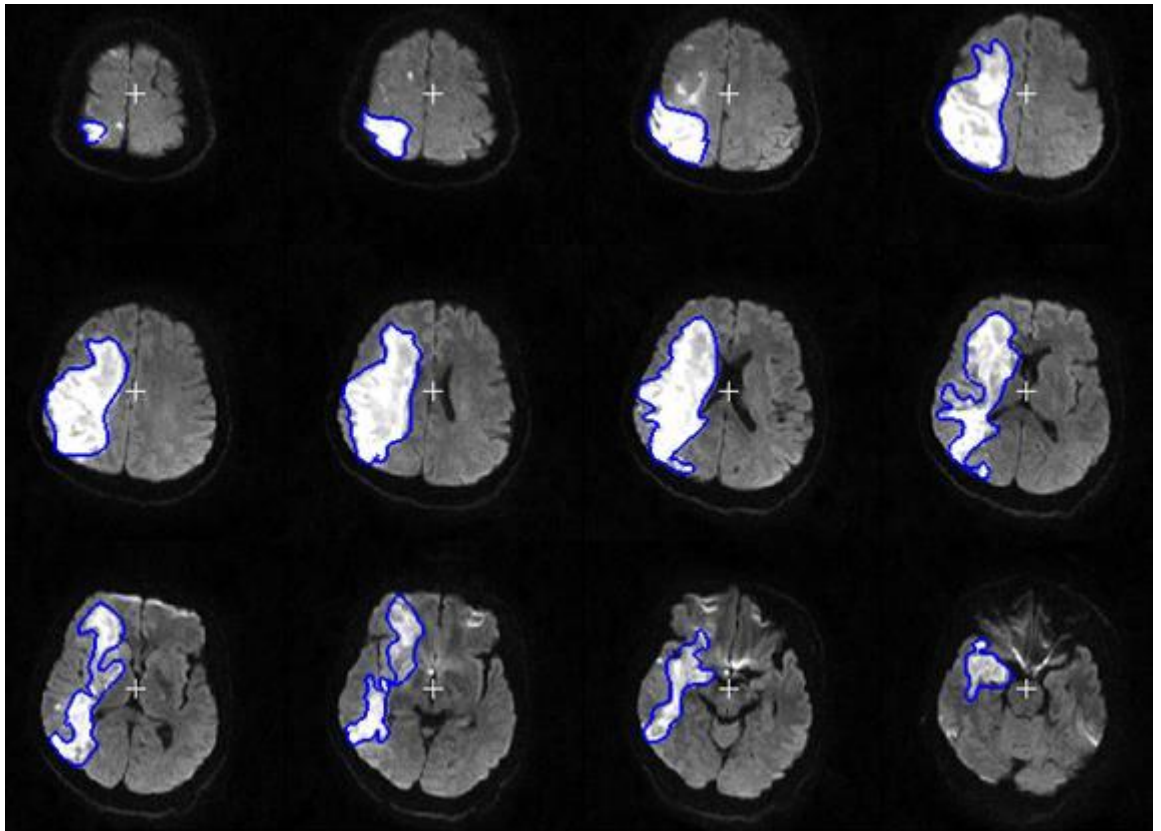


Fig 9a.

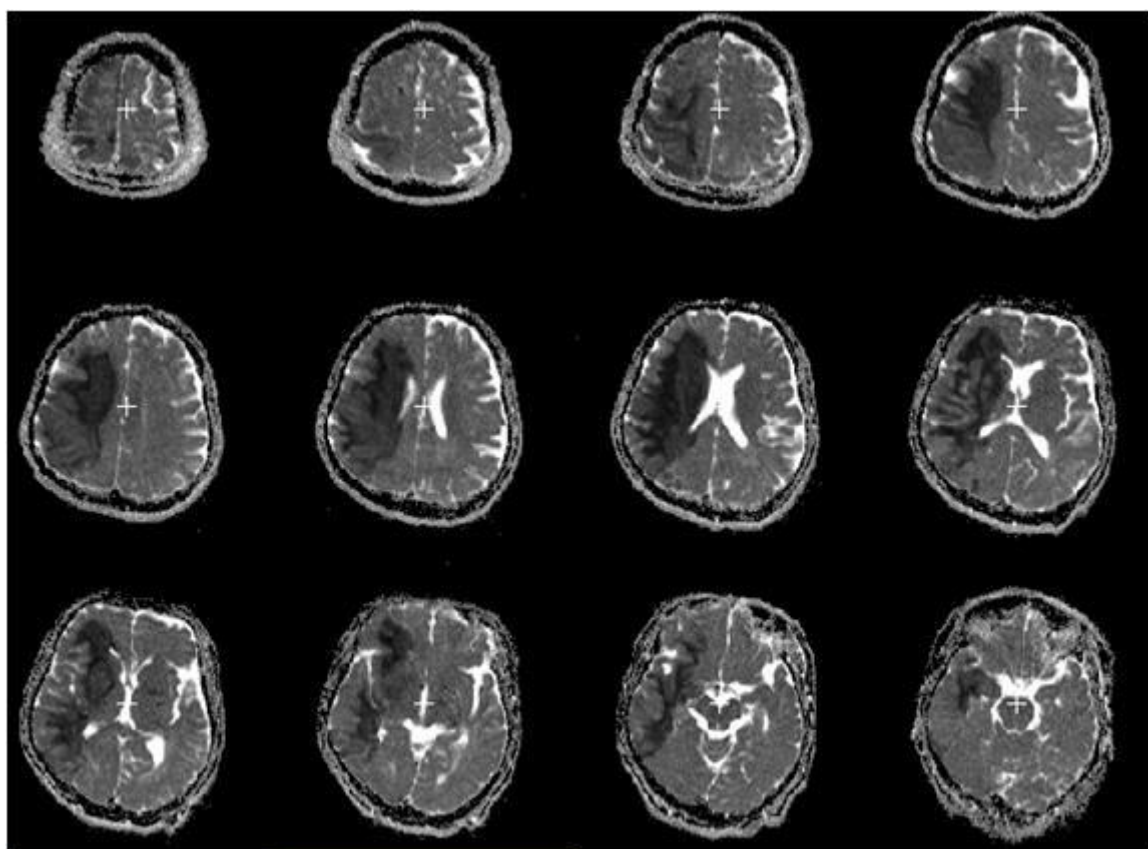


Fig 9b.



Fig 9c.

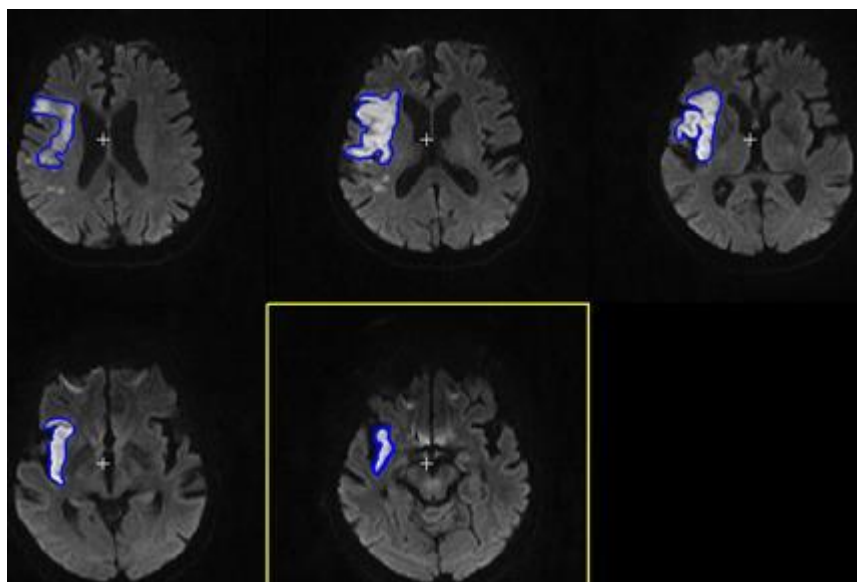


Fig 10a.

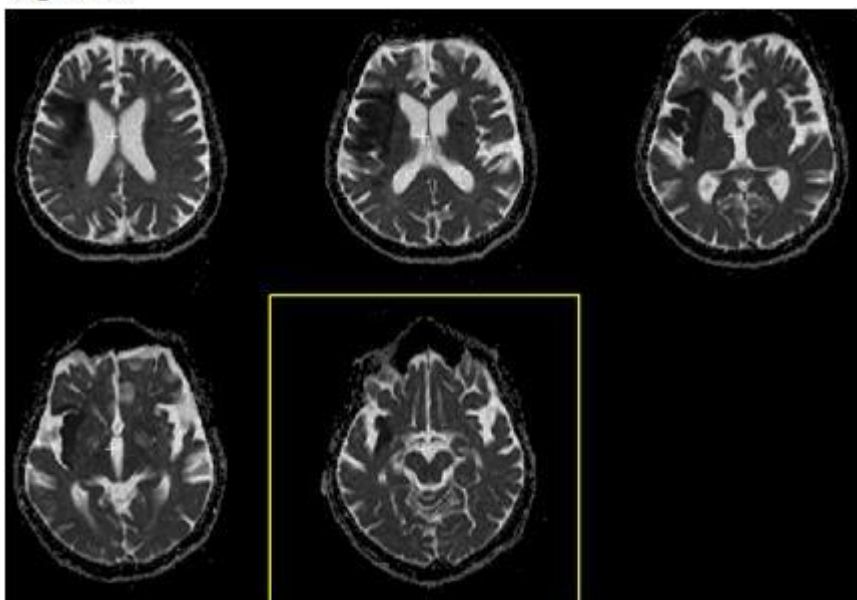


Fig 10b.

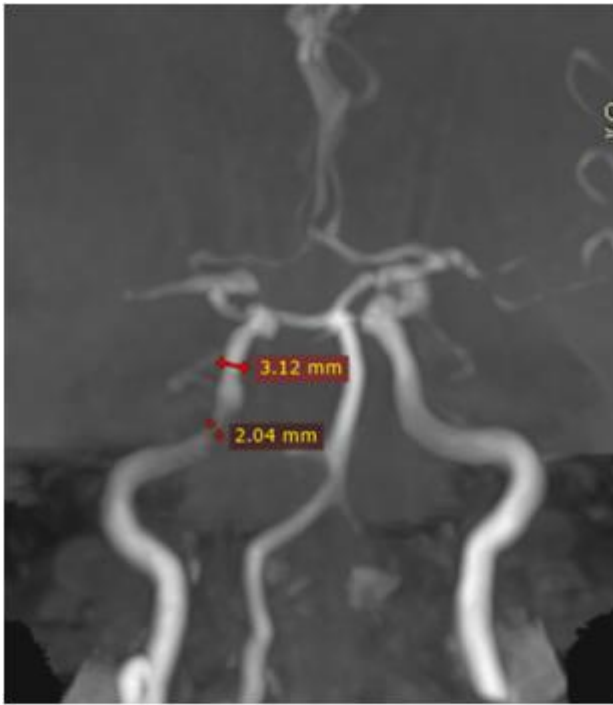


Fig 10c.

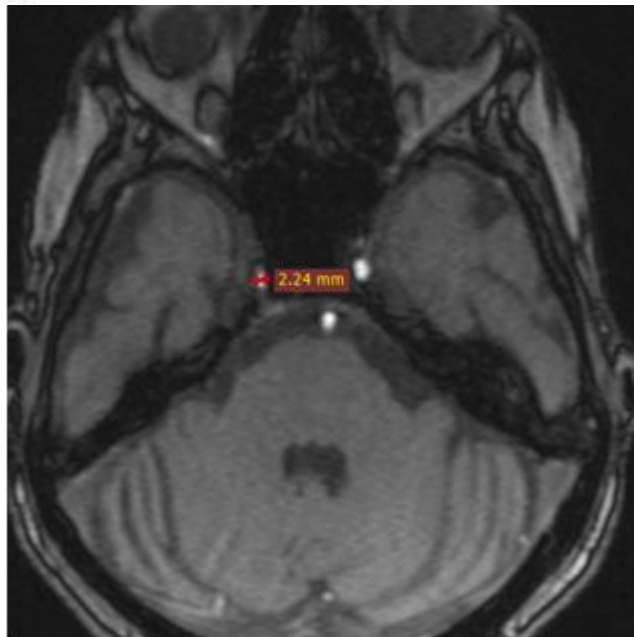


Fig 10d.

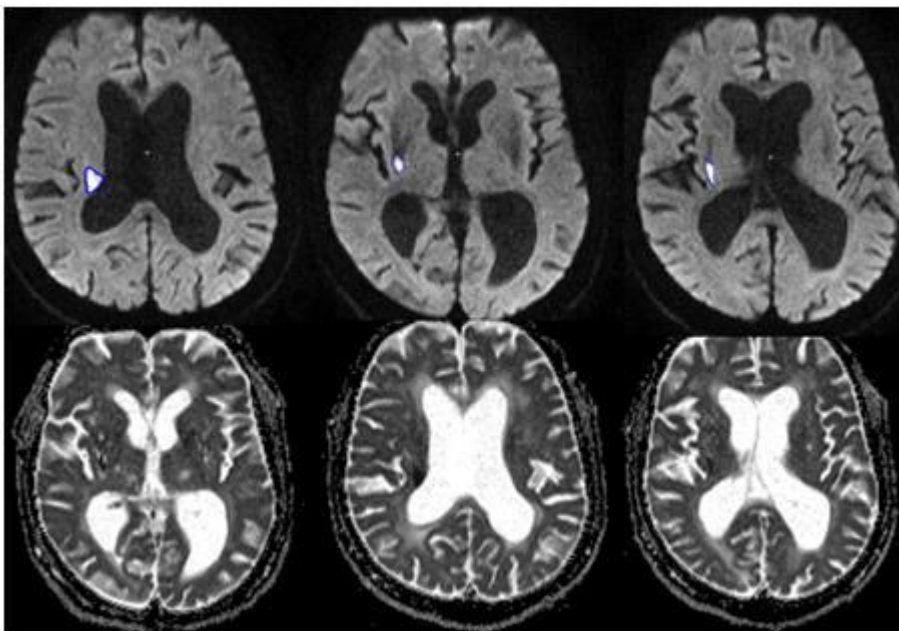


Fig 11a.

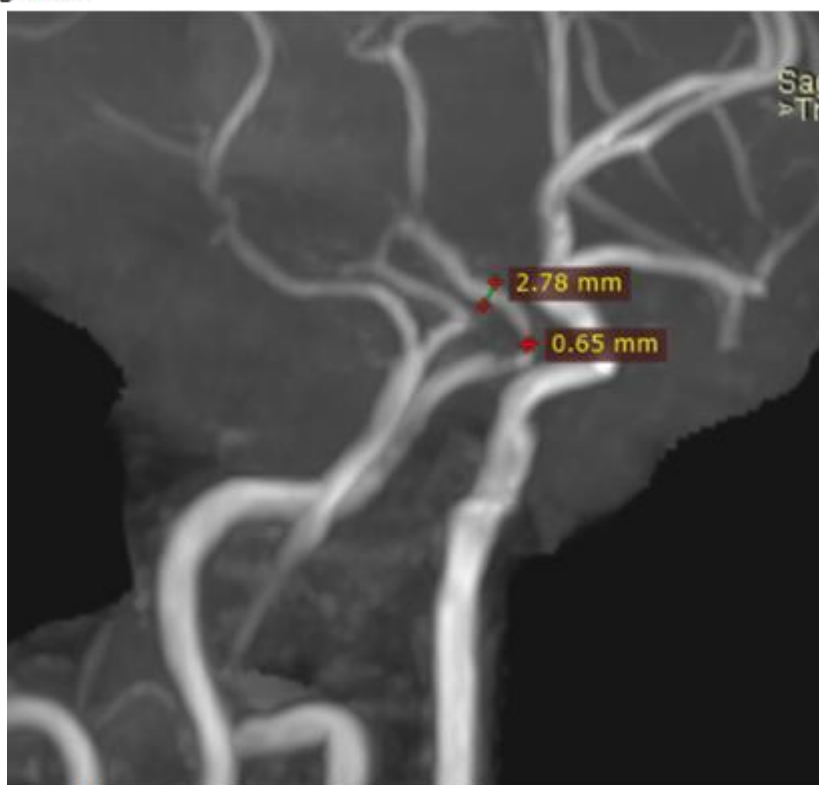


Fig 11b

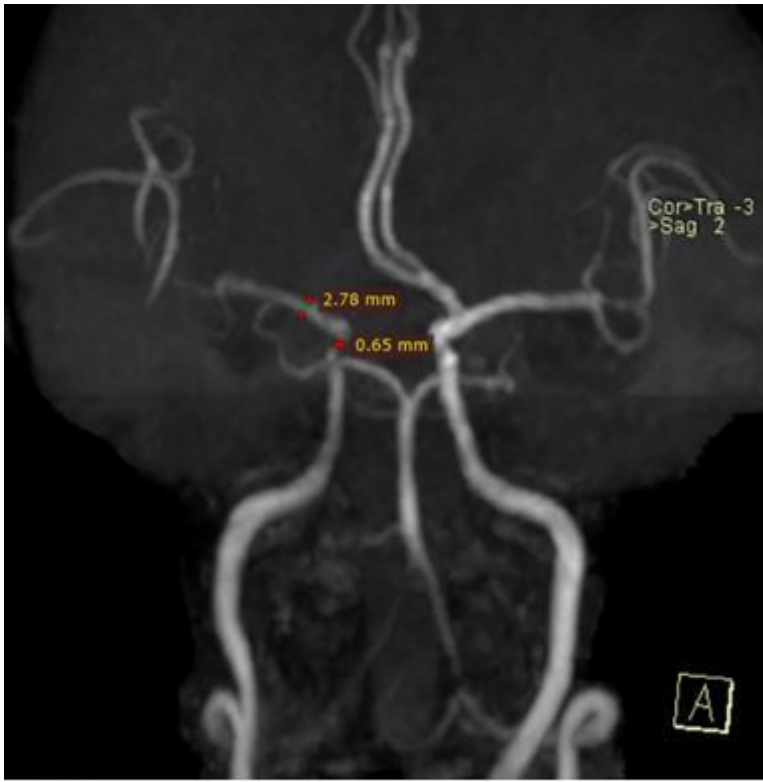


Fig 11c.