COMPARATIVE ANALYSIS OF COMPUTED TOMOGRAPHY ANGIOGRAPHY WITH DIGITAL SUBTRACTION ANGIOGRAPHY FOR COLLATERAL STATUS IN PATIENTS WITH ACUTE LARGE VESSEL ISCHEMIC STROKE AND TO CORRELATE THE COLLATERAL STATUS WITH CLINICAL OUTCOME

DR HARI KISHORE KAMEPALLI

DM NEUROIMAGING AND INTERVENTIONAL RADIOLOGY THESIS

2023

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A THESIS SUBMITTED BY

DR HARI KISHORE KAMEPALLI

TO

SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND TECHNOLOGY, TRIVANDRUM.

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE AWARD OF

DM NEUROIMAGING AND INTERVENTIONAL RADIOLOGY

2023

DECLARATION BY THE STUDENT

CERTIFICATE

I, **DR HARI KISHORE KAMEPALLI**, hereby certify that I had personally carried out the work depicted in the thesis titled, **"COMPARATIVE ANALYSIS OF COMPUTED TOMOGRAPHY ANGIOGRAPHY WITH DIGITAL SUBTRACTION ANGIOGRAPHY FOR COLLATERAL STATUS IN PATIENTS WITH ACUTE LARGE VESSEL ISCHEMIC STROKE AND TO CORRELATE THE COLLATERAL STATUS WITH CLINICAL OUTCOME".** No part of this thesis has been submitted for the award of any other degree or diploma prior to this date.

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APPROVAL OF THE THESIS

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of

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SYNOPSIS

BACKGROUND: Although some previous studies have compared CTA and DSA in assessing collateral status and their correlation with functional outcomes, they were limited by small sample sizes and conflicting results. Therefore, this study seeks to address the existing gaps in collateral assessment in acute stroke patients by comparing CTA and DSA in a larger population and its relation to clinical outcomes

AIMS & OBJECTIVES: To compare single and multiphase CTA with DSA collateral status in acute ischemic stroke of the anterior circulation due to large vessel occlusion and to correlate these collateral assessments with 90-day functional outcome.

MATERIALS & METHODS: This retrospective and prospective observational study conducted between December 2021 and March 2023 at a comprehensive stroke centre aimed to evaluate the correlation between collateral circulation and clinical outcomes in acute stroke patients with large vessel occlusion in the anterior circulation who underwent endovascular thrombectomy. The study enrolled 138 cases after exclusions. Demographic data, risk factors, pre-stroke modified Rankin Scale (mRS), and NIH Stroke Scale (NIHSS) score were recorded for each patient. Stroke etiology was evaluated using TOAST classification. Eligibility for endovascular thrombectomy was determined using CT angiography (CTA) and/or CT perfusion. Collateral status (CS) was assessed using the Tan scale for single-phase CTA and the modified ASITN/SIR scale for multi-phase CTA and DSA.

RESULTS & DISCUSSION: Good interobserver agreement between various imaging modalities and poor concordance between CTA and DSA CS scores were observed. Multi-phase CTA showed excellent discriminatory power in predicting functional outcomes, with an AUC of 0.87. In contrast, DSA displayed acceptable discriminatory power (AUC of 0.69), while single-phase CTA performed poorly in predicting functional outcomes. Our study aimed to establish cut-off values for CS to predict functional outcomes, with multi-phase CTA being the best predictor at a cut-off point of >2 and above, with an 88% chance of correctly predicting good functional outcomes.

Among the variables strongly associated with functional outcome, only multi-phase CTA showed a significant association with an odds ratio of 9.4. On the other hand, admission NIHSS, admission and 24-hour CT ASPECTS, final mTICI score, and single-phase CTA did not display significant independent predictive capability for the final clinical outcome. We also observed a higher incidence of poor collaterals in patients with a prior stroke and diabetic patients. However, we did not find an increased chance of haemorrhagic transformation in patients with poor collateral grades.

CONCLUSION: This study highlights that multiphasic CTA is superior to DSA and single-phase CTA in predicting functional outcomes for acute ischemic stroke patients. It also establishes useful cut-off values for collateral scores, demonstrating the excellent discriminatory power of multiphasic CTA in predicting functional outcomes in these patients.

1 Introduction

The grade of collateral filling in acute ischemic stroke is linked to their clinical outcomes (Ribo et al., 2011). Previous studies concluded that collateral vessels can delay the ischemic process by providing blood flow to the still recoverable tissue i.e., Penumbra (Vagal et al., 2018). In individuals who receive endovascular therapy (EVT), better collateral status is correlated with less significant volume of final infarct and good clinical outcomes than those with poor or absent collateral filling (Vagal et al., 2018; Elijovich et al., 2016; Wufuer et al., 2018). In recent times, there has been an increasing focus on evaluating collateral circulation, and several grading systems have been devised for diverse imaging modalities (McVerry et al., 2012; Martinon et al., 2014). Computed tomography (CT) scans are commonly employed to assess patients suspected of having acute strokes due to their speed, affordability, and noninvasive nature.

Single-phase computed tomographic angiography (CTA) can be limited in accurately grading collateral circulation, especially when there is delay in contrast arrival which can impact treatment decisions and patient outcome predictions. Multi-phase CTA is a promising solution to this challenge and has been shown to outperform single-phase CTA in predicting final infarct size and clinical outcome (Menon et al., 2015; Garcia-Tornel et al., 2016). Digital subtraction angiography (DSA) is the reference standard for assessing collateral blood flow in patients with acute stroke however, it is an invasive procedure, more expensive and time-consuming (Liu et al., 2018). Therefore, it is typically reserved for patients who undergo endovascular treatment.

Very few previous studies have compared the effectiveness of CTA and DSA in evaluating the collateral status of acute stroke and how it relates to the 90-day functional outcome. However, these studies were conducted on a small number of participants and produced conflicting results. Moreover, there is still no agreement on the use of collateral assessments and their correlation with functional outcomes in larger sample sizes. Hence we aim to compare collateral scores obtained from CTA & DSA and correlate these collateral scores with clinical outcome.

AIMS AND OBJECTIVES

To compare single and multiphase CTA with DSA collateral status in acute ischemic stroke of the anterior circulation due to large vessel occlusion and to correlate these collateral assessments with 90-day functional outcome.

2. REVIEW OF LITERATURE

Stroke burden

Globally, stroke remains a significant health burden, with over 12.2 million new cases reported each year. Unfortunately, during their lifetime1 in 4 individuals over the age of 25 may experience stroke resulting in more than 101 million individuals who have had a stroke Stroke-related mortality is also high, with approximately 6.5 million people succumbing to stroke annually. Ischemic strokes, which account for more than 62% of all strokes, affect over 7.6 million individuals and result in over 77 million people living with a history of ischemic stroke. Intracerebral hemorrhages, comprising over 28% of all stroke incidents globally, are also a significant contributor to the overall burden of stroke (WHO Global stroke fact sheet., 2022).

The severity of brain damage caused by acute ischemic stroke, which is often due to atherosclerosis and thromboembolism, can vary in the first few hours after the stroke occurs. Factors that can influence the extent of neural damage include the presence and degree of intracranial collaterals that provide alternative routes for blood flow to the brain. Management of acute ischemic stroke usually involves procedures such as intravenous thrombolysis or mechanical thrombectomy to restore blood flow to the affected arteries and minimize brain damage (Hammer., et al 2012). The presence of robust leptomeningeal collaterals can protect against infarct evolution and sustain their viability for extended periods, ranging from many hours to days, while infarcts with inadequate collaterals may undergo complete evolution within a few hours.

Collaterals refer to a system of blood vessels that can restore blood flow in the event of main artery occlusion (Faber et al., 2014). They are considered crucial for maintaining the "penumbra" - the region of brain tissue that is at risk of damage in patients with acute ischemic stroke. The adequacy of collateral circulation is believed to be a predictor of infarct size resulting from an acute ischemic stroke and is associated with more favorable clinical outcomes following intravenous thrombolysis and endovascular thrombectomy (Bang et al., 2011; Menon et al., 2013; Lima et al., 2010; Menon et al., 2011; Liebeskind et al., 2014; Nambiar et al., 2014; Ramaiah et al., 2014; Libeskind., 2003; Libeskind et al., 2014)

Collateral circulation – Anatomical types (Table 2.1)

Collateral type	Type of the vessels
Primary	Circle of Willis arterial segments (Acom and Pcom)
Secondary	Internal – external carotid artery anastomosis (mainly seen in chronic occlusion)
Tertiary	Angiogenesis, where new blood vessels are formed representing leptomeningeal collaterals, ACA-MCA, MCA-PCA, ACA-PCA (mainly seen in acute occlusion)

Factors affecting collateralization

Hypertension may decelerate the formation of collaterals (Lima et al., 2010). The use of statins before experiencing a stroke has been linked to better development of collateral blood vessels (Ovbiagele et al., 2007). The ability of collateral formation may decrease with age. The status of collateral blood vessels is also influenced by various factors such as hemodynamic fluctuations, including duration of ischemia and associated co-morbidities. Hyperglycemia, smoking, obesity, heart failure, pulmonary compromise, kidney disease, dyslipidemia and atherosclerosis have been variably shown to influence collateral vessel formation (Lima et al., 2010). Having an incomplete circle of Willis can also result in reduced collateral formation. The speed at which an occlusion, or blockage of blood flow, occurs also impacts collateral vessel development, with gradual onset occlusions, such as in Moya Moya syndrome showing better collateral vessel development compared to acute occlusions.

Imaging of collateral circulation

Various imaging modalities available to evaluate the collateral vessels include transcranial doppler scan, computed tomographic angiography (CTA), CT perfusion, magnetic resonance angiography (MRA),

arterial spin labelling (ASL) and digital subtraction angiography (DSA)

Digital subtraction angiography (DSA)

DSA, which allows for assessment of collateral flow in ischemic stroke, is considered the most reliable method (Higashida et al., 2003) as it provides high-quality images with precise time and space resolution (Chng et al., 2008; McVerry et al., 2012) However, it is not practical as the first-line diagnostic procedure for acute stroke triage due to the need for quick treatment and the relatively low expected benefit compared to the resources required. In other words, while DSA is considered the gold standard, because of the resources and time it consumes, it is not the first diagnostic test of choice in acute stroke, as well as the limited additional benefit it may provide compared to other faster diagnostic methods.

DSA is considered the benchmark for evaluating primary and secondary collaterals. When it comes to non-invasive imaging, CTA is generally more dependable than MRA in assessing the existence and extent of collateral networks (class II, level C evidence) (McVerry et al., 2012)

The ASITN/SIR (American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology) grading system, which is widely accepted, is used to evaluate the collaterals in acute stroke. This system categorizes collateral flow into grades 0-4, where grades 0-1 indicate poor collaterals, grade 2 indicates moderate collaterals and grades 3-4 indicate good collaterals (Higashida et al., 2003). Christoforidis along with his colleagues have presented an alternative collateral grading system that utilizes digital subtraction angiography (DSA), although it is not commonly used. This grading system divides collateral status into five grades. Studies utilising this scale observed that patients with rich collateral status (graded as 1 or 2) tend to have lower final infarct volumes, less chance of hemorrhagic transformation and better outcomes in a limited series of population (Menon et al., 2015; Christoforidis et al., 2005)

CT Angiography scan

Alternatively, computed tomographic angiography scan (CTA) is commonly utilized to assess collateral status due to its widespread availability and quick acquisition (Menon et al., 2015; Christoforidis et al., 2005; Menon et al., 2011). Studies have reported good agreement with CTA between different raters (Lima et al., 2010; Maas et al., 2009). One of the advantages of CTA is it gives snapshot of collateral flow from all the vessels, including both intra- and extracranial vessels, simultaneously (Lima et al., 2010) However, it has limited temporal information, although this can be addressed with the use of multiphase CT angiography.

Single phase collateral scoring systems

Currently, there are several methods for grading collateral flow using single phase CTA in the context of cerebral artery occlusion. These methods include Miteff et al grading (Miteff et al., 2009) (focused on collateral reformation in relation to sylvian fissure) Maas et al (Maas et al., 2009), (assesses collaterals reformation at specific anatomical locations such as the Sylvian sulcus, cerebral convexity and circle of Willis) Tan et al (Tan et al., 2009), (assess collateral reformation along the MCA territory) regional leptomeningeal collateral (rLMC) score (Menon et al., 2011) (evaluates collaterals in parasagittal anterior cerebral artery (ACA) territory, MCA cortical regions, sylvan sulcus and the basal ganglia and ASPECTS scale (assessed collaterals in the corresponding ASPECTS segments)

Miteff system

Grading	Collateral description
Grade 3	Reformation of collaterals distal to occlusion site
Grade 2	Reformed collaterals only at sylvian fissure
Grade 1	Reformed collaterals seen only in the superficial distal branches

A study observed that the Miteff score (Table 2.2) was more effective in predicting clinical outcome compared to other single phase collateral scales. Apart from good prognosis, patients with good collaterals had lower NIHSS, smaller infarct volumes (Yeo et al., 2015)

Mass grading

This is a 5-point scoring system assessing collaterals at specific anatomical locations such as the Sylvian sulcus, cerebral convexity, circle of Willis and comparing the affected side with contralateral side (Table 2.3).

Score	Collateral description
1	Collaterals not seen
2	Diminished, compared to contralateral side
3	Same, compared to the contralateral side
4	Increased, compared to the contralateral side
5	Richly collateralized, compared to contralateral side

Tan scale

This scale assigns a score of 0-1 for poor collateral circulation and a score of 2-3 for good collateral circulation along the MCA territory (Table 2.4)

Tan score	**Findings (MCA territory)**
0	Completely absent collaterals beyond the occlusion
1	Partially reformed collaterals filling ≤ 50%, ≥ 0% beyond the occlusion
2	Partially reformed collaterals filling ≥50%, ≤ 100% beyond the occlusion
3	Completely reformed collaterals (≥100%) beyond the occlusion

Modified Tan scale

The mTAN (modified TAN) scoring system (Baydemir et al., 2021) assess cerebral collateral circulation with least inter observer variability and rapid evaluation. In this system, collateral status is classified as poor if it is filling below 50% and as good if it is above 50% of the occluded circulation (middle cerebral artery)

Regional leptomeningeal collateral (rLMC) score

This scale (with score from 0-20) assesses the amount of contrast attenuation (MIP images) in the collateral vessels that have reformed in the affected region (MCA circulation) beyond the occlusion, in comparison to the opposite side (Table 2.5). A higher score on the rLMC scale indicates good collateral circulation, meaning that there is more effective blood flow through alternate routes to compensate for the blocked artery (Menon et al., 2011)

Sites involved	Grade 0 - Collaterals not seen Grade 1 - Diminished, compared to contralateral side Grade 2 - Same, compared to contralateral side Grade 3 - Increased, compared to contralateral side
M1 cortical regions	
Sylvian region	
M2 cortical regions	
M3 cortical regions	
M4 cortical regions	
M5 cortical regions	
M6 cortical regions	
ACA territory	
Basal ganglia	
Total score	

ASPECTS collateral grading

This system assigns scores ranging from 0- 20 to assess collaterals in each of the corresponding 10 of ASPECTS scale (Table 2.6).

Grade	**Corresponding site**
0	Collaterals not seen
1	Diminished, compared to contralateral side
2	Same/increased compared to contralateral side

Multi-phase collateral scoring systems

Multiphase CT angiography images gives better temporal resolution when compared with mono phasic CT angiography images.

The multiphase CTA collateral score is a widely used scale that assess the phase delay in filling of collateral vessels compared to contralateral side. This scoring system has been demonstrated to be more effective than a decision based solely on single-phase CT angiography in predicting clinical outcomes and determining eligibility for endovascular interventions.

To evaluate the phase delay in the filling of collateral and pial vessels in cases of acute stroke, a grading scale ranging from 0 to 5 is used. A higher score on this scale (with 5 being the highest) corresponds to normal filling and pial vessels, while a lower score (with 0 being the lowest) indicates a reduced or absence of visible vessels. A score of <3 is indicative of a poor prognosis (Boers et al., 2017)

Additionally, there are collateral grading methods, initially developed for DSA, that have been modified and can now be used with CT angiography such as the ASITN/SIR (24) and the Christoforidis collateral grading systems (Christoforidis et al., 2005)

The clinical impact of existing grading methods for collateral status has been studied, but the results have been inconsistent, and none of these methods have been verified in studies involving large amounts of data. However poor collateral grades as assessed

by the Maas collateral grade, Miteff collateral grades and the rLMC score was found to be associated with an unfavorable clinical outcome (mRS score 5-6) when analyzed independently (Yeo et al., 2015, Seker et al., 2016)

Computed tomographic Perfusion (CTP)

CTP has the potential to offer an objective and numerical assessment of collateral status without being reliant on user interpretation. Prasetya et al in their study "CT Perfusion for intracranial collateral Status evaluation in acute stroke patients" quantified blood flow of collaterals using a threshold of >6 seconds for delay time, with sensitivity and specificity of 88%, 92% respectively. CTP collateral index, calculated as delay time >6 seconds to >2 seconds, correlated with CTA collateral scores with an optimal threshold of ~32% for predicting good collateral status (Sensitivity and specificity is 83%, 86% respectively) (Prasetya et al., 2022)

Magnetic resonance imaging (MRI)

FLAIR imaging

In patients with MCA occlusion, a noticeable increase in hyper intense signals on T2/FLAIR imaging in the distal (farther from the occlusion site) region is linked to smaller infarct volume, larger mismatches between diffusion and perfusion imaging, better scores on the NIHS scale noted (Lee et al., 2009, Karadeli et al., 2016) Although not conclusively proven, these findings suggest that the presence of prominent T2/FLAIR hyper intense signals in the distal region may be indicative of good collateral reformation (Mahdjoub et al., 2018; Gawlitza et al., 2017)

Time of flight angiography (TOF MRA)

While TOF MRA can be used to evaluate the status of primary intracranial collaterals, it is not suitable for assessing secondary and tertiary collateral status due to its limited spatial resolution. Sensitivity in detecting collaterals near circle of Willis anterior and posterior segments are high and low respectively while specificity is high (Hendrikse et al., 2008).

Arterial spin labelling (ASL)

The use of territorial ASL can offer insights into the presence of intracranial collaterals among individuals with occlusion (Chng et al., 2008). Studies have shown that the combination of 3D pseudo-continuous arterial spin labeling (ASL) and multiple post-labeling delays (PLD) can be used to calculate the blood flow in the occluded vessels and in the collaterals as well (Lyu et al., 2016).

Studies have demonstrated a correlation between the clinical outcome of patients with acute stroke and the presence of collaterals detected by ASL (De Havenon et al., 2017; Lou et al., 2019).

Susceptibility weighted imaging (SWI)

Studies have shown that, it can assess the status of collaterals in acute stroke and additionally, it can also be utilized for prognostication (Hua et al., 2018)

Studies have alsoshown that susceptibility-diffusion mismatch technique can be helpful in identifying individuals who could potentially gain from intravenous thrombolytics or endovascular treatment (Lou et al., 2014)

Transcranial Doppler (TCD)

The ability of doppler in detecting flow indices including collateral vessel formation and flow velocity largely depends on the operator's expertise. This is an inexpensive and non-invasive technique for evaluating these parameters, but the skill and experience of the operators play a crucial role in obtaining accurate results (Alexandrov et al., 2012)

The ability of transcranial Doppler (TCD), to directly or indirectly detect blood flow through the collaterals has been reported to have a sensitivity, specificity of 95%, 100% respectively in detecting a patent Acom and a sensitivity, specificity of 87%, 95% respectively in assessing collateral flow through the basilar artery, with digital subtraction angiography (DSA) used as a reference standard (Brunser et al., 2016). In other words, when there is a blockage or significant narrowing in the MCA, the ACA or PCA may show increased flow velocity and reduced resistance, indicating a

phenomenon known as flow diversion. This suggests the presence of collateral connections between the ACA and PCA including the small calibered distal branches of the MCA (Muller et al., 1995; Kim et al., 2009)

Imaging in posterior circulation

Goyal et al (Goyal et al., 2016) had introduced collateral grading basing on the posterior communicating artery (Pcom) status with scores ranging from 0-2 (Table 2.7).

Score	Pcom status
0	Not seen
1	Seen only one side
2	Seen bilaterally

The existence of bilateral Pcom prior to endovascular treatment is linked with good prognosis.

Van der Hoeven erik et al (Erik et al., 2016) developed an alternative scoring method for CT angiography collateral assessment, which involves assigning scores on a 10-point scale (Table 2.8).

Vessel inv.	**Pcom**	**SCA**	**AICA**	**PICA**
Score	1 – One side only 2- Both sides 1 (Diameter < PCA) 2 (Diameter > PCA)	1 – One side only 2- Both sides	1 – One side only 2- Both sides	1 – One side only 2- Both sides

In this approach, a score of 1 is assigned to each visible SCA, PICA and AICA Additionally, If the maximum diameter of a posterior communicating artery (Pcom) is smaller than that of the posterior cerebral artery (PCA), it is assigned a score of 1 and a score of 2 is given if its diameter is larger than the PCA. A collateral score ranging from 6 to 10 is considered indicative of good collateral status.

Qureshi et al. (Alqadri et al., 2013) introduced another novel collateral grading system in the posterior circulation. Grade 1 corresponds to retrograde filling of the basilar artery via the posterior cerebral artery (PCA), while Grade 2 indicates retrograde filling of the superior cerebellar artery (SCA) which in turn is filling the basilar artery. Grades 3 and 4 refer to either bilateral or unilateral connection between cerebellar arteries or the PCA respectively.

Interventions to enhance intracranial collateral status

To implement experimental collateral therapeutics such as nitric oxide inhalation (NO) (Terpolilli et al., 2012), sphenopalatine ganglion activation (Khurana et al., 2019), high amount of albumin infusion (Ginsberg et al., 2013) and external counter pulsation (Hammer et al., 2009) in clinical practice, further research on collaterals pathophysiology needs to be evaluated in large-data studies before their widespread use in humans. These experimental methods have shown promising results in improving collaterals in animal models, but their safety and effectiveness in human populations need to be thoroughly investigated through extensive research before they can be considered for clinical application.

Impact of collaterals in radiological and clinical outcome

- According to the updated guidelines from the American Stroke Association (ASA), (Powers et al., 2018) it is reasonable to consider the status of collateral blood flow when making clinical decisions for some patients who are being considered for mechanical thrombectomy in acute stroke - Evidence C with a class 2B recommendation, indicating moderate-quality evidence supporting this consideration.

- Interventional management of stroke - III trial (Broderick et al., 2013) found that patients with better collateral status had smaller final infarct core volume and a higher mismatch. Hence CT perfusion and angiography collaterals have been used as imaging criteria to include patients in in stroke trials conducted for endovascular treatment.

- The EXTEND IA (Campbell et al., 2015) and SWIFT PRIME (Saver et al., 2015) trials employed CT perfusion imaging to select patients for endovascular treatment, while the ESCAPE trial used CT angiography imaging. CT perfusion has certain limitations, including delays in processing time, potential inconsistencies in acquisition, and variations in post-processing software.

- The SWIFT study (Saver et al., 2012) found better recanalization rates in thrombectomy procedures using the stent retriever was more likely to occur when better collaterals were seen in angiography.

- Rich collateral status at the sylvian fissure was found to be associated with favorable functional recovery (mRS score ≤ 2) (Kim et al., 2017). This beneficial effect was likely attributed to a reduction in the final infarct volume.

- A meta-analysis (Wufuer et al., 2018; Leng et al., 2016) investigated the impact of collateral status on clinical outcomes following thrombolytic therapy, and found that patients with better collateral scores had higher rates of successful recanalization and improved long-term functional outcomes. Patients who have well-developed collateral blood vessels may experience improved dissolution of clots with intravenous tissue plasminogen activator (tPA) due to better transport of fibrinolytics to both sides of the clot.

- In a study, it was noted that the poor collateral reformation in acute stroke patients had a significant hemorrhage rate (> 25 ml) of 25% after intra-arterial treatment however patients with improved collateral reformation had a much lower rate of 2.7% (Christoforidis et al., 2009; Bang et al., 2011) As a result, caution was advised when considering intra-arterial treatment for the candidates having with poor collaterals.

3. MATERIALS AND METHODS

Present study was approved by institute ethics committee (Annexure). This study was a retrospective and prospective observational study performed in the department of radiology, SCTIMST, Trivandrum between Dec 2021 and March 2023.

The study obtained written consent from individuals or their guardians who were prospectively enrolled. However, for retrospective patients, consent was waived by the institute. All consecutive patients with acute ischemic stroke satisfying the inclusion criteria were included in the study.

Inclusion criteria:

1.Acute stroke with large vessel occlusion in the anterior circulation who underwent CT angiography.

2.The same patients who underwent DSA on the affected side as a part of endovascular thrombectomy (EVT)

Exclusion criteria :

1. Non-availability of CTA
2. DSA images degraded by artifacts
3. Non-availability of complete angiographic runs for review.

Study design:

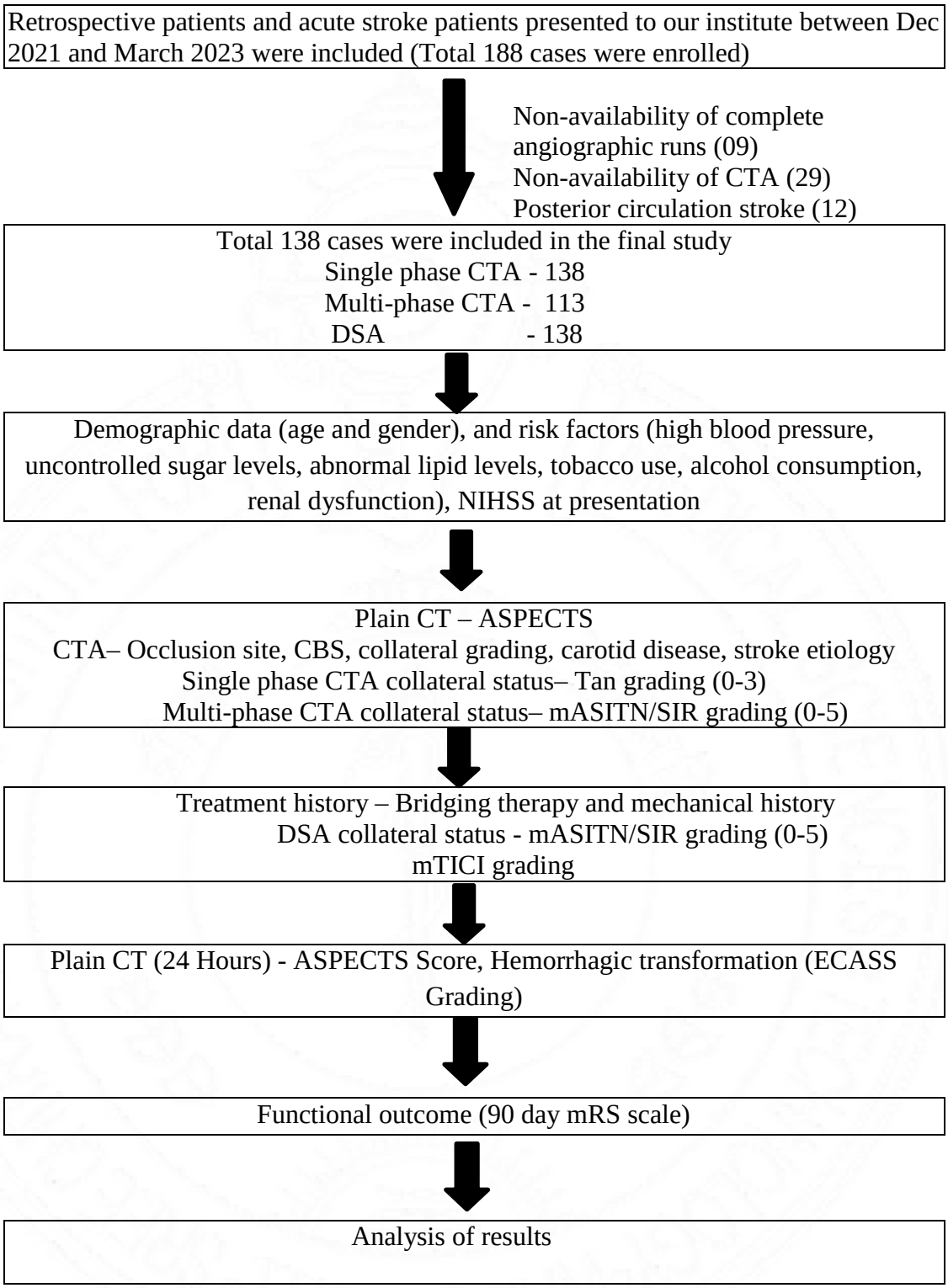
1. Study was started after approval by institute ethics committee
2. Written informed consent was obtained for prospectively enrolled patients and consent was waivered for retrospective patients
3. The study obtained written consent from individuals or their guardians who were prospectively enrolled and for retrospective patients, consent was waived by the institute
4. The data was evaluated after removing any identifiable information.
5. Demographic data (age and gender), and risk factors (high blood pressure, uncontrolled sugar levels, abnormal lipid levels, tobacco use, alcohol consumption, renal dysfunction), were noted.
6. Pre-stroke mRS score and stroke severity at baseline was assessed using NIHSS Score
7. Early brain parenchymal changes in CT scan was evaluated to calculate the ASPECTS score.
8. In the CTA, the site of occlusion, clot burden score and collateral status (CS) was noted.
9. Single phase CTA collateral status was assessed with TAN scale and Multiphase CTA and DSA collateral status was assessed using modified ASITN/SIR collateral scale.
10. The CS on DSA & CTA source images was determined separately by 2 Neuro radiologists (HK and VK) and any discrepancies between them was solved by an experienced third neuroradiologist (SK)
11. DSA & CT collateral scores were analyzed separately at different times.
12. Treatment history including bridging therapy and mTICI grading was also noted.

13. As per our institution protocol, 24 hours plain CT was done for all the patients and CT ASPECTS score, hemorrhagic transformation was noted (ECASS grading)

14. Finally, CTA and DSA grades was correlated with functional outcome (modified Rankin scale- 90 days after index event). The criteria for distinguishing favorable outcomes from unfavorable ones were based on mRS scores, with scores ranging from 0 to 2 indicating good functional outcomes and scores from 3 to 6 indicating poor functional outcomes.

15. Kolmogorov-Smirnov test was used for normally distributed data and non-parametric tests were used when the data were not normally distributed. Inter-rater kappa agreement was used to determine the strength of agreement between observers and between DSA and CTA. Statistical tests such as Mann-Whitney test, independent t-test, Chi-square test, Fisher's exact test, uni and multivariate logistic regression, univariate and multivariate linear regression, and Spearman correlation coefficient were used to analyze the data and identify independent significant factors affecting functional outcome. ROC curve was used to find out the cut-off point, sensitivity, specificity, and predictive values of various imaging modalities in forecasting good clinical outcome.

Study design flow chart



Study protocols

Head plain CT

In the present study, we used 256-slice CT scanner (Brilliance ICT, Philips CT Scanner, Netherlands). All eligible patients, first underwent axial plain CT acquisition with a section thickness of 0.6 mm. Subsequently, the images were reformatted to 0.3 mm thickness for the assessment of CT ASPECTS score.

Single and multiphase CT angiography

A CT-angiography was performed using an automated trigger technique with bolus tracking.

An area of interest was selected within the aortic arch and a trigger threshold of 150 Hounsfield units (HU) was established. Afterward, a contrast agent (Iohexol - Omnipaque 350 / Iodixanol / Visipaque) was injected at a speed of 5 mL per second, with a total volume of 50 milliliters (mL). Then, a flush of 30 milliliters of saline solution was given

Images are acquired from the aortic arch in the thoracic region to the vertex of head during the phase in which arteries had maximum contrast opacification (peak arterial phase) followed by early and delayed venous phases covering from the skull base to head vertex. Arterial phase images were acquired after a plain CT, and early and delayed venous phase images were acquired with an 8-second delay each.

Images were obtained with a collimation of 128 x 0.6 mm, pitch of 0.9, and reconstructed at a thickness of 0.3 mm into axial, coronal, and sagittal sections with 50% overlap for axial images.

Digital subtraction angiography

A bi-planar GE neuro angiography suite was utilized to perform endovascular thrombectomy, with standard anteroposterior (AP) and lateral DSA views obtained on the affected side. Stent retriever was employed for all the cases, and the extent of final recanalization was noted employing the (mTICI) scale.

Definition of parameters:

ASPECTS (Plain CT)

The ASPECTS (Barber et al., 2000; Pexman et al., 2001) is a scoring system that is utilized to evaluate the initial changes in brain parenchyma secondary to acute stroke along anterior circulation in CT scans. This evaluation is performed at two different levels - At the level of the capsuloganglionic region and lateral ventricles just above the capsuloganglionic region. Scale ranges from 0 to 10, with 1 point deducted from the total score of 10 based on the region affected, including the caudate head, lentiform nucleus, internal capsule, insula, and M1-M3 cortices at the basal ganglia level, and M4-M6 cortices at the lateral ventricle level. The ASPECTS score is calculated at the time of admission and is also assessed 24 hours later to determine the extent of ischemic injury or infarct extent.

NIHSS

The NIHSS (NIH Stroke Scale., 2023; Lyden et al., 2017) is a quantitative scale used to assess neurological deficits in acute stroke. It is known for its good inter-observer agreement and quick administration.

The NIHSS is a numerical scoring system that is utilized to measure neurological impairments in patients who have experienced acute stroke. This evaluation tool is recognized for its reliability in terms of consistency between different individuals who use it and patient's condition, can also be assessed quickly. The scale consists of 11 responses, each scored from 0 to 4 based on the degree of response exhibited by the patient. These responses include assessments for loss of consciousness, visual field, eye movements, facial palsy, motor leg and arm responses, ataxic limbs, language, speech, sensory symptoms, extinction, and inattention.

A high score (Maximum and minimum score – 42 and 0 respectively) implies the presence of significant neurological impairments. In general, individuals who have a score lower than 5 are usually classified as having experienced a mild stroke. This subset of population is not considered for endovascular intervention; hence they are not included in the study. However, for endovascular intervention, individuals with

middle cerebral artery (MCA) and/or internal carotid artery (ICA) occlusion with NIHSS scores between 6 and 25 are generally considered eligible.

Modified Rankin scale (mRS)

This is a commonly used clinical tool to assess the degree of impairment or dependency in routine activities of a person who have experienced an acute stroke. It has a scale that spans from 0 to 6 - Score of 0 specifies no symptoms whereas a score of 6 specifies the occurrence of death. In this study, the admission and 90-day mRS scores were noted (Table 3.1).

A mRS score of ≤2 was considered as a favorable functional outcome, indicating good recovery, while a score of ≥3 was considered as an unfavorable functional outcome, indicating poor recovery (Rankin., 1957; Van Swieten et al., 1988)

Score	Description
0	No symptoms, meaning no signs of illness or impairment
1	Mild impairment: Symptoms are present, but the individual is still able to carry out regular duties and activities.
2	Mild to moderate impairment: Some difficulty in performing previous activities, but able to manage personal activities independently
3	Moderate impairment: The person needs assistance with walking, but they can still move without constant aid
4	Moderate to severe impairment: The individual cannot walk without help and requires assistance for basic bodily needs.
5	Severe impairment: The person is bedridden, has no control over their bladder or bowels, and requires continuous nursing care
6	Deceased

Single phase CT angiographic collateral scale:

The study used the Tan scale (Tan et al., 2009) which is a commonly used grading scale to assess anterior circulation collateral circulation for acute stroke. The Tan scale is a single-phase grading system that assigns a score of 0-1 for poor collateral circulation and a score of 2-3 for good collateral circulation. This scoring system is used for both single-phase CT angiography and the first phase of multi-phase CT angiography (Table 3.2).

Tan score	**Findings**
0	There is no collateral blood flow at all to the area of the brain supplied by the blocked middle cerebral artery (MCA)
1	Some collateral blood flow is present, but it only fills up to 50% of the blocked MCA territory
2	Collateral blood flow is present and fills between 50% and 100% of the blocked MCA territory
3	The blocked MCA territory is completely supplied by collateral blood flow, which is equal to or greater than the amount of blood flow that would normally be provided by the MCA

Multi-phase CT and DSA collateral grading (mASITN/SIR):

In our study, we used modified ASITN/SIR (Higashida et al., 2003) scale to assess collateral scoring in multiphase CT angiography and DSA. This scale gives both spatial and temporal status of the collaterals. Scores from 0-2 are considered as poor collaterals and 3-4 as good collateral circulation (Table 3.3).

Modified ASITN/SIR scale	**Findings**
0	The ischemic site shows only minimal/no visible collaterals at any phase.
1	In the delayed venous phase, there are collaterals at the ischemic site for partially compensation, but they do so only in the periphery

2	Collaterals are seen at the ischemic site before the venous phase, and they compensate only in the periphery
3	The ischemic site is fully compensated for in both the center and periphery by collaterals during the late venous phase
4	Before the venous phase, collaterals are present that provide complete collateralization of the ischemic site, both in the center and periphery

ECASS- II hemorrhagic transformation grades

We employed the hemorrhagic transformation imaging scale from the European Cooperative Acute Stroke Study (ECASS), specifically the ECASS II scale, in this study (Hacke et al., 1998; Sussman et al., 2013) to assess for any occurrence of hemorrhagic transformation in the follow-up CT scan. A rating of ECASS II parenchymal hematoma 2 was indicative of an unfavorable radiological outcome (Table 3.4).

Hemorrhagic infarction (HI)/parenchymal hematoma (PH) scale	**Findings in 24 hours follow up plain CT scan**
HI – Type 1	Petechial hemorrhages at the margins of the infarcted area
HI – Type 2	Petechial hemorrhages spread throughout the infarcted area, causing no significant mass effect
PH – Type 1	Hematoma occupies ≤30% of the final infarct and causes minimal mass effect.
PH – Type 2	Hematoma occupies >30% of the final infarct causing marked mass effect.

Modified treatment in cerebral ischemia (mTICI) scale

The study assessed the degree of ante grade blood flow at the end of a thrombectomy procedure using mTICI score (Zaidat et al., 2013). Successful recanalization was defined as achieving a revascularization status of mTICI score ≥ 2b (Table 3.5).

mTICI Grade	Definition
Grade 0	No blood flow restoration
Grade 1	Some blood flow is able to pass beyond the initial blockage, but it only partially fills the distal branches and reperfusion is slow.
Grade 2a	Partial blood flow is reconstituted in less than half of the affected area in the artery in the forward direction
Grade 2b	Partial blood flow is reconstituted in more than half of the affected area in the artery in the forward direction.
Grade 3	Blood flow is fully restored in the affected artery's territory, with no visible blockages in the distal branches.

Statistics

The Data was entered into Microsoft Excel spreadsheet and the analysis was done using Statistical Package for Social Sciences (SPSS) software, version 25.0

The categorical variables were represented in the form of percentages (%), while quantitative data as means with standard deviations (±SD), as well as medians with interquartile ranges (25th and 75th percentiles).

1. The normality of the data was assessed using the Kolmogorov-Smirnov test. Non-parametric tests were used when the data did not follow a normal distribution.

2. To assess the relationship between variables that were quantitatively measured and did not adhere to a normal distribution, the Mann-Whitney test was employed. On the other hand, for variables that were quantitatively measured and normally distributed, the independent t-test was used. A statistical significance was considered if the p-value was less than 0.05.

3. To analyze the association between variables that were qualitative in nature, the Chi-square test was employed. Similarly, if the anticipated value of a cell in a contingency table was less than 5, Fisher's exact test was used.

4. To determine the factors that had an impact on the clinical outcome, both univariate and multivariate logistic regression analyses were employed.

5. Kappa test was employed to determine the level of agreement between the observers, as well as between DSA and CTA observations.

6. To ascertain an optimal threshold point (cut-off value) and to compute the specificity, sensitivity and predictive values of various imaging modalities in predicting a good clinical outcome, a receiver operating characteristic (ROC) curve was employed.

7. Univariate and multivariate linear regression methods were utilized to determine the factors that had an impact on the clinical outcome.

8. Spearman correlation coefficient was used for correlation of CTA single phase, DSA and CTA multi-phase with other imaging metrics.

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4. RESULTS

Demographic data:

The final study comprised 138 participants who presented with anterior circulation ischemic strokes with large vessel occlusion.

Table 4.1 :- Age distribution.

Age(years)	Frequency	Percentage
<=50 years	33	23.91%
51-60 years	28	20.29%
61-70 years	49	35.51%
71-80 years	20	14.49%
81-90 years	8	5.80%
Mean ± SD	60.99 ± 12	
Median (25th-75th percentile)	62(51-68.75)	
Range	39-88	

The age of patients who experienced acute stroke ranged from 39 to 88 years, with a mean age of 60 years **(Table 4.1).** Most of the patients (35%) presented with acute stroke between the ages of 61 and 70 years

Table 4.2: - Gender distribution.

Gender	Frequency	Percentage
Female	58	42.03%
Male	80	57.97%
Total	138	100.00%

The study included approximately 80 males (58%) and 58 (42%) females **(Table 4.2)** resulting in a male-to-female ratio of 1.3.

Table 4.3: - Risk factors distribution.

Risk factors	Frequency	Percentage
Hypertension	82	59.42%
Diabetes	49	35.51%
Smoking	31	22.46%
CAD	22	15.94%
RHD	18	13.04%
Dyslipidemia	27	19.57%
Past stroke	16	11.59%
Carotid disease	7	5.07%

The most prevalent risk factor observed in our patients was hypertension **(Table 4.3)**, which was present in 60% of the cases. This was followed by diabetes, which was seen in 35% of the patients. Other risk factors, such as smoking, dyslipidemia, coronary artery disease, rheumatic heart disease, and carotid disease, were noted in 22%, 20%, 16%, 13%, and 5% of the patients, respectively. Additionally, a history of stroke in the past was documented in 12% of the total participants.

Table 4: - Stroke etiology distribution (TOAST Classification)

Stroke etiology	Frequency	Percentage
Large artery Atherosclerosis	30	21.74%
Cardio embolic	68	49.28%
Other specific Causes	3	2.17%
Undetermined	37	26.81%
Total	138	100.00%

In our study, a significant proportion of stroke cases **(Table 4.4)** are due to a cardio embolic source (68%), with atherosclerosis being the second leading cause (30%). However, the etiology of stroke remains unknown in 37% of cases.

Table 4.5: - Descriptive statistics of NIHSS and MRS at admission.

Variable	Mean ± SD	Median (25th-75th percentile)	Range
NIHSS at admission	15.68 ± 5.31	16(12-20)	1-26
MRS at admission	4.2 ± 0.54	4(4-5)	3-5

Mean admission NIHSS and mRS were 16 ±5 (Range 4-24) and 4 ±1 respectively **(Table 4.5)**

Table 4.6: - Bridging therapy distribution.

Bridging therapy	Frequency	Percentage
No	99	71.74%
Yes	39	28.26%
Total	138	100.00%

Bridging therapy was given in nearly 28% of the cases **(Table 4.6)**

Table 4.7: - Site of occlusion distribution.

Site of occlusion	Frequency	Percentage
Intracranial internal carotid artery	27	19.57%
M1 MCA	132	95.65%
ACA A1	17	12.32%

Approximately 96% of cases involved occlusion of the middle cerebral artery (MCA), with around 20% of cases extending into the internal carotid artery (ICA) and 12% of cases involving the anterior cerebral artery (ACA) **(Table 4.7).**

Table 4.8 :- Descriptive statistics of clot burden score.

Variable	**Mean ± SD**	**Median (25th-75th percentile)**	**Range**
Clot burden score	5.72 ± 1.75	6(5-6.75)	0-9

Mean clot burden score in the present study was 6 **±**2 **(Table 4.8)**

Table 4.9: - CTA single phase collaterals distribution.

CTA single phase	Frequency	Percentage
Poor	63	45.65%
Good	75	54.35%
Mean ± SD	1.56 ± 0.6	
Median (25th-75th percentile)	2(1-2)	
Range	0-3	

Table 4.10:- CTA multi phase distribution.

CTA Multi phase	Frequency	Percentage
Poor	67	59.29%
Good	46	40.71%
Mean ± SD	2.1 ± 1.03	
Median (25th-75th percentile)	2(1-3)	
Range	0-4	

Table 4.11 :- DSA(modified ASITN/SIR) distribution.

DSA(ASITN/SIR)	Frequency	Percentage
Poor	84	60.87%
Good	54	39.13%
Mean ± SD	2.17 ± 0.84	
Median (25th-75th percentile)	2(2-3)	
Range	1-4	

Good (Tan grade 2-3) and poor (Tan grade 1-2) collateral scores (2-3) were seen in 54%, 46% of the cases respectively in single phase CTA, while multi-phase CTA and DSA showed good (mASITN grade 3-4) collaterals in 40% and 39% respectively and poor (mASITN grade 0-2) collaterals in 60% and 59% of the cases respectively **(Tables 4.9-4.11)**

Table 4.12 :- Final TICI score distribution.

Final TICI score	Frequency	Percentage
0	2	1.45%
1	5	3.62%
2A	11	7.97%
2B	48	34.78%

2C	16	11.59%
3	56	40.58%
Total	138	100.00%

86% of cases showed successful recanalization (≥ 2B) with mTICI scores of 2B, 2C, or 3 observed in 35%, 11%, and 40% of cases, respectively. Poor recanalization (≤ 2A) indicated by mTICI scores of 0, 1, or 2A, was seen in 14% of cases, with 1%, 4%, and 8% of cases falling into these categories, respectively **(Table 4.12)**

Table 4.13 :- Descriptive statistics of CT ASPECTS.

CT ASPECTS	**Mean ± SD**	**Median (25th-75th percentile)**	**Range**
At 24 hours	5.65 ± 2.2	6(4.25-7)	0-10

Mean 24 hours CT ASPECTS scores was 6 **±**2 respectively **(Table 4.13)**

Table 4.14 :- Hemorrhagic transformation distribution.

Hemorrhagic transformation	**Frequency**	**Percentage**
No	105	76.09%
HI 1	19	13.77%
HI 2	6	4.35%
PH 1	3	2.17%
PH 2	5	3.62%
Total	138	100.00%

HI1 and HI 2 was observed in approximately 18% of the patients while PH1 and PH2

was noted in 5.7% of the patients and in rest of the patients (~76%) hemorrhagic transformation was not observed. **(Table 4.14)**

Table 4.15 :- Descriptive statistics of mRS

MRS	Mean ± SD	Median (25th-75th percentile)	Range
At 3 months	2.57 ± 1.78	3(1-4)	0-6

Mean 3 months mRS scores was 2.57 ± 1.78 **(Table 4.15)**

Table 4.16 :-Association of parameters with CTA single phase collateral score.

Variables	Poor(n=63)	Good(n=75)	Total	P value
Age(years)				
<=50 years	13 (20.63%)	20 (26.67%)	33 (23.91%)	0.7*
51-60 years	16 (25.40%)	12 (16%)	28 (20.29%)	
61-70 years	22 (34.92%)	27 (36%)	49 (35.51%)	
71-80 years	9 (14.29%)	11 (14.67%)	20 (14.49%)	
81-90 years	3 (4.76%)	5 (6.67%)	8 (5.80%)	
Mean ± SD	61.11 ± 11.06	60.89 ± 12.86	60.99 ± 12.03	0.916‡
Median (25th-75th percentile)	62(51-67.5)	62(50-70)	62(51-68.75)	
Range	40-82	39-88	39-88	
Gender				
Female	21 (33.33%)	37 (49.33%)	58 (42.03%)	0.058†
Male	42 (66.67%)	38 (50.67%)	80 (57.97%)	
Risk factors				
Hypertension	38 (60.32%)	44 (58.67%)	82 (59.42%)	0.844†
Diabetes	18 (28.57%)	31 (41.33%)	49 (35.51%)	0.119†
Smoking	12 (19.05%)	19 (25.33%)	31 (22.46%)	0.378†
CAD	13 (20.63%)	9 (12%)	22 (15.94%)	0.168†
RHD	7 (11.11%)	11 (14.67%)	18 (13.04%)	0.537†
Dyslipidemia	9 (14.29%)	18 (24%)	27 (19.57%)	0.152†
Past stroke	12 (19.05%)	4 (5.33%)	16 (11.59%)	**0.016***

Carotid disease	3 (4.76%)	4 (5.33%)	7 (5.07%)	1*
Stroke etiology				
Atherosclerosis	12 (19.05%)	18 (24%)	30 (21.74%)	0.594*
Cardioembolic	35 (55.56%)	33 (44%)	68 (49.28%)	
Specific Causes	1 (1.59%)	2 (2.67%)	3 (2.17%)	
Undetermined	15 (23.81%)	22 (29.33%)	37 (26.81%)	
NIHSS at admission				
Mean ± SD	18.06 ± 4.14	13.68 ± 5.39	15.68 ± 5.31	**<.0001**§
Median (25th-75th percentile)	18(15.5-21)	13(11-18.5)	16(12-20)	
Range	7-26	1-24	1-26	
MRS at admission				
Mean ± SD	4.3 ± 0.46	4.11 ± 0.58	4.2 ± 0.54	0.051§
Median (25th-75th percentile)	4(4-5)	4(4-4)	4(4-5)	
Range	4-5	3-5	3-5	
CT aspects at admission				
Mean ± SD	6.44 ± 1.57	6.6 ± 1.58	6.53 ± 1.57	0.385§
Median (25th-75th percentile)	6(5-7)	7(6-8)	6(5-8)	
Range	4-10	3-10	3-10	
Site of occlusion				
Intracranial internal carotid artery	16 (25.40%)	11 (14.67%)	27 (19.57%)	0.113†
M1 MCA	61 (96.83%)	71 (94.67%)	132 (95.65%)	0.688*
ACA A1	13 (20.63%)	4 (5.33%)	17 (12.32%)	**0.009***
Clot burden score				
Mean ± SD	5.16 ± 1.93	6.19 ± 1.44	5.72 ± 1.75	**0.001**§
Median (25th-75th percentile)	6(4-6)	6(5.5-7.5)	6(5-6.75)	
Range	0-9	3-9	0-9	

‡ Independent t test, * Fisher's exact test, † Chi square test, § Mann Whitney test

Following the categorization of data into good and poor collateral status based on single phase CTA, there were no significant differences observed between the two groups in terms of demographics and risk factors, except for a history of previous stroke. Poor collaterals were more frequently observed in patients with previous stroke (19% vs 5%, P value- 0.01), higher admission NIHSS score (18 ± 4 vs 14 ± 5, P value - 0.0001), higher clot burden (5 ± 2 vs 6 ± 1, P value - 0.001) and involvement of anterior cerebral artery (21 vs 5, P value - 0.009). Multivariate logistic regression analysis conducted for statistically significant variables revealed that only admission NIHS score was an important predictor affecting collateral formation (P value < 0.0001, odds ratio 0.8) **(Table 4.16).**

Table 4.17: Association of parameters with CTA multi-phase collateral score.

Variables	Poor(n=67)	Good(n=46)	Total	P value
Age(years)				
<=50 years	17 (25.37%)	11 (23.91%)	28 (24.78%)	0.562*
51-60 years	14 (20.90%)	9 (19.57%)	23 (20.35%)	
61-70 years	20 (29.85%)	20 (43.48%)	40 (35.40%)	
71-80 years	12 (17.91%)	5 (10.87%)	17 (15.04%)	
81-90 years	4 (5.97%)	1 (2.17%)	5 (4.42%)	
Mean ± SD	61.27 ± 12.6	59.98 ± 11.21	60.74 ± 12.02	0.577‡
Median (25th-75th percentile)	61(50.5-69)	63.5(51-68)	62(51-68)	
Range	39-88	40-86	39-88	
Gender				
Female	28 (41.79%)	20 (43.48%)	48 (42.48%)	0.859†
Male	39 (58.21%)	26 (56.52%)	65 (57.52%)	
Risk factors				
Hypertension	42 (62.69%)	28 (60.87%)	70 (61.95%)	0.845†

Diabetes	28 (41.79%)	11 (23.91%)	39 (34.51%)	**0.05**[†]
Smoking	13 (19.40%)	15 (32.61%)	28 (24.78%)	0.11[†]
CAD	9 (13.43%)	8 (17.39%)	17 (15.04%)	0.563[†]
RHD	5 (7.46%)	9 (19.57%)	14 (12.39%)	0.055[†]
Dyslipidemia	14 (20.90%)	9 (19.57%)	23 (20.35%)	0.863[†]
Past stroke	11 (16.42%)	2 (4.35%)	13 (11.50%)	0.07[*]
Carotid disease	4 (5.97%)	2 (4.35%)	6 (5.31%)	1[*]
Stroke etiology				
Atherosclerosis	16 (23.88%)	12 (26.09%)	28 (24.78%)	0.378[*]
Cardio embolic	30 (44.78%)	24 (52.17%)	54 (47.79%)	
Specific Causes	1 (1.49%)	2 (4.35%)	3 (2.65%)	
Undetermined	20 (29.85%)	8 (17.39%)	28 (24.78%)	
NIHSS at admission				
Mean ± SD	15.66 ± 5.5	15.89 ± 5.28	15.75 ± 5.39	0.833[§]
Median (25th-75th percentile)	16(11-20)	17(11.25-20)	16(11-20)	
Range	1-26	4-24	1-26	
MRS at admission				
Mean ± SD	4.24 ± 0.52	4.24 ± 0.57	4.24 ± 0.54	0.955[§]
Median (25th-75th percentile)	4(4-5)	4(4-5)	4(4-5)	
Range	3-5	3-5	3-5	
CT aspects at admission				
Mean ± SD	6.42 ± 1.26	6.7 ± 1.77	6.53 ± 1.49	0.42[§]
Median (25th-75th percentile)	6(6-7)	7(5.25-8)	6(6-7)	
Range	4-10	3-10	3-10	

Site of occlusion				
Intracranial internal carotid artery	11 (16.42%)	12 (26.09%)	23 (20.35%)	0.21†
M1 MCA	63 (94.03%)	44 (95.65%)	107 (94.69%)	1*
ACA A1	8 (11.94%)	6 (13.04%)	14 (12.39%)	0.861†
Clot burden score				
Mean ± SD	5.84 ± 1.77	5.61 ± 1.41	5.74 ± 1.63	0.39§
Median (25th-75th percentile)	6(5-7)	6(5-6)	6(5-6)	
Range	1-9	2-8	1-9	

‡ Independent t test, * Fisher's exact test, † Chi square test, § Mann Whitney test

Similarly, in multi-phase CTA after dichotomization, there were no significant differences observed between the two groups in terms of demographics and risk factors, except for diabetes. Poor collaterals were more frequently observed in diabetic patients (42% vs 24%, p-value - 0.05). Multivariate logistic regression analysis also has not shown any variable that could predict the collateral formation **(Tables 4.17)**

Table 4.18: -Association of parameters with DSA collateral score.

Variables	Poor(n=84)	Good(n=54)	Total	P value
Age(years)				
<=50 years	22 (26.19%)	11 (20.37%)	33 (23.91%)	0.571*
51-60 years	15 (17.86%)	13 (24.07%)	28 (20.29%)	
61-70 years	27 (32.14%)	22 (40.74%)	49 (35.51%)	
71-80 years	14 (16.67%)	6 (11.11%)	20 (14.49%)	
81-90 years	6 (7.14%)	2 (3.70%)	8 (5.80%)	
Mean ± SD	61.31 ± 12.89	60.5 ± 10.65	60.99 ± 12.03	0.701‡
Median (25th-75th percentile)	62(50-70)	61.5(52.5-67.75)	62(51-68.75)	
Range	39-88	40-88	39-88	
Gender				

Female	35 (41.67%)	23 (42.59%)	58 (42.03%)	0.914†
Male	49 (58.33%)	31 (57.41%)	80 (57.97%)	
Risk factors				
Hypertension	48 (57.14%)	34 (62.96%)	82 (59.42%)	0.497†
Diabetes	29 (34.52%)	20 (37.04%)	49 (35.51%)	0.763†
Smoking	15 (17.86%)	16 (29.63%)	31 (22.46%)	0.106†
CAD	10 (11.90%)	12 (22.22%)	22 (15.94%)	0.106†
RHD	11 (13.10%)	7 (12.96%)	18 (13.04%)	0.982†
Dyslipidemia	15 (17.86%)	12 (22.22%)	27 (19.57%)	0.528†
Past stroke	10 (11.90%)	6 (11.11%)	16 (11.59%)	0.887†
Carotid disease	4 (4.76%)	3 (5.56%)	7 (5.07%)	1*
Stroke etiology				
Atherosclerosis	14 (16.67%)	16 (29.63%)	30 (21.74%)	0.223*
Cardioembolic	43 (51.19%)	25 (46.30%)	68 (49.28%)	
Specific Causes	3 (3.57%)	0 (0%)	3 (2.17%)	
Undetermined	24 (28.57%)	13 (24.07%)	37 (26.81%)	
NIHSS at admission				
Mean ± SD	15.74 ± 5.04	15.59 ± 5.75	15.68 ± 5.31	0.946§
Median (25th-75th percentile)	16(11.75-19)	15(12-21)	16(12-20)	
Range	5-26	1-24	1-26	
MRS at admission				
Mean ± SD	4.24 ± 0.57	4.13 ± 0.48	4.2 ± 0.54	0.209§
Median (25th-75th percentile)	4(4-5)	4(4-4)	4(4-5)	
Range	3-5	3-5	3-5	
CT aspects at admission				
Mean ± SD	6.71 ± 1.55	6.24 ± 1.58	6.53 ± 1.57	0.085§
Median (25th-75th percentile)	7(6-8)	6(5-7)	6(5-8)	
Range	3-10	3-10	3-10	
Site of occlusion				
Intracranial internal carotid artery	20 (23.81%)	7 (12.96%)	27 (19.57%)	0.117†
M1 MCA	79 (94.05%)	53 (98.15%)	132 (95.65%)	0.404*

ACA A1	14 (16.67%)	3 (5.56%)	17 (12.32%)	0.065*
Clot burden score				
Mean ± SD	5.58 ± 1.9	5.93 ± 1.49	5.72 ± 1.75	0.529§
Median (25th-75th percentile)	6(5-7)	6(5-6)	6(5-6.75)	
Range	0-9	2-9	0-9	

‡ Independent t test, * Fisher's exact test, † Chi square test

Following the categorization of data into good and poor collateral status based on DSA, there were no significant differences observed between the two groups in terms of demographics and risk factors **(Table 4.18).** Multivariate logistic regression analysis also had not shown any variable that predicted the collateral formation.

CTA single phase (Tan grading) {Observer 1}	**CTA single phase (Tan grading) {Observer 2}**					**Total**	**P value**	**Kappa**
	0(n=2)	**1(n=43)**	**2(n=66)**	**3(n=25)**	**4(n=2)**			
0	2 (1.45%)	0 (0.00%)	0 (0.00%)	1 (0.72%)	0 (0.00%)	3 (2.17%)	<0.0001	0.599
1	0 (0.00%)	43 (31.16%)	12 (8.70%	5 (3.62%)	0 (0.00%)	60 (43.48%)		
2	0 (0.00%)	0 (0.00%)	54 (39.13%)	14 (10.14%)	2 (1.45%)	70 (50.72%)		
3	0 (0.00%)	0 (0.00%)	0 (0.00%)	5 (3.62%)	0 (0.00%)	5 (3.62%)		
Total	2 (1.45%)	43 (31.16%)	66 (47.83%)	25 (18.12%)	2 (1.45%)	138 (100.00%)		

Table 4.19:-Inter-rater kappa agreement to find out strength of agreement between observer 1 and observer 2 regarding CTA single phase collateral score (Tan Grade).

The similarity in findings with Observer 1 varied among different grades assigned by Observer 2 with in interpreting collateral status with CTA single phase:

CTA Multi-phase (Modified ASITN/SIR) {Observer 1}	**CTA Multi-phase (Modified ASITN/SIR) {Observer 2}**					**Total**	**P value**	**Kappa**
	0(n=1)	**1(n=1=34)**	**2(n=3=29)**	**3(n=41)**	**4(n=8)**			
0	1 (0.88%)	0 (0.00%)	0 (0.00%)	1 (0.88%)	0 (0.00%)	2 (1.77%)	<0.0001	0.776
1	0 (0.00%)	34 (30.09%)	4 (3.54%)	2 (1.77%)	0 (0.00%)	40 (35.40%)		
2	0 (0.00%)	0 (0.00%)	20 (17.70%)	5 (4.42%)	0 (0.00%)	25 (22.12%)		
3	0 (0.00%)	0 (0.00%)	5 (4.42%)	32 (28.32%)	0 (0.00%)	37 (32.74%)		
4	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.88%)	8 (7.08%)	9 (7.96%)		
Total	1 (0.88%)	34 (30.09%)	29 (25.66%)	41 (36.28%)	8 (7.08%)	113 (100.00%)		

Among the patients interpreted as grade 0 by Observer 2, all 2 patients had similar findings with Observer 1. Among the patients interpreted as grade 1 by Observer 2, all 43 patients had similar findings with Observer 1. Among the patients interpreted as grade 2 by Observer 2, 54 out of 66 patients had similar findings with Observer 1. Among the patients interpreted as grade 3 by Observer 2, 5 out of 25 patients had similar findings with Observer 1. Among the patients interpreted as grade 4 by Observer 2, none of the patients had similar findings with Observer 1.

The concordance rate between the 2 observers was 75.36%, meaning that in about three-quarters of the cases, their findings were similar. The overall discordance rate

was 24.63%. Over all, moderate interobserver agreement was noted between the 2 observers in collateral status interpretation using CTA single phase (kappa 0.599, P value <.0001) **(Table 4.19)**

Table 4.20: - Inter-rater kappa agreement to find out strength of agreement between observer 1 and observer 2 regarding CTA Multi-phase collateral score (Modified ASITN/SIR).

The findings from multi-phase CTA collateral status assessment were compared between two observers, Grade 0: Observer 2 interpreted 1 patient as grade 0, and Observer 1 had similar findings in multi-phase CTA for 1 patient. Grade 1: Observer 2 interpreted 34 patients as grade 1, and Observer 1 had similar findings in multi-phase CTA for all 34 patients. Grade 2: Observer 2 interpreted 29 patients as grade 2, and Observer 1 had similar findings in multi-phase CTA for 20 out of 29 patients. Grade 3: Observer 2 interpreted 41 patients as grade 3, and Observer 1 had similar findings in multi-phase CTA for 32 out of 41 patients. Grade 4: Observer 2 interpreted 8 patients as grade 4, and Observer 1 had similar findings in multi-phase CTA for all 8 patients.

Overall concordance rate was 84.07% between 2 observers in multi-phase CTA collateral status assessment. In summary, good agreement exists between 2 observers in interpreting collateral status using multi-phase CTA (kappa 0.776, P value <.0001) **(Table 4.20)**

Table 4.21: - Inter-rater kappa agreement to find out strength of agreement between observer 1 and observer 2 regarding DSA

DSA (Modified ASITN/SIR) {Observer 1}	DSA (mASITN/SIR) {Observer 2}				Total	P value	Kappa
	1(n=33)	2(n=49)	3(n=50)	4(n=5)			
1	31 (22.63%)	2 (1.46%)	1 (0.73%)	0 (0.00%)	34 (24.82%)	<0.0001	0.849
2	2 (1.46%)	43 (31.39%)	4 (2.92%)	0 (0.00%)	49 (35.77%)		

3	0 (0.00%)	4 (2.92%)	45 (32.85%)	1 (0.73%)	50 (36.50%)		
4	0 (0.00%)	0 (0.00%)	0 (0.00%)	4 (2.92%)	4 (2.92%)		
Total	33 (24.09%)	49 (35.77%)	50 (36.50%)	5 (3.65%)	137 (100.00%)		

The findings from DSA in assessing collateral status between 2 Observers were compared. Among 33 patients who were interpreted as grade 1 by Observer 2, 31 of them had similar findings in DSA by Observer 1. Similarly, among 49 patients interpreted as grade 2 by Observer 2, 43 of them had similar findings in DSA by Observer 1. Among 50 patients interpreted as grade 3 by Observer 2, 45 of them had similar findings in DSA by Observer 1. Lastly, among 5 patients interpreted as grade 4 by Observer 2, 4 of them had similar findings in DSA by Observer 1.

Overall concordance rate was 89.79% and excellent agreement exist between 2 observers in collateral status assessment with DSA (kappa 0.849 and p value <.0001) **(Table 4.21)**

Table 4.22:-Inter-modality kappa agreement between CTA single phase (Tan grading) and DSA collateral scores (modified ASITN/SIR).

CTA single phase (Tan grading)	**DSA (Modified ASITN/SIR)**				**Total**	**P value**	**Kappa**
	1(n=34)	**2(n=50)**	**3(n=50)**	**4(n=4)**			
0	0 (0.00%)	1 (0.72%)	2 (1.45%)	0 (0.00%)	3 (2.17%)	0.387	0.042
1	16 (11.59%)	20 (14.49%)	21 (15.22%)	3 (2.17%)	60 (43.48%)		
2	18 (13.04%)	27 (19.57%)	24 (17.39%)	1 (0.72%)	70 (50.72%)		
3	0 (0.00%)	2 (1.45%)	3 (2.17%)	0 (0.00%)	5 (3.62%)		
Total	34 (24.64%)	50 (36.23%)	50 (36.23%)	4 (2.90%)	138 (100.00%)		

Poor agreement existed between DSA (Modified ASITN/SIR) and CTA single phase (Tan grading) with kappa 0.042 and p value 0.387.

Among 34 patients diagnosed as 1 via DSA Modified ASITN/SIR), 16 patients had similar findings in CTA single phase (Tan grading). Among 50 patients diagnosed as 2 via DSA (Modified ASITN/SIR), 27 patients had similar findings in CTA single phase (Tan grading). Among 50 patients diagnosed as 3 via DSA (Modified ASITN/SIR), 3 patients had similar findings in CTA single phase (Tan grading). Among 4 patient diagnosed as 4 by DSA (Modified ASITN/SIR), none of the patient had similar findings in CTA single phase (Tan grading). Overall concordance rate was 33.33% and discordance rate was 66.65% between DSA (Modified ASITN/SIR) and CTA single phase (Tan grading) (Table 4.22)

Table 4.23 :- Inter-rater kappa agreement between CTA multi-phase (Modified ASITN/SIR) and DSA (Modified ASITN/SIR).

CTA Multi phase (Modified ASITN/SIR)	DSA (Modified ASITN/SIR)				Total	P value	Kappa
	1(n=29)	2(n=39)	3(n=43)	4(n=2)			
0	1 (0.88%)	1 (0.88%)	0 (0.00%)	0 (0.00%)	2 (1.77%)	0.647	-0.027
1	9 (7.96%)	10 (8.85%)	20 (17.70%)	1 (0.88%)	40 (35.40%)		
2	7 (6.19%)	10 (8.85%)	8 (7.08%)	0 (0.00%)	25 (22.12%)		
3	10 (8.85%)	14 (12.39%)	12 (10.62%)	1 (0.88%)	37 (32.74%)		
4	2 (1.77%)	4 (3.54%)	3 (2.65%)	0 (0.00%)	9 (7.96%)		
Total	29 (25.66%)	39 (34.51%)	43 (38.05%)	2 (1.77%)	113 (100.00%)		

Poor agreement existeds between DSA (Modified ASITN/SIR) and CTA multi-phase (Modified ASITN/SIR) with kappa -0.027 and p value 0.647.

Among 29 patients diagnosed as 1 via DSA (Modified ASITN/SIR), 9 patients had similar findings in CTA multi-phase (Modified ASITN/SIR). Among 39 patients diagnosed as 2 via DSA (Modified ASITN/SIR), 10 patients had similar findings in CTA multi-phase (Modified ASITN/SIR). Among 43 patients diagnosed as 3 via DSA (Modified ASITN/SIR), 12 patients had similar findings in CTA multi-phase (Modified ASITN/SIR). Among 2 patients diagnosed as 4 via DSA (Modified ASITN/SIR), 0 patient had similar findings in CTA multi -phase (Modified ASITN/SIR). Overall concordance rate was 27.43% and discordance rate was 72.54% between DSA (Modified ASITN/SIR) and CTA multi-phase (Modified ASITN/SIR) (Table 4.23)

Table 4.24:- Univariate linear regression to find out factors affecting MRS at 3 months.

Variable	Beta coefficient	Standard error	P value	Lower bound (95%)	Upper bound (95%)
Age(years)	-0.001	0.013	0.961	-0.026	0.024
Gender					
Male/Female ratio	-0.440	0.306	0.152	-1.045	0.164
Risk factors					
Hypertension	0.062	0.310	0.842	-0.550	0.674
Diabetes	0.378	0.316	0.234	-0.247	1.003
Smoking	-0.197	0.364	0.588	-0.917	0.522
CAD	0.076	0.415	0.855	-0.745	0.897
RHD	-0.403	0.450	0.372	-1.293	0.487
Dyslipidemia	0.532	0.381	0.165	-0.221	1.284
Past stroke	1.049	0.466	**0.026**	0.127	1.971
Carotid disease(risk factors)	0.601	0.691	0.386	-0.765	1.967
Stroke etiology(risk factors)					

Undetermined					
Atherosclerosis	-0.350	0.440	0.427	-1.220	0.519
Cardioembolic	-0.298	0.366	0.416	-1.022	0.425
Specific Causes	0.550	1.074	0.610	-1.576	2.675
PH 2 bleed	0.651	0.812	0.424	-0.954	2.256
NIHSS at admission	0.073	0.028	**0.010**	0.018	0.128
MRS at admission	0.593	0.279	**0.035**	0.041	1.144
Intracranial internal carotid artery	-0.159	0.383	0.678	-0.917	0.598
M1 MCA	-0.621	0.744	0.405	-2.092	0.849
ACA A1	-0.049	0.463	0.916	-0.964	0.866
Bridging therapy	0.239	0.337	0.480	-0.428	0.905
CT aspects at admission	-0.200	0.096	**0.038**	-0.389	-0.011
CT aspects at 24 hours	-0.389	0.061	**<0.0001**	-0.510	-0.269
Clot burden score	0.017	0.087	0.842	-0.155	0.190
CTA single phase (Tan grading)	-0.421	0.250	0.094	-0.915	0.073
DSA (Modified ASITN/SIR)	0.013	0.182	0.943	-0.348	0.374
CTA Multi phase (Modified ASITN/SIR)	-1.207	0.113	**<0.0001**	-1.432	-0.983
Final TICI score					
0					
1	1.500	1.447	0.302	-1.362	4.362
2A	-0.773	1.329	0.562	-3.402	1.857
2B	-1.313	1.248	0.295	-3.781	1.156
2C	-0.750	1.297	0.564	-3.315	1.815
3	-0.929	1.244	0.457	-3.390	1.533

Table 4.25 :- Multivariate linear regression to find out factors affecting MRS at 3 months.

Variable	Beta coefficient	Standard error	P value	Lower bound (95%)	Upper bound (95%)
NIHSS at admission	0.055	0.025	**0.030**	0.005	0.104
MRS at admission	-0.060	0.245	0.807	-0.545	0.425
Admission CT ASPECTS	0.026	0.079	0.741	-0.131	0.184
CT ASPECTS at 24 hours	-0.200	0.057	**0.001**	-0.312	-0.087
CTA Multi phase (Modified ASITN/SIR)	-1.009	0.119	**<0.0001**	-1.245	-0.774
Past stroke	0.197	0.352	0.577	-0.501	0.895

On performing univariate regression for all the variables, NIHSS at admission (P value 0.01), MRS at admission (P value 0.03), CT aspects at admission (P value 0.03), CT aspects at 24 hours (P value < 0.0001), past stroke (P value 0.02), CTA multi-phase collateral status (P value < 0.0001) were significant risk factors of MRS at 3 months. With the increase in CT aspects at admission, CT aspects at 24 hours by 1 unit, MRS at 3 months significantly decreased by -0.2, -0.389 units respectively. With the increase in NIHSS at admission, MRS at admission by 1 unit, mRS at 3 months significantly increased by 0.073, 0.593 units respectively. Patients with past stroke, good collateral status on CTA multi-phase had significantly low mRS at 3 months with beta coefficient of 1.049(0.127 to 1.971), -1.207 (-1.432 to -0.983) respectively **(Table 4.24)**

On performing multivariate regression, NIHSS at admission (P value 0.03), CT ASPECTS at 24 hours (P value 0.001) and CTA multi-phase collateral status (P value <0.0001) were predictive 3 months MRS at 3 months after adjusting for confounding factors. With the increase in CT aspects at 24 hours, CTA multiphase by 1 unit, mRS at 3 months significantly decreased by -0.2, -1.009 units respectively. With the increase in NIHSS at admission by 1 unit, MRS at 3 months significantly increased by 0.055 units **(Table 4.25)**

Table 4.26(a): -Receiver operating characteristic curve of CTA single phase (Tan grading), CTA Multi phase (Modified ASITN/SIR), DSA (Modified ASITN/SIR) and CT aspects at admission for predicting good functional outcome.

Variables	CTA single phase (Tan grading)	CTA Multi phase (Modified ASITN/SIR)	DSA (Modified ASITN/SIR)
Area under the ROC curve (AUC)	0.543	0.878	0.694
Standard Error	0.0436	0.0298	0.0432
95% Confidence interval	0.456 to 0.628	0.803 to 0.932	0.610 to 0.769
P value	0.3219	**<0.0001**	**<0.0001**
Sensitivity (95% CI)	58.46%(45.6 - 70.6%)	98%(89.4 - 99.9%)	81.54%(70.0 - 90.1%)
Specificity (95% CI)	49.32%(37.4 - 61.3%)	65.08%(52.0 - 76.7%)	57.53%(45.4 - 69.0%)
PPV (95% CI)	50.7%(38.9 - 62.4%)	69%(56.9 - 79.5%)	63.1%(51.9 - 73.4%)
NPV (95% CI)	57.1%(44.0 - 69.5%)	97.6%(87.4 - 99.9%)	77.8%(64.4 - 88.0%)
Diagnostic accuracy	53.62%	79.65%	39.86%

Table 4.26(b) :- CTA single phase (Tan grading)

Criterion	Sensitivity	95% CI	Specificity	95% CI	+PV	95% CI	-PV	95% CI
≥0	100	94.5 - 100.0	0	0.0 - 4.9	47.1	38.6 - 55.8		
>0	100	94.5 - 100.0	4.11	0.9 - 11.5	48.1	39.5 - 56.9	100	29.2 - 100.0
>1	58.46	45.6 - 70.6	49.32	37.4 - 61.3	50.7	38.9 - 62.4	57.1	44.0 - 69.5
>2	3.08	0.4 - 10.7	95.89	88.5 - 99.1	40	5.3 - 85.3	52.6	43.8 - 61.3
>3	0	0.0 - 5.5	100	95.1 - 100.0			52.9	44.2 - 61.4

Table 4.26(c) : - CTA multi-phase (Modified ASITN/SIR)

Criterion	Sensitivity	95% CI	Specificity	95% CI	+PV	95% CI	-PV	95% CI
≥0	100	92.9 - 100.0	0	0.0 - 5.7	44.2	34.9 - 53.9		
>0	100	92.9 - 100.0	3.17	0.4 - 11.0	45	35.6 - 54.8	100	15.8 - 100.0
>1	98	89.4 - 99.9	65.08	52.0 - 76.7	69	56.9 - 79.5	97.6	87.4 - 99.9
>2	72	57.5 - 83.8	84.13	72.7 - 92.1	78.3	63.6 - 89.1	79.1	67.4 - 88.1
>3	18	8.6 - 31.4	100	94.3 - 100.0	100	66.4 - 100.0	60.6	50.5 - 70.0

Table 4.26(d) : - DSA (Modified ASITN/SIR)

Criterion	Sensitivity	95% CI	Specificity	95% CI	+PV	95% CI	-PV	95% CI
<1	0	0.0 - 5.5	100	95.1 - 100.0			52.9	44.2 - 61.4
≤1	33.85	22.6 - 46.6	83.56	73.0 - 91.2	64.7	46.5 - 80.3	58.7	48.6 - 68.2
≤2	81.54	70.0 - 90.1	57.53	45.4 - 69.0	63.1	51.9 - 73.4	77.8	64.4 - 88.0
≤3	96.92	89.3 - 99.6	2.74	0.3 - 9.5	47	38.3 - 55.8	50	6.8 - 93.2
≤4	100	94.5 - 100.0	0	0.0 - 4.9	47.1	38.6 - 55.8		

CTA multi-phase (Modified ASITN/SIR) had sensitivity of 98.00% followed by DSA (Modified ASITN/SIR) (81.54%), CTA single phase (Tan grading) (58.46%) and CT aspects at admission (18.46%). In prediction of good functional outcome, CT aspects at admission had lowest sensitivity of 18.46%. On the other hand, CT aspects at admission had specificity of 95.89% followed by CTA multi-phase (Modified ASITN/SIR) (65.08%), DSA (Modified ASITN/SIR) (57.53%) and CTA single phase (Tan grading) (49.32%). In prediction of good functional outcome, CTA single phase (Tan grading) had lowest specificity of 49.32%. Highest positive predictive value was found in CT aspects at admission (80.00%) and highest negative predictive value was found in CTA multi-phase (Modified ASITN/SIR) (97.60%). There is always a trade-off between sensitivity and specificity so we choose that variable as best in which combination of sensitivity and specificity gives the maximum predictive value i.e. maximum diagnostic accuracy so overall CTA multi-phase (Modified ASITN/SIR) was best predictor of good functional outcome (Tables 4.26 a-d)

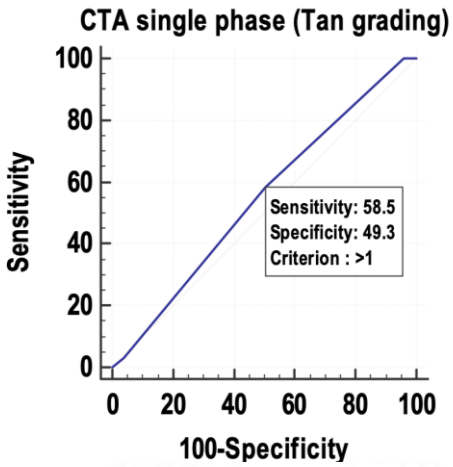

Fig. 4.1A: ROC curve of single phase CTA for predicting good functional outcome

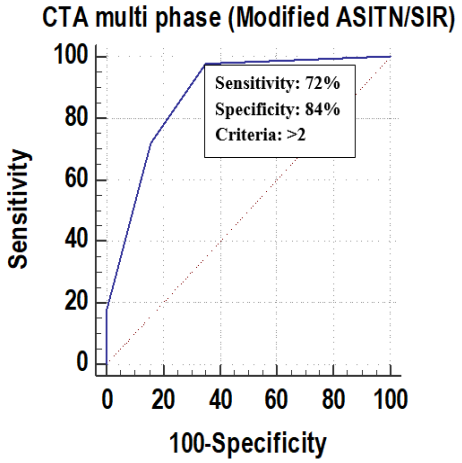

Fig. 4.1B: ROC curve of multi-phase CTA for predicting good functional outcome

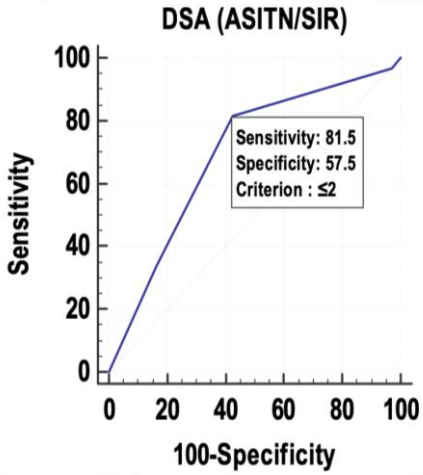

Fig. 4.1C: ROC curve of DSA for predicting good functional outcome

Figure 4.1 A-C: - Receiver operating characteristic curve of CTA single phase (Fig. 4.1 A), CTA Multi-phase CTA (Fig. 4.1B) and DSA (4.1C) for predicting good functional outcome.

ROC curves above the diagonal line are considered to have reasonable discriminating ability to predict good functional outcome. Discriminatory power of CTA multi-phase (Modified ASITN/SIR) (AUC 0.878; 95% CI: 0.803 to 0.932) was excellent and discriminatory power of DSA (Modified ASITN/SIR) (AUC 0.694; 95% CI: 0.610 to 0.769) was acceptable. On the other hand, discriminatory power of CTA single phase (Tan grading) (AUC 0.543; 95% CI: 0.456 to 0.628) and CT aspects at

admission (AUC 0.569; 95% CI: 0.482 to 0.653) was non-significant. Among all the parameters, CTA multi-phase (Modified ASITN/SIR) was the best predictor of good functional outcome at cut off point of >2 with 87.80% chances of correctly predicting good functional outcome (Figure 4.1 A-C).

Table 4.27:-Univariate logistic regression to find out significant factors affecting good functional outcome.

Variable	Beta coefficient	Standard error	P value	Odds ratio	Odds ratio Lower bound (95%)	Odds ratio Upper bound (95%)
NIHSS admission	0.237	0.248	0.264	1.274	1.021	1.426
CT ASPECTS at admission	0.183	0.112	0.100	1.201	0.965	1.495
CTA single phase (Tan grading)	0.299	0.286	0.296	1.349	0.770	2.364
CTA Multi phase (Modified ASITN/SIR)	1.896	0.325	**<0.0001**	**6.659**	3.521	12.595
DSA (Modified ASITN/SIR)	0.855	0.229	**0.0002**	**0.425**	0.271	0.666
mTICI score	1.294	0.276	**0.0001**	**1.297**	1.124	1.454
24 hours CT ASPECTS	0.354	0.254	0.326	1.137	0.924	1.273

Table 4.28: - Multivariate logistic regression to find out significant factors affecting good functional outcome.

Variable	Beta coefficient	Standard error	P value	Odds ratio	Odds ratio Lower bound (95%)	Odds ratio Upper bound (95%)
CTA Multi phase (Modified ASITN/SIR)	2.242	0.411	**<0.0001**	9.415	4.203	21.090
DSA (Modified ASITN/SIR)	1.405	0.403	**0.0005**	0.245	0.111	0.540
mTICI score	0.937	0.532	**0.237**	0.043	0.021	0.062

The results of the univariate regression analysis showed that CTA multi-phase (p-value < 0.0001), DSA (p-value 0.0002) and final mTICI score (P value 0.0001) were found to be significant variables that

influenced the functional outcome. An increase in DSA, multi-phasic CTA collateral scores and final mTICI scores was associated with a significant increase in the probability of a good functional outcome, with odds ratios of 0.4 (95% confidence interval: 0.3 to 0.6), 6.7 (95% confidence interval: 3.5 to 12.5) and 1.3 (95% confidence interval: 0.9 to 1.2) respectively **(Table 4.27)**

In a multivariate regression analysis, it was found that only CTA multi-phase and DSA were significant independent variables that affected functional outcome, even after adjusting for confounding factors. Specifically, with an increase in DSA and multi-phase CTA collateral score, the probability of a good functional outcome significantly increases with an adjusted odds ratio of 0.2 (95% CI, 0.1- 0.5) and 9.4 (95% CI, 4.2- 21) respectively **(Table 4.28)**

REPRESENTATIVE CASES

Illustrative case 1 (Fig. 4.2)

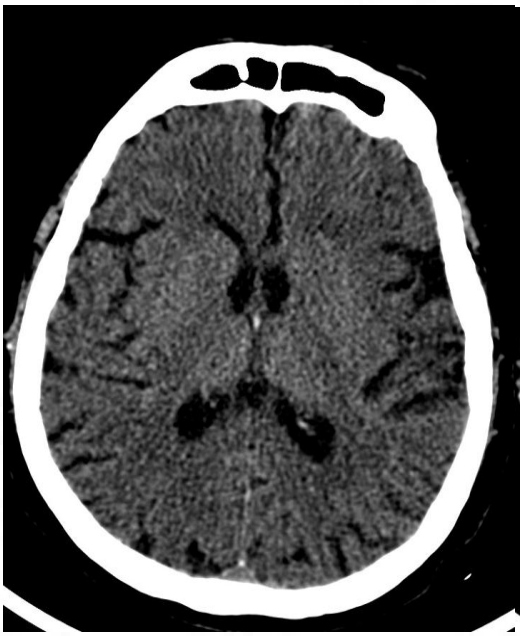

Figure 4.2A – Plain CT Axial (ASPECTS 6)

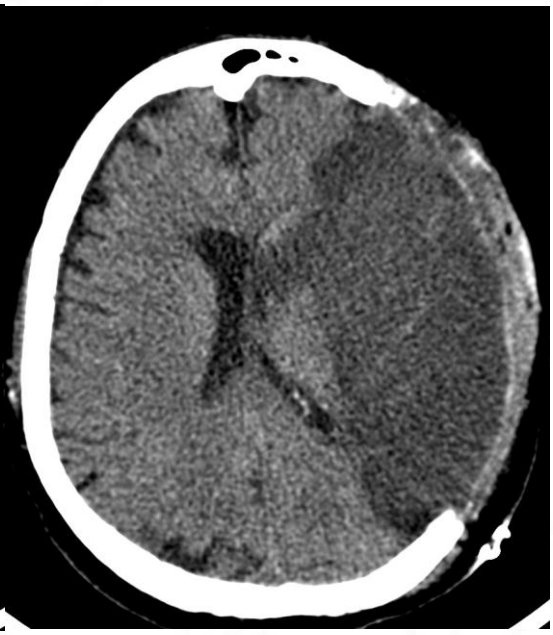

Figure 4.2B - Post MT showing left MCA territory malignant infarct with craniectomy

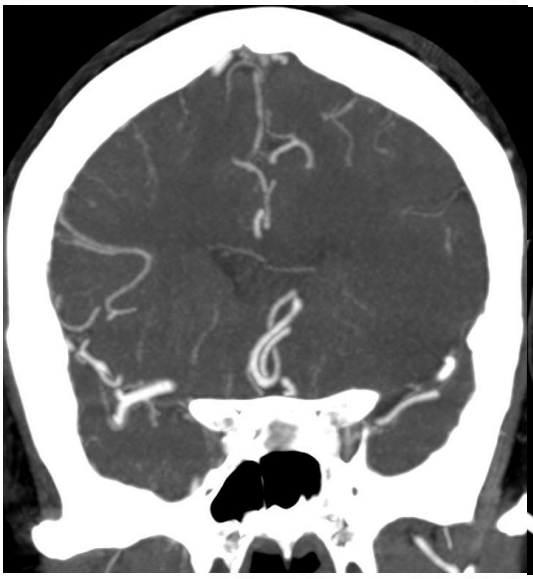

Figure 4.2C – Coronal CT MIP single phase showing poor collateral score (TAN grade 1)

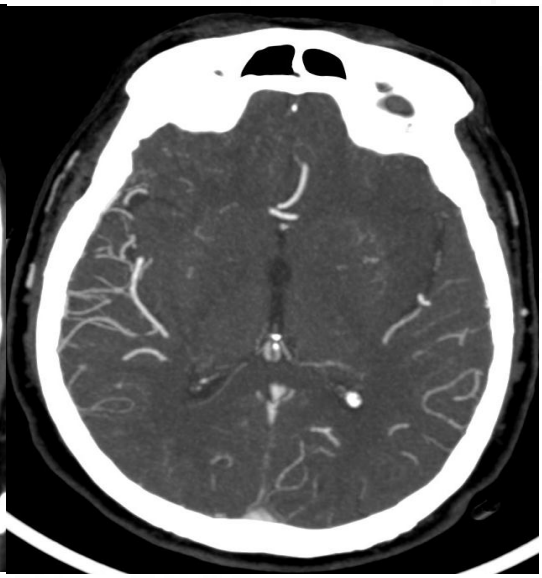

Figure 4.2D – Axial CT MIP single phase showing poor collateral score (TAN grade 1)

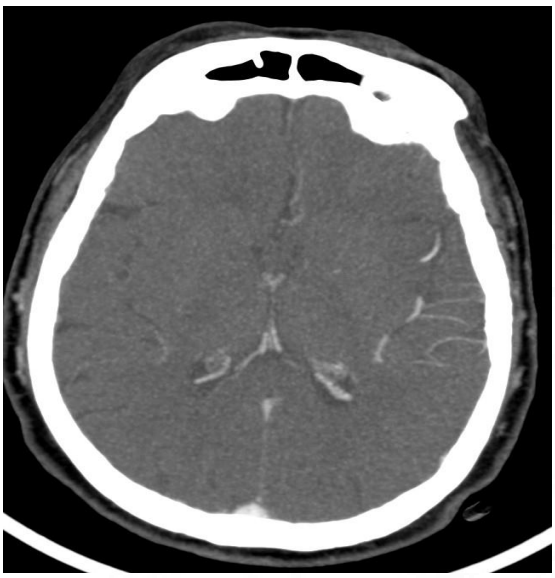

Figure 4.2E – Axial CT MIP Art. Del. phase showing Poor collateral score (mASITN/SIR 1)

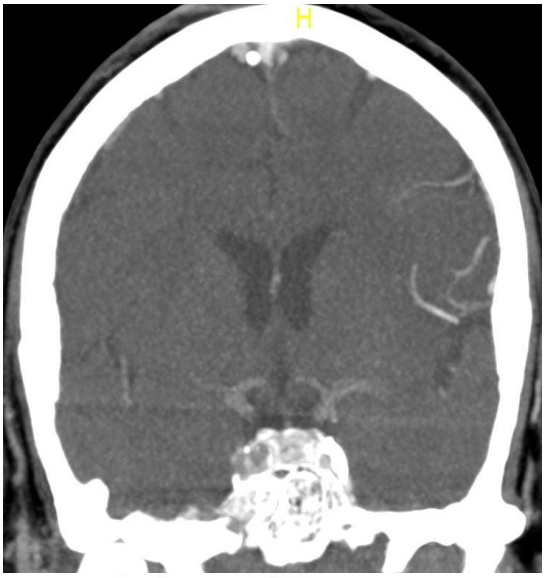

Figure 4.2F – Coronal CT MIP Art. Del. phase showing Poor collateral score (mASITN/SIR 1)

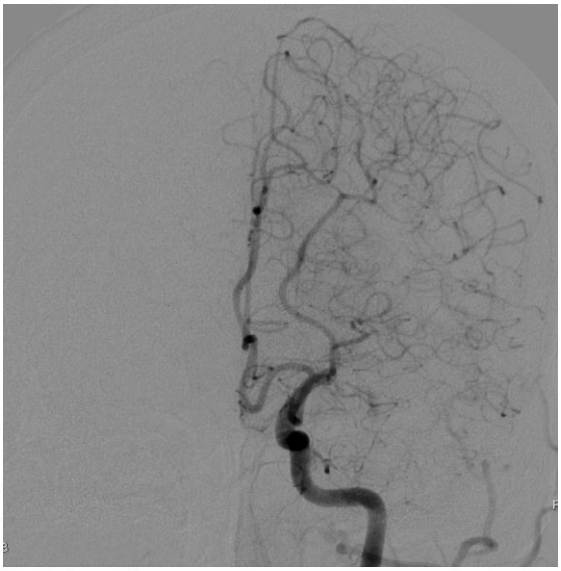

Figure 4.2G – DSA (ICA AP view) showing good collateral score (mASITN/SIR grade 4)

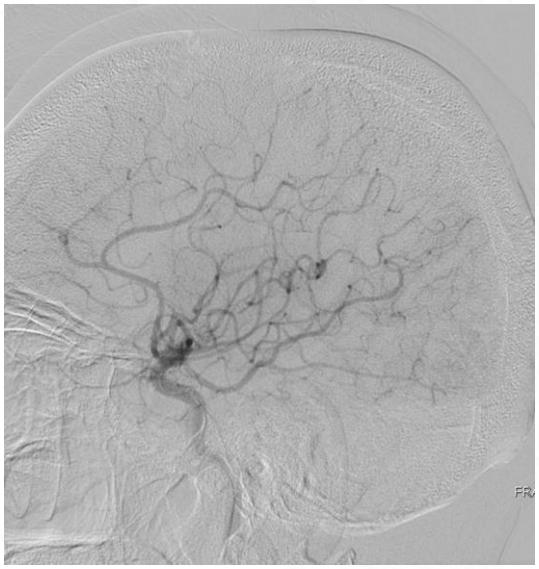

Figure 4.2H – DSA (Lateral) showing good collateral score (mASITN/SIR grade 4)

Case 4.2: 60-year-old female, a known hypertensive and coronary artery disease patient presented with acute stroke. At admission, NIHS score was 17 and mRS score is 4. Plain CT showed an ASPECTS score of 6 (Fig. 4.2A). CTA revealed left M1 middle cerebral artery (MCA) occlusion. Single phase CTA (Tan Grade: Fig 4.2C-D), Multi-phase CTA (mASITN/SIR Grade: Fig.4.2C-F) and DSA (mASITN/SIR Grade: Fig: 4.2G-H) collateral scores were 1,1 and 4 respectively. Mechanical thrombectomy was done achieving mTICI 2b recanalization. 24 hours plain CT revealed a malignant acute infarct along left MCA territory (Fig. 4.2B) and decompression craniectomy was done. At the 90-day follow-up visit, the patient's clinical recovery remained poor, with an mRS score of 5.

Illustrative Case 2 (Fig 4.3)

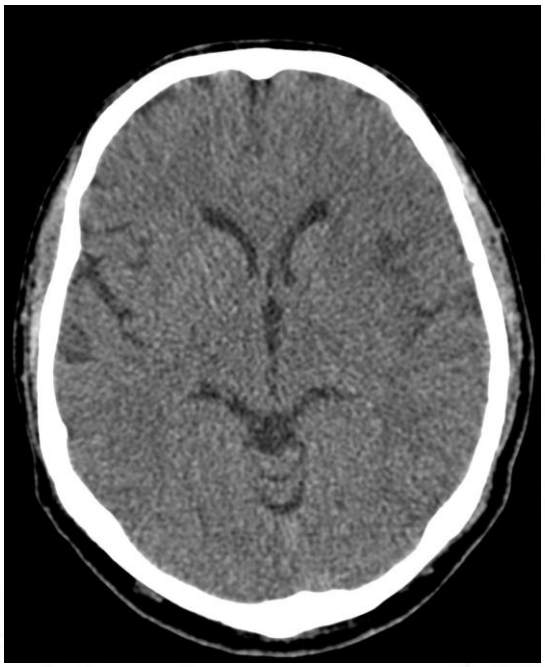

Figure 4.3A – Plain CT (ASPECTS 7)

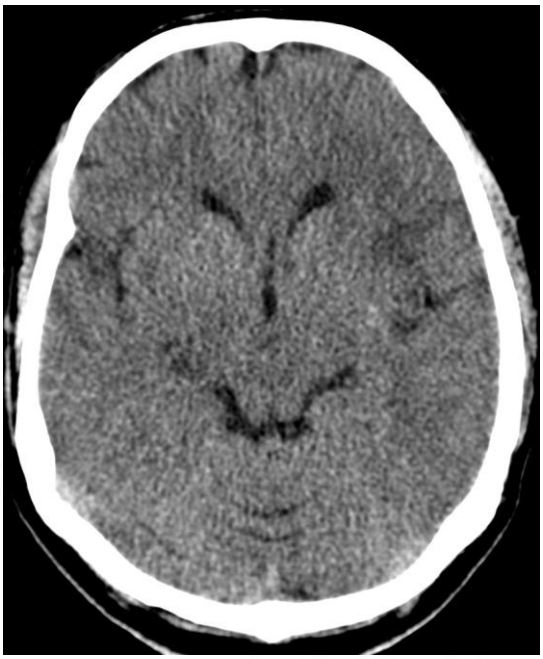

Figure 4.3B - Post MT showing no evidence of increase in Infarct size (ASPECTS 7)/HI transformation.

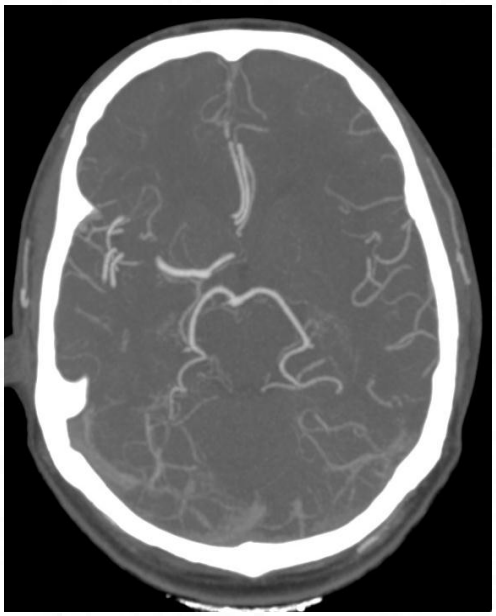

Figure 4.3C – Axial CT MIP single phase showing good collateral score (TAN grade 2)

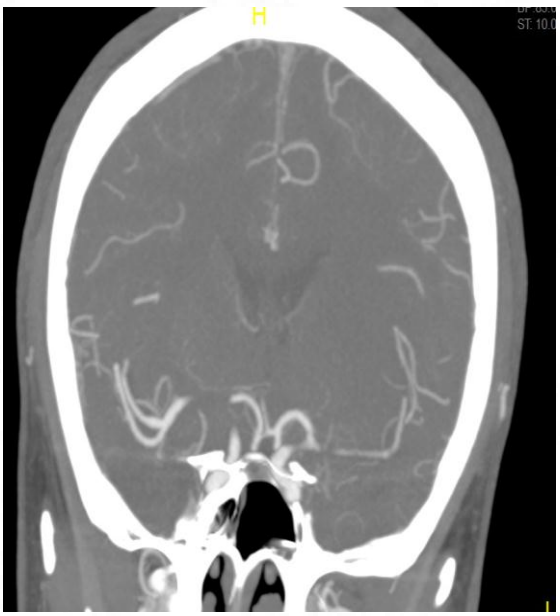

Figure 4.3D – Coronal CT MIP single phase showing good collateral score (TAN grade 2)

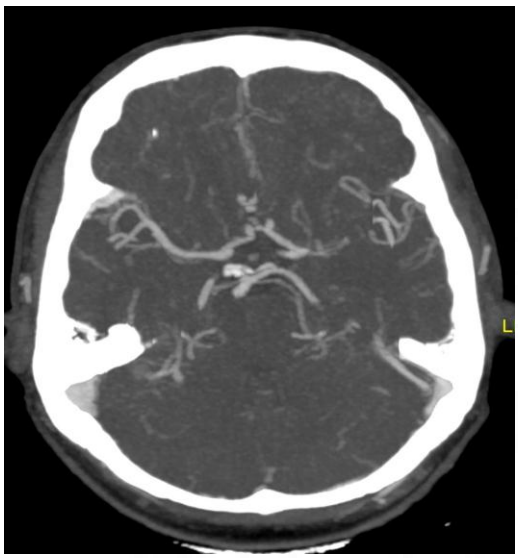

Figure 4.3E – Axial CT MIP Del. Art. phase showing good col. score (mASITN/SIR grade 4)

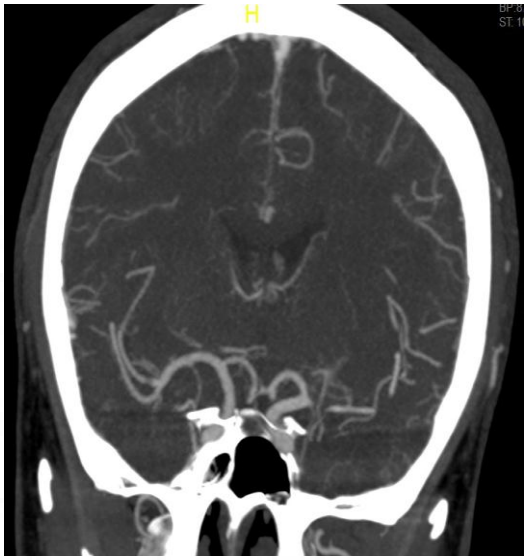

Figure 4.3F – Coronal CT MIP Art. del. phase showing good col. score (mASITN/SIR grade 4)

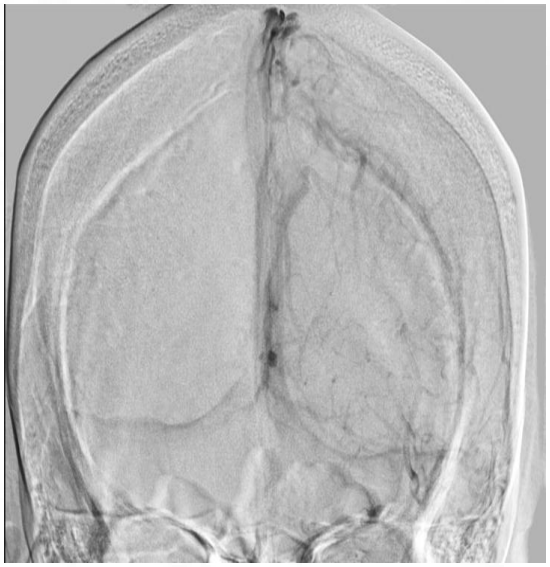

Figure 4.3G – DSA (ICA AP view) showing Poor collateral score (mASITN/SIR grade 1)

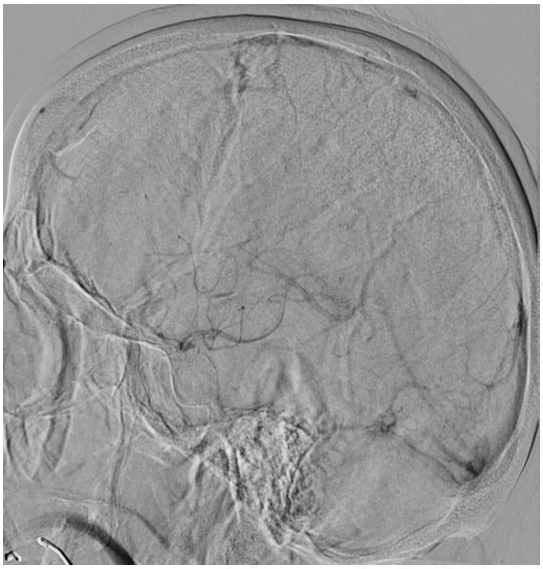

Figure 4.3H – DSA (Lateral) showing poor collateral score (mASITN/SIR grade 1)

Case 4.3: 40-year-old male, a known hypertensive and chronic smoker presented with acute stroke. At admission, NIHS score was 10 and mRS score is 4. Plain CT showed an ASPECTS score of 7 (Fig.4.3A). CTA revealed left M1 middle cerebral artery (MCA) occlusion. Single phase CTA (Tan Grade- Fig.4.3C-D), Multi-phase CTA (mASITN/SIR Grade- Fig.4.3C-F) and DSA (mASITN/SIR Grade-Fig.2G-H) collateral scores were 2,4 and 1 respectively. Mechanical thrombectomy was done achieving mTICI 3 recanalization. 24 hours plain CT (Fig.4.3B) showed no evidence

of increase in infarct size (ASPECTS score 7)/haemorrhagic transformation. At the 90-day follow-up visit, the patient's showed significant clinical improvement (mRS score 1).

Illustrative case 3 (Fig. 4.4)

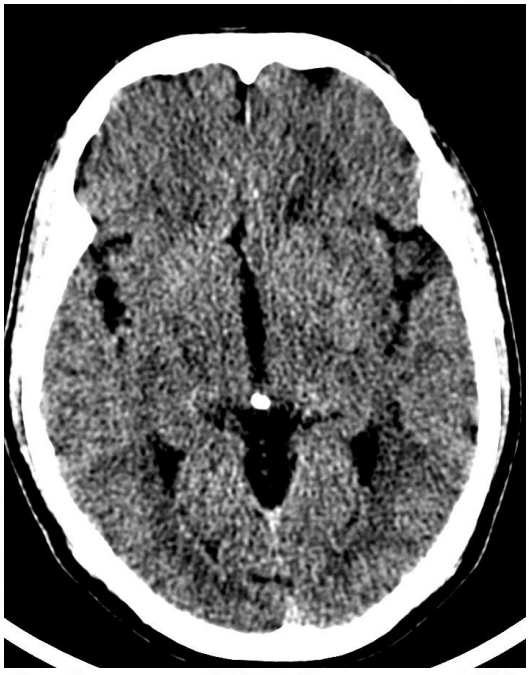

Figure 4.4A – Plain CT (ASPECTS 5)

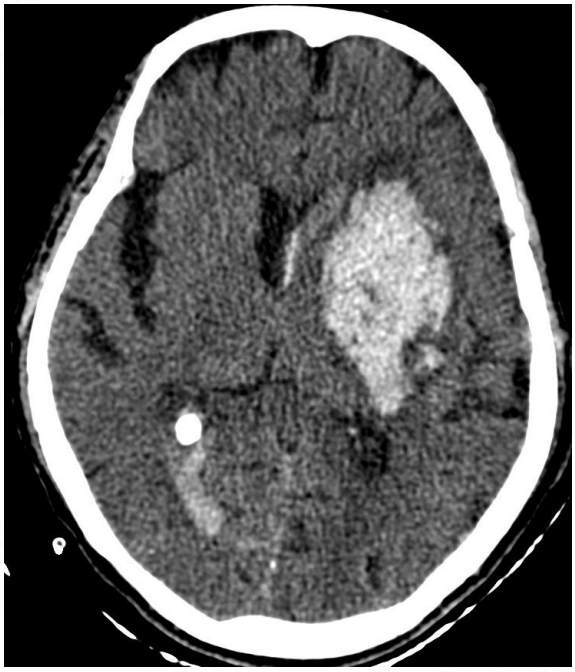

Figure 4.4B - Post MT showing HT of the left MCA territory infarct (PH2)

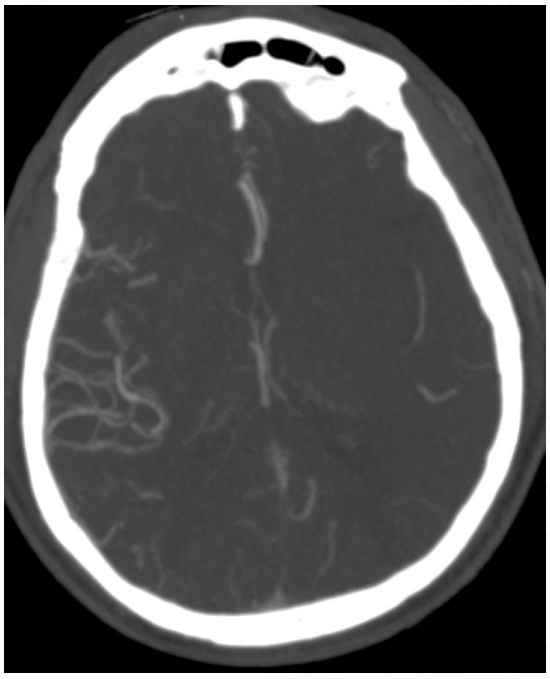

Figure 4.4C – Axial CT MIP single phase showing poor collateral score (TAN grade 1)

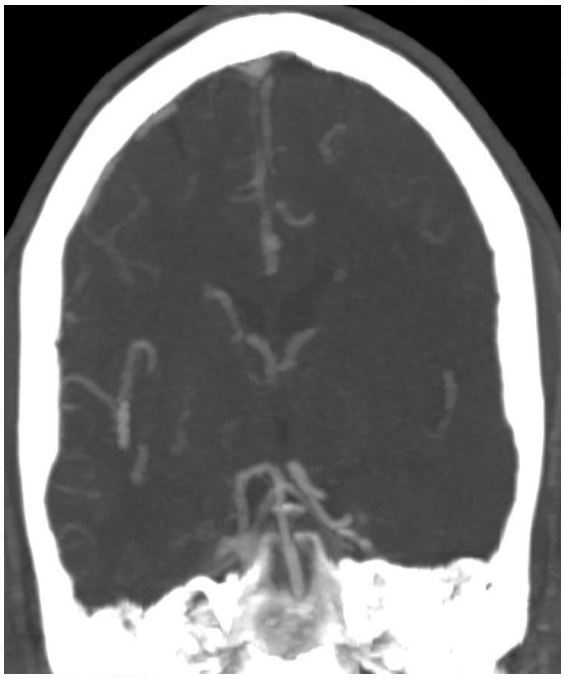

Figure 4.4D – Coronal CT MIP single phase showing poor collateral score (TAN grade 1)

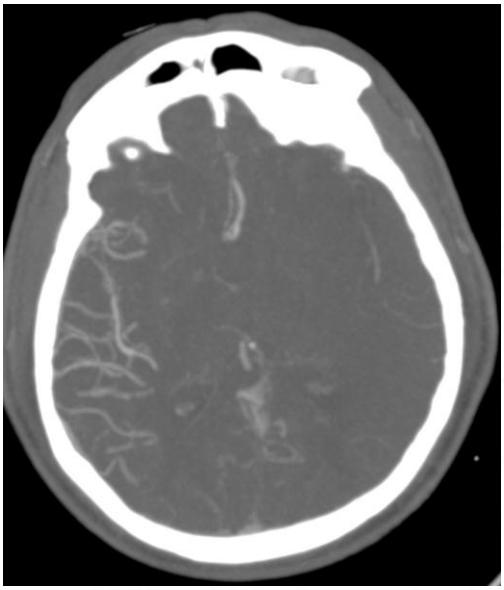

Figure 4.4E – Axial CT MIP Del. Art. phase showing poor col. score (mASITN/SIR grade 1)

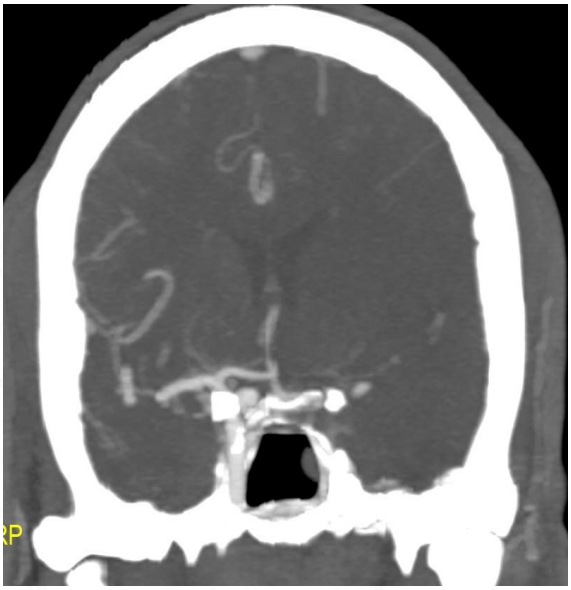

Figure 4.4F – Coronal CT MIP Art. del. phase showing poor col. score (mASITN/SIR grade 1)

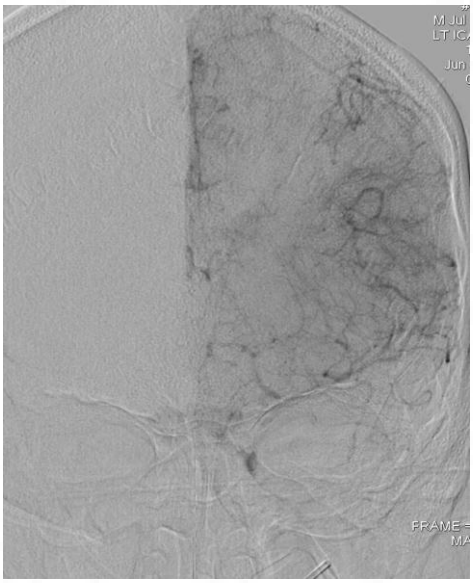

Figure 4.4G – DSA (ICA AP view) showing Good collateral score (mASITN/SIR grade 3)

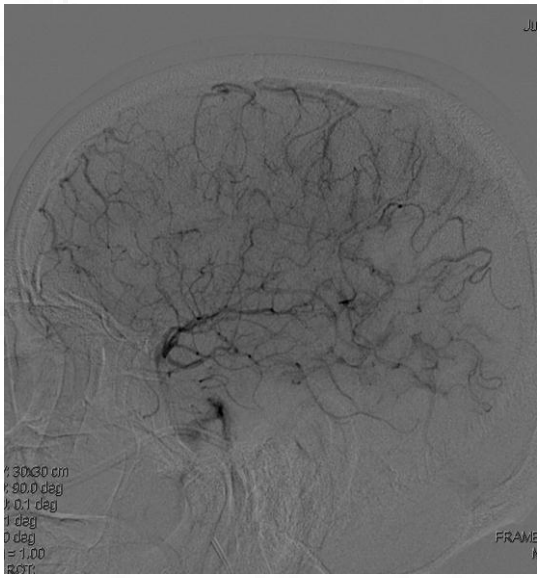

Figure 4.4H – DSA (Lateral) showing good collateral score (mASITN/SIR grade 3)

Case 4.4: 51-year-old male, a known hypertensive and diabetic presented with acute stroke. At admission, NIHS score was 24 and mRS score is 4. Plain CT showed an ASPECTS score of 5 (Fig.4.4A). CTA revealed left M1 middle cerebral artery (MCA) occlusion. Single phase CTA (Tan Grade-Fig.4.4C-D), Multi-phase CTA (mASITN/SIR Grade- Fig.4.4C-F) and DSA (mASITN/SIR Grade- Fig.4.4G-H) collateral scores were 1,1 and 3 respectively. Mechanical thrombectomy was done achieving mTICI 2b recanalization. 24 hours plain CT (Fig.4.4B) revealed haemorrhagic transformation of the infarct (ECASS – PH 2). At the 90-day follow-up visit, the patient's clinical recovery remained poor, with an mRS score of 5.

Illustrative Case 4 (Fig. 4.5)

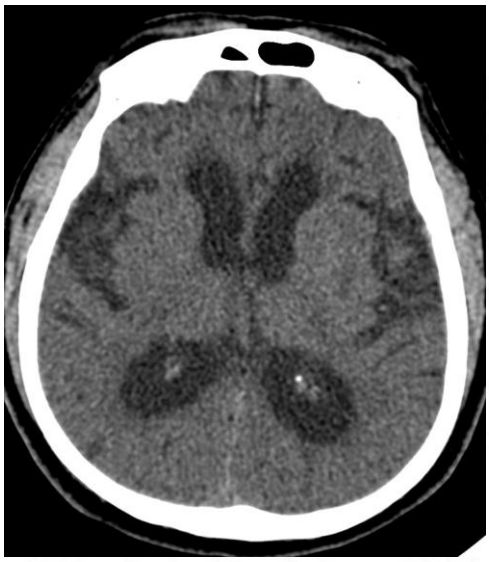

Figure 4.5A – Plain CT (ASPECTS 9)

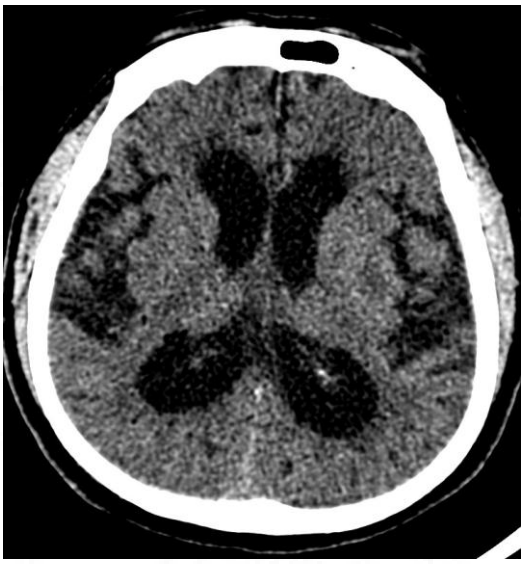

Figure 4.5B - Post MT showing no evidence of increase in Infarct size (ASPECTS 7)/HI transformation

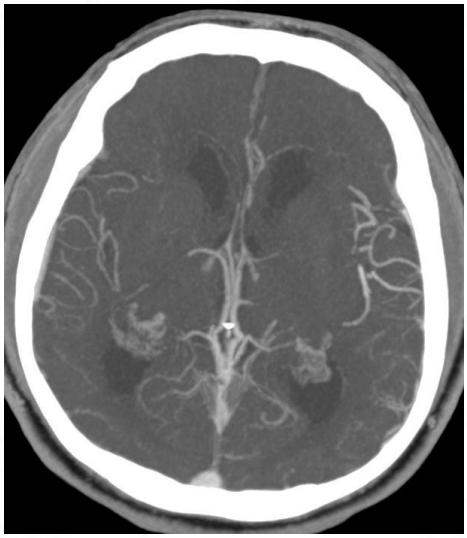

Figure 4.5C – Axial CT MIP single phase showing good collateral score (TAN grade 2)

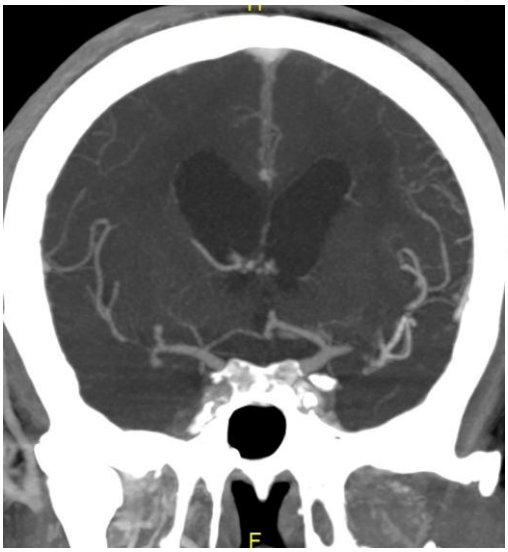

Figure 4.5D – Coronal CT MIP single phase showing poor collateral score (TAN grade 2)

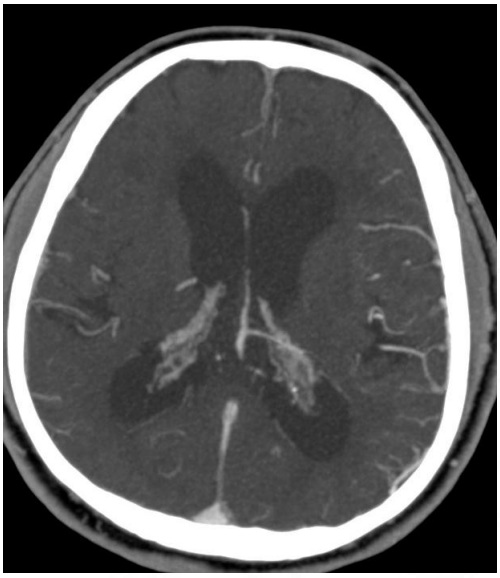

Figure 4.5E – Axial CT MIP Del. Art. phase showing good col. score (mASITN/SIR grade 4)

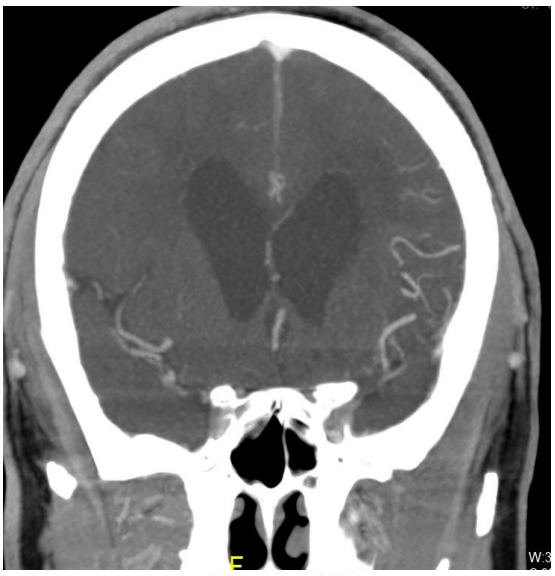

Figure 4.5F – Coronal CT MIP Art. del. phase showing good col. score (mASITN/SIR grade 4)

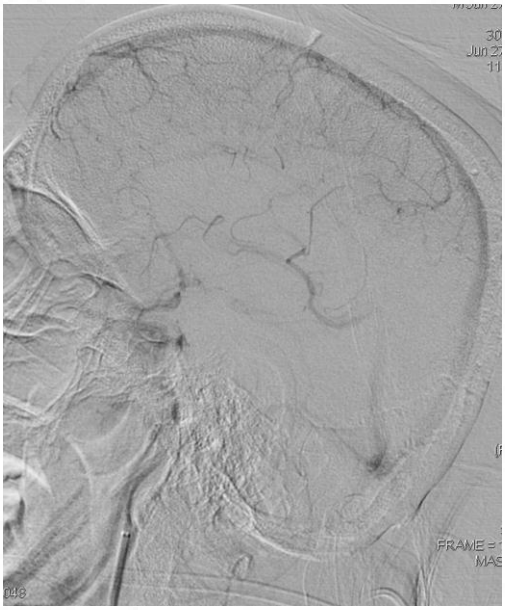

Figure 4.5G – DSA (ICA AP view) showing Poor collateral score (mASITN/SIR grade 1)

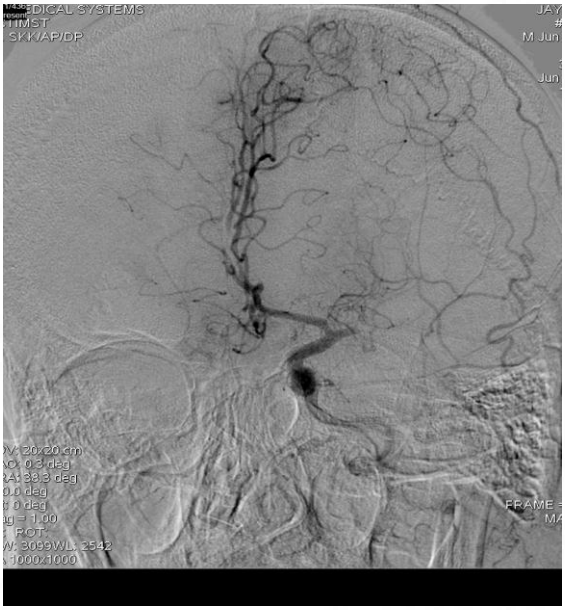

Figure 4.5H – DSA (Lateral) showing good collateral score (mASITN/SIR grade 1)

Case 4.5: 73-year-old male, a known hypertensive and diabetic presented with acute stroke. At admission, NIHS score was 10 and mRS score is 3. Plain CT showed an ASPECTS score of 9 (Fig.4.5A). CTA revealed left M1 middle cerebral artery (MCA) occlusion. Single phase CTA (Tan- Fig.4.5C-D), Multi-phase CTA (mASITN/SIR - Fig.4.5C-F) and DSA (mASITN/SIR –Fig.4.5G-H) collateral scores were 2,4 and 1 respectively. Mechanical thrombectomy was done achieving mTICI 3 recanalization. 24 hours plain CT (Fig.4.5B) showed no evidence of increase in infarct size (ASPECTS score 9)/haemorrhagic transformation. At the 90-day follow-up visit, the patient's showed significant clinical improvement (mRS score 1).

5. DISCUSSION

Our study compared the collateral status of different imaging modalities (Single phase and multi-phase CTA to DSA) and furthermore aimed to predict the functional outcome based on these collateral statuses. Sample size was largest to date and a standardized methodology was applied to the entire sample.

We found that multiphase CT angiography along with NIHS score at admission and 24 hours CT aspects score was more effective than the other imaging methods, showing higher levels of sensitivity, specificity, and accuracy in predicting functional outcome. Additionally, it was found to be well correlated with 24 hours CT aspects score. Our study also demonstrated good inter observer agreement of various imaging modalities and also noted poor concordance between CTA and DSA.

BK Menon et al (Menon et al., 2015) studied the use of multiphase CTA as an imaging selection tool in patients with acute ischemic stroke and highlights its interrater reliability and ability to determine clinical outcomes. Baseline unenhanced CT, single and multi- phase CTA and perfusion CT were evaluated and the clinical outcomes considered were, a 50% or greater decrease in the NIHS Score over 24 hours and a 90-day mRS score of 0-2. The ability to predict clinical outcomes was compared between single-phase CT angiography, multiphase CT angiography, and perfusion CT using receiver operating curve analysis.

Out of the 147 patients included in the study, multiphase CT angiography demonstrated excellent interrater reliability (k- 0.81, $P < .001$), similar to our study (k - 0.87($P < .0001$). The study also showed superior performance of multi-phase CTA in predicting outcomes with C statistic value of 0.6 while our study also showed good performance of CTA in predicting clinical outcome (C statistic value of 0.87). However, unlike their study, we had not included distal as well as posterior circulation cases. In conclusion, multiphase CT angiography is a reliable imaging tool for selecting appropriate treatments in patients with AIS.

ESCAPE trial (Goyal et al., 2015) evaluated the effectiveness of rapid endovascular treatment in patients with acute ischemic stroke. Specifically, it focused on patients with a small infarct core, a proximal intracranial arterial occlusion in the anterior

circulation, and moderate-to-good collateral circulation. The trial concluded that the addition of rapid endovascular treatment to standard care resulted in improved functional outcomes and reduced mortality in this patient population.

Notably, the ESCAPE trial defined moderate-to-good collateral circulation based solely on spatial information (Filling of 50% or more of the pial collaterals) whereas our study incorporated both spatial and temporal information. Additionally, the ESCAPE trial excluded patients with a large infarct core or poor collateral circulation, which differs from the inclusion criteria of our study.

Liebeskind et al (Liebeskind et al., 2014) analyzed the impact of collaterals on endovascular revascularization and clinical outcomes. They also used baseline angiography to assess collateral grade, employing a similar scale as our study (mASITN/SIR). They investigated the relationship between collateral grade and various clinical, laboratory, and imaging parameters.The median NIHSS score was 18, indicating a moderate to severe stroke. They found that worse collaterals were associated with elevated baseline blood glucose levels, a similar observation was noted in our study too.They also observed a strong association between collaterals and the ASPECTS at baseline and 24 hours, similar to our findings.

Interobserver agreement and concordance between various imaging modalities

In collateral status interpretation, moderate to excellent inter observer agreement was reported between two observers using different imaging techniques. A concordance rate of 75% and a kappa value of 0.6 ($p < .0001$) were reported for CTA single phase, 84% concordance rate and a good agreement of kappa 0.77 ($p < .0001$) for mCTA, and 90 % concordance rate and an excellent agreement of kappa 0.85 ($p < .0001$) for DSA. These findings are consistent with previous studies where a kappa value of 0.68 (Jansen et al., 2016) and 0.87 (Tan et al., 2007) was reported for single phase CT and 0.81 (Menon et al., 2015) for multi-phasic CTA. The agreement between single (k 0.04) and multi-phase CTA (k 0.02) with DSA was found to be poor with low kappa values even though the better inter observer agreement was seen in CTA and DSA. The overall concordance rate between DSA and single-phase CTA was 33%, while it was 27% for multi-phase CTA. There is no agreement in the existing literature and

previous studies have shown varying degrees of concordance (Jansen et al., 2016; Tan et al., 2007; Kauw et al., 2020; Casault et al., 2017; Kim et al., 2012). This discrepancy may be due to the fact that the pressure applied in DSA during contrast injection via the intra-arterial route may open physiological collateral vessels that are not actually formed (pathological collaterals) in the case of mechanical occlusion. On the other hand, CTA only detects pathological collateral vessels that form secondary to mechanical occlusion. Furthermore, DSA has superior temporal resolution, almost 10 times (Davis et al., 2013) faster compared to CTA, (DSA acquisition 2-7.5 frames/sec, CTA: 8-10 second delay between contrast phases). As a result, delayed collateral formation in DSA may appear early in CTA leading to an upgraded CTA collateral score. Our observations are consistent with previous study findings (Jansen et al., 2016; Kauw et al., 2020).

Clinical outcome (90 day mRS scale)

A multivariate linear regression analysis found that admission NIHSS score, CT scan aspects at 24 hours, and CTA multi-phase collateral status were significant independent predictors for 90 day mRS score after adjusting for confounding factors. A higher 24 hours CT ASPECTS and CTA multi-phase collateral status were associated with a decrease in MRS at 3 months, while an increase in NIHSS score at admission was associated with an increase in MRS at 3 months. However single phase CTA and DSA collateral scores have not demonstrated independent predictive capability for clinical outcome (90 day mRS score). A study by Frans Kauw et al (Kauw et al., 2020) found higher collateral scores assessed on 3-phase CTA and multiphase CTA, but not on DSA, were linked to a mRS of ≤ 2 suggesting that 3-phase CTA and multiphase CTA may be useful in predicting clinical outcomes in patients with acute ischemic stroke. These findings are consistent with the results of our study, indicating that CTA is better than DSA in predicting functional outcomes.

Jansen et al. (Jansen et al., 2016) conducted a study to examine how collateral status (CS), determined by CTA single phase and digital subtraction angiography (DSA), relates to clinical outcomes in patients with acute anterior circulation stroke. Their findings indicated a significant association between CTA CS and the 90-day modified Rankin Scale (mRS) score, while DSA did not show a similar relationship with the outcome measure. The study also revealed limited agreement between DSA and CTA collateral scores (k 0.24), which is comparable to our study's findings (kappa 0.33).

However, unlike our study, their sample size is small, lacked a standardized imaging protocol for the entire study population, and only incorporated spatial information in the collateral scoring, disregarding the temporal information that our study addressed.

Collateral score cut-off value to predict clinical outcome

Our study aimed to establish cut-off values for collateral scores to predict functional outcomes, a task that was not addressed in prior studies. Among all the imaging modalities, multi-phase CTA was the best predictor of good functional outcome at cut off point of >2 and above (mASITN/SIR collateral scale, ranges from 0-4) with 88% chances of correctly predicting good functional outcome. Although DSA was also able to predict favorable functional outcome with statistical significance, it was not as accurate as multi-phase CTA in making these predictions. In our study, we did not find any statistically significant cut-off value for single phase CTA collateral score that could predict good functional outcome.

The study also evaluated the discriminatory power of different imaging techniques in predicting functional outcomes in patients with stroke. The results showed that CTA multi-phase had excellent discriminatory power with an AUC of 0.87 (95% CI, 0.80 to 0.93) indicating its ability to distinguish between patients with good or poor functional outcome. The discriminatory power of DSA was acceptable with an AUC of 0.69 (95% CI, 0.61 to 0.76) However, the discriminatory power of CTA single phase was non-significant, with an AUC of 0.54 and a 95% CI of 0.45 to 0.62.

Similar to our study, BK Menon et al (Menon et al., 2015) also observed that the multi-phase CTA collateral score is better than single-phase CTA in predicting the clinical outcome with a C statistic value of 0.6. Similarly, Shan-shan Lu et al (Lu et al., 2019) also observed the superiority of multi-phase CTA collateral score over single phase CTA in predicting the clinical outcome (AUC - 0.77).

Risk factors in collateralization

In our study, poor collaterals were more frequently observed in patients with a prior stroke (19% vs 5%, P value 0.01) and achieved statistical significance in single phase CTA. Similarly, it was found that diabetic patients had a higher incidence of poor collaterals compared to non-diabetic patients, with a statistically significant difference between the two groups (42% vs 24%, P value 0.05). Previous studies also observed poor collaterals in patients with high glucose levels (Adhithyan et al., 2021; Wiegers et al., 2020). We could not find any increased chance of hemorrhagic transformation in patients with poor collateral grades unlike the previous studies (Bang et al., 2011). Additionally, other risk factors did not show a statistically significant correlation in predicting collateral status and lot of variability is noted in the existing literature regarding the risk factor prediction of collateral status (Wiegers et al., 2020).

Limitations of the study:

1. The retrospective cases included in the study introduces the selection bias.

2. DSA was done only for the cases with a favorable clinical and imaging profile, which may have led to an over-representation of patients with good collateral scores. Nevertheless, in actual clinical practice, DSA is typically performed for the patients with similar indications.

3. Posterior circulation stroke cases were not included in the study.

4. Although automated software was not used in the current study, previous studies have demonstrated that manual assessment can effectively determine the collateral status.

6. Conclusion

- This study provides valuable insights into the effectiveness of collateral status assessed by different imaging modalities in predicting the functional outcome of acute stroke patients
- Multi-phase CT angiography was found to be the best predictor of functional outcomes, with higher levels of sensitivity, specificity, and accuracy compared to single-phase CTA and DSA.
- The study also showed good inter observer agreement among various imaging modalities (single phase CTA, multi-phase CTA and DSA) in assessing collateral status however poor inter modality concordance was noted
- The study established cut-off values for collateral scores to predict functional outcomes (Multi-phase CTA, mASITN/SIR collateral score >2) and found that multi-phase CTA had excellent discriminatory power in predicting functional outcomes in patients with acute ischemic stroke.
- The study also identified significant independent predictors for clinical outcome including admission NIHS S score, CT scan aspects at 24 hours apart from CTA multi-phase collateral status.

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ANNEXURES

Curriculum vitae

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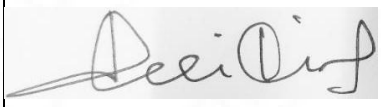
Current and previous positions (most recent position first)		
Month and Year	Title	Institution/Company, Country
Jan 2021	Senior resident	SCTIMST, TVM, India

Brief summary of relevant research experience:

1. An observational MRI study of invasive breast carcinoma
2. Role of SWI, DWI & Perfusion in differentiating ring enhancing lesions of brainparenchyma
3. Unusual presentation of a ruptured temporal arachnoid cyst
4. Imaging recommendations for the diagnosis, staging and management of adult brain tumors.

Current project/s at hand:

1. Usefulness of ASL smearing artefact in differentiating aggressive from benign intracranial Dural arteriovenous fistulas
2. Utility of Zero Time of Echo (ZTE) sequence for assessing bony lesions of skull
3. Multiphasic CT Thrombus attenuation gradient can predict successful first pass recanalization following stentriever thrombectomy.
4. Multi contrast EPI sequence (EPIMix) in clinical situations demanding faster MRI Brain scans



Signature:

Date: 02-09-2021

Place: Thiruvananthapuram

Last Name: Kannath	First Name: Santhosh	Middle Name: Kumar
Date of Birth (dd/mm/yy): 30-05-1979		Sex: M
Study Site Affiliation: Co-Principal Investigator		
Professional Mailing Address (Include Institution name)	Study Site Address (Include Institution name)	
Dept of Imaging Sciences and Interventional Radiology, SCTIMST, Trivandrum	SCTIMST	
Telephone (Office): 0471-2524117	Mobile Number: 8129610796	
Telephone (Residence):	Email:drsanthoshkannath@gmail.com	
Academic Qualifications (Most recent qualification first)		
Degree/Certificate	Year	Institution, Country
PDCC	2007	SCTIMST, Trivandrum
MD RADIODIAGNOSIS	2006	JIPMER, Pondicherry
MBBS	2003	JIPMER, Pondicherry
Details of professional registration : (MCI/State Registration/Bar Council/DCI/etc including Registration Number and Year of Registration TCMC Registration 68885,2018		
Current and previous positions (most recent position first)		
Month and Year	Title	Institution/Company, Country
September 2018 onwards	Additional Professor	SCTIMST, Trivandrum
September 2015 to August 2018	Associate Professor	SCTIMST, Trivandrum
September 2012 to August 2015	Assistant Professor	SCTIMST, Trivandrum
October 2011 to September 2012	Adhoc consultant	SCTIMST, Trivandrum
April 2009 to September 2012	Assistant Professor	SRMC&RI, Chennai
February 2008 to April 2009	Assistant Professor	SUTAMS, Trivandrum
April 2006 to December 2006	Senior resident	JIPMER, Pondicherry

Brief summary of relevant research experience: Projects and research related to neuroimaging and endovascular treatment of neurovascular diseases. Also involved in device development related projects such as flow diverter and clot retriever.	
Current projects at hand: • Development of novel prototype mechanical clot retriever for the treatment of acute cerebral ischemic stroke, funded by DBT • Flow Diverter Stent project (FDS), funded by TRC,SCTIMST • Evaluation of cerebral hemodynamic using functional near infrared spectroscopy and neuropsychological evaluation in intracranial dural arteriovenous fistula, funded by TDF, SCTIMST	
Signature: 	Date: 19/05/2020 Place: Trivandrum

Last Name: **Sylaja**	First Name: **P.N.**	Middle Name:
Date of Birth (dd/mm/yy): **1- 6 -1963**		Sex: **Female**
Study Site Affiliation (e.g. Principal Investigator, Co-Investigator, Coordinator): **Principal Investigator**		
Professional Mailing Address (Include Institution name)		Study Site Address (Include Institution name)
Professor and Head, Department of Neurology, in-charge, Comprehensive Stroke Care Program, Department of Neurology, SCTIMST, PIN - 695 011		**Professor and Head, Department of Neurology, in-charge, Comprehensive Stroke Care Program, Department of Neurology, SCTIMST, PIN - 695 011**
Telephone (Office): **0471- 2524482**		Mobile Number: **+91 9446566287**
Telephone (Residence): **04712452287**		Email: **sylajapn@sctimst.ac.in**

Academic Qualifications (Most recent qualification first)

Degree/Certificate	Year	Institution, Country
Fellow of the Indian Academy of Neurology (FIAN)	**2020**	**Indian Academy of Neurology**
FESO	**2018**	**European Stroke Organization**
FRCP (Edinburgh)	**2017**	**Royal College of Physicians of Edinburgh, Scotland**
Fellowship in Stroke	**2006**	**University of Calgary, Alberta, Canada**
DM (Neurology)	**1998**	**Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum**
MD	**1993**	**Government Medical College, Thiruvananthapuram Kerala**
MBBS	**1987**	**Government Medical College, Thiruvananthapuram Kerala**

Details of professional registration: (MCI/State Registration/Bar Council/DCI/etc including Registration Number and Year of Registration: **15289 Travancore Medical Council**

Current and previous positions (most recent position first)

Month and Year	Title	Institution/Company, Country
August 2021 - Present	**Head**	**Department of Neurology, SCTIMST**
July 2014 - continuing	**Professor of Neurology**	**Department of Neurology, SCTIMST**
June 2010 - July 2014	**Additional Professor in Neurology and in-charge, Comprehensive Stroke care program**	**Department of Neurology, SCTIMST**
January 2007- May 2010	**Consultant in Neurology**	**Ananthapuri Hospital and Research Institute, Thiruvananthapuram**
May 2004 - June 2005	**Assistant Professor**	**Department of Neurology, SCTIMST**
February 1999 - May 2004	**Assistant Professor (Adhoc) in Neurology**	**Department of Neurology, SCTIMST**

Brief summary of relevant research experience:

Involved in research since 1999. The areas of research involve stroke with special interest in neuroepidemiology, intracranial atherosclerotic disease, thrombolysis, stroke rehabilitation.

Involved in many collaborative projects with US, UK and Australia and received funding from NIH, DBT, ICMR and NIHR.

Professional Awards and Honours (selected)

- Commissioner representing India in the Lancet Neurology Commission on Stroke in LMICs
- Member of the Educational Committee of the World Stroke Organization (2018-2020)
- Global Co-Chair, South Asia for India for Mechanical thrombectomy 2020 Global Alliance- from 2019
- Member of the Professional membership committee of the European Stroke Organization
- Honorary Clinical Professor, University of Central Lancashire, UK
- President of the Indian Stroke Association (2018-2019)
- Member of the Research area panel on Stroke of the NCDIR, Bengaluru. 2020- 2022
- Scientific committee member from India in the Global ResQ registry
- National CME convenor of Indian Academy of Neurology (2020-2023)
- Member of the Task force group of the Noncommunicable diseases division of ICMR
- Member of the GBD Cardiovascular diseases and Stroke working group
- Associate editor of the cerebrovascular diseases journal and the Journal of stroke medicine.
- Technical consultant for the State for stroke care, Ministry of Health and Family Welfare
- Life time achievement award in teaching from Indian Medical Association, 2015 Current project/s at hand:

Externally funded projects completed and ongoing – 18

Internal projects, completed and ongoing – 35

Publications – 155

Citations – 11067

h-index- 34

i10 index - 76

Selected Publications:

1. Pandian JD,Verma SJ,Arora D,Sharma M,Dhaliwal RS, Khatter H,Huilgol R,Sylaja PN et al. INSTRUCT: Protocol,infrastructure and governance. Stroke 2021. doi: 10.1161/STROKEAHA.120.033149
2. Nair SN,Sylaja PN, Pandian JD,Srivastava MVP, Khurana D,Kaul S,Arora D, Sarma PS,Singhal AB.Impact of revascularization therapies on outcome of posterior circulation ischemic stroke-The Indo US Stroke project.J Neurol Sci 2021 doi: 10.1016/j.jns.2021.117499
3. Vedartham V,Kesav P,Maniangatt S,Nagesh C,Sreedharan SE,Jayadevan ER,Sarma S, Sylaja PN. Hypodensities within haematoma is time dependant and predicts outcome after spontaneous intracerebral haemorrhage. Neurol India 2021; 69:676-80.
4. Paramasivan NK,Sundaram S,Sharma DP,Sreedharan SE, Sylaja PN. Rituximab for primary angiitis of central nervous system: Experience in two patients. Mult scler Relat disord.2021: doi: 10.1016/j.msard.2021.102907.
5. Kumar A,Chauhan G,Sharma S, Dabla S, Sylaja PN, Chaudhry N,Gupta S, Agrawal C, Anand KS, et al. Association of SUMOylation Pathway Genes With Stroke in a Genome-Wide Association Study in India. Neurology 2021. doi: 10.1212/WNL.0000000000012258.
6. Yagaval D, Saini V,Inoa V,Gardener HE,Martins SO,Fakey M,Ortega S,Mansour O,Leung T,AlMufti F,Jadhav AP,Potter-Vig J,Mairal A,Zhongrong M, Sylaja PN et al. International survey of mechanical thrombectomy stroke systems of care during COVID19.JStroke Cerebrovasc Dis 2021. doi: 10.1016/j.jstrokecerebrovasdis.2021.105806.
7. Shani SD, Sylaja PN,Kutty VR. Facilitators and barriers to medication adherence to stroke survivors in India. J Clin Neurosci 2021;88:185-90.
8. Nogueira RG et al.Global impact of COVID 19 on stroke care and intravenous thrombolysis.Stroke .Neurology 2021. doi: 10.1212/WNL.0000000000011885.
9. Chen C, Parson MW,Levi CR,Spratt NJ,Lin L,Kleing T,Butcher K,Cheng X,Dong Q,Lou M,Obrien B, Avivi RL, Krause M, PN Sylaja, Choi P,Bhuta S, Yin C, Yang J, Wang P, Qiu W, Bivard A.What is the optimal target mismatch criteria for acute ischemic stroke.? Front Neurol 2021 .doi: 10.3389/fneur.2020.590766. eCollection 2020.
10. Shani SD,Sarma PS,Varma RP,Sylaja PN, Kutty VR.Lifestyle and behavioural factors are associated with stroke recurrence among survivors of first episode of stroke.:case control study. J Stroke Cerebrovas Dis.

2021 . doi: 10.1016/j.jstrokecerebrovasdis.2021.105606
11. Sylaja PN,Gurpreet Singh,Sivasambath S,Arun K,Jeemon P,Antony R,Kalani R,Gopal BK,Sylaja PN. Secondary prevention of stroke by primary health care approach- an open label cluster randomized trial. J Clinical Neurosci 2021;84:53-59.
12. Arun K, Shafeeque CM,Sudhir J Banerjee M,Sylaja PN. Ethnic variation and clinical relevance of homozygous RNF 213 p.R4810.Kvariant in the phenotype of Indian Moyamoya disease.PLoS One.2020 . doi: 10.1371/journal.pone.0243925.
13. Divani AA,Andalib S,Biller J,Mc Cullough LD,RubinosCA,Cruz-flores S,NobelezaC,Sylaja PN,Lattanzi S, DiNapoli M,Toledano M,Moghimi N , Torbey M,Azarpazhooh R.Central nervous system manifestations associated with COVID 19.Curr Neurol Neurosci Rep 2020 . doi.org/10.1007/s11910-020-01079-7.
14. Ghoreishi A,Arsang-Jang S,Sabaa-Ayoun Z,Yassi N, Sylaja PN et al.CASCADE investigators.Stroke care trends during COVID 19 pandemic in Zanjan province, Iran-From CASCADE initiative:statistical analysis plan and preliminary results.J Stroke Cerebrovas Dis.2020 doi: 10.1016/j.jstrokecerebrovasdis.2020.105321
15. Hiremath N, Mohimen A, Kesavadas C, PN Sylaja. Risk factors of white matter hyperintensities in South Asian patients with TIA and minor stroke. Neuroradiology.2020;10.1007/ s00234-020-02429-5. doi:10.1007/s00234-020-02429-5
16. Kharal GA, Sylaja PN, Singhal AB. A 66 year old woman with recurrent stroke. Neurology India 2020;68:17-19.
17. Sylaja PN, Srivastava MP, Shah S, Bhatia R, Khurana D, Sharma A, Pandian JD, KaliaK, Sarmah D, Nair SS, Yavagal D. The SARS-CoV-2/COVID-19 pandemic and challenges in stroke care in India. Annals of the New York Academy of Sciences. 2020 Doi: 10.1111/nyas.14379
18. Sreedharan SE, Thomas B, Sylaja PN, Sarma SP. Cerebral Amyloid Angiopathy: AClinico-Radiological Study from South India. Neurol India. 2020;68(2):378-382.
19. Abootalebi S, Aertker BM, Andalibi MS, Asdaghi N, Aykac O, Azarpazhooh MR,Bahit MC, Barlinn K, Basri H, Shahripour RB, Bersano A. Call to Action: SARS-CoV-2 and Cerebrovascular Disorders (CASCADE).has been accepted for publication in the Journal of Stroke and Cerebrovascular Diseases.
20. Kaushik, Ajay, Vikram, Yavagal D, Sylaja PN. "Mechanical Thrombectomy 2020,India's biggest health care challenge yet has been submitted to Annals of IndianAcademy of Neurology.
21. Raina A, Trivedi M, Kate MP, Kumar L, SreedharanSE, PN Sylaja. Temporal sustainability of guideline based door to needle time for intravenous thrombolysis for acute ischemic stroke.J Clin Neurosci 2020 doi: 10.1016/j.jocn.2020.02.002.
22. Kalani R, Krishnamoorthy S, DamayanthiD,Gopala Prabhakaran D,Tirswell D, Sylaja PN.Apolipoproteins B and A1 in ischemic stroke subtypes. J Stroke Cerebrovasc Dis 2020 Apr;29(4):104670. doi: 10.1016/j.jstrokecerebrovasdis.2020.104670.
23. NampoothiriS,Yesodharan D, BhattacherjeeA,Ahamed H, PuriR,Gupta N, Kabra M,RanganathP,Bhat M, Phadke S , Rama Devi AR,Jagdeesh S, Danda S, PN Sylaja, MandalK, Bijarnia-Mahay S, Makkar R, IC Verma, Dalal AB, RamaswamiU. Fabry disease in Indian population.Multicentric retrospective analysis of clinical and mutation spectrum of 54 patients. Has been sent for publication to the Clinical Genetics.
24. Sylaja PN, GurpreetSingh, SivasambathS, ArunK, JeemonP, AntonyR, KalaniR,GopalBK. Secondary prevention of stroke by primary health care approach.- an openlabel cluster randomized trial. Has been submitted for publication to the International Journal of Stroke.
25. 25.SreedharanSE, JaffarS, VipinaVP, MohanM, PaulR, SylajaPN. Post stroke dysphagia and disability in minor strokes.-an institutional study. Has been submitted for publication to the Journal of Stroke and Cerebrovascular Disease.
26. 26.RenjithV, SomanB, SivasambathS, ArunK, JeemonP, AntonyR, GopalBK, SylajaPN. Stroke awareness among community health workers of rural blocks of Thiruvananthapuram, India. Has been submitted for publication to the Journal of Stroke and Cerebrovascular disease.
27. 27. Krishnamoorthy S, Deepa D, Gopal S, Rejith P, PN Sylaja. High sensitivity C reactive protein and lipoprotein treated phospholipase A2 in predicting recurrence and severity of stenosis in symptomatic intracranial atherosclerotic disease. Has been accepted for publication in the Clinical Proteomics.
28. 28.Kashani N, Ospel JM, Menon BK ,Saposnik G, Almekhlafi M, Sylaja PN, Campbell BCV, Heo JH, Mitchell PJ, Cherian M, Turjman F, Kim BM, Fischer U, Wilson AT, Baxter B, Rabinstein A, Yoshimura S, Hill MD, Goyal M. Influence of guidelines in EVT decision making in acute ischemic stroke: Insights from UNMASK EVT Survey. Stroke .doi: .1161/STROKEAHA.119.026982
29. Janet Bettger,ChelseaLiu,DorcasGandhi,Nitha Jayaram, PN Sylaja, Jeyaraj Pandian.Emerging areas of stroke rehabilitation research in low and middle income countries – A scoping review. Stroke 2019 ;50:3307-3313.
30. Saposnik G, Menon BK, Kashani N, Wilson AT, Yoshimura S, Campbell BCV, Baxter B, Rabinstein A, Turjman F, Fischer U, Ospel JM, Mitchell PJ, Sylaja PN, Cherian M, Kim B, Heo JH, Podlasek A, Almekhlafi M, Foss MM, Demchuk AM, Hill MD, Goyal M.Factors associated with decision making of endovascular thrombectomy in management of acute ischemic stroke. Stroke 2019 ;50:2441-2447.
31. SaposnikG, MenonBK, WilsonAT, ShinichiYoshimura, BruceCampbell, BlaiseBaxter, AlejandroRabinstein,

FrancisTurjmon, UrsFischer, PeterMitchell, SylajaPN, MathewCherian, Ji Hoe Heo, Podlasek, AlmekhlafiM, FossM, DemchukAM, HillMD, GoyalM. Endovascular treatment decision in acute stroke.Does physician gender matter.Insights from an international multidisciplinary survey.J of Neurointerventinal Surg2019 doi: 10.1161/STROKEAHA.119.025631

32. Ospel JM, KashaniN, GoyalM, MenonBK, CampbellB, FischerU, TurjmanF, MitchellP, YoshimaraS, PodalasekA, RabinsteinAA, WilsonAT, KimBM, Baxter BW, Cherian M, HoeHJ, FossM, DemchukAM, SylajaPN, Hill MD, Saposnik G, Almekhlafi M Time of day and endovascular treatment decision in acute stroke with relative endovascular indication-Insights from UNMASK EVT International survey.Journal of NeurointerventionalSurg 2019 doi: 10.1136/neurintsurg-2019-014976
33. Arun K, PN Sylaja, SenthilvelanS,KesavadasC,Moinak Banerjee M, Sudhir J.Vessel wall thickening and enhancement in high resolution intracranial vessel wall imaging:a predictor of future ischemic events in Moyamoya disease. AJNRdoi: 10.3174/ajnr.A6360.
34. Saraf U,Arun K, BabikerA,Kesava das C, Prabhakaran S ,PN Sylaja.Comparison of the risk factors and outcome of intracranial atherosclerotic disease between India and United States.Ann Ind AcadNeurol (in press)
35. Sujesh Sreedharan,ArunKM,Sylaja PN,C Kesavadas,RanganathaSitaram.Functional connectivity of language regions of stroke patients with expressive aphasia during real time functional MRI neurofeedback .Brain connectivity 2019;9:613-626.
36. Sujesh S,Anuvitha C,Y Vijay Raj,SylajaPN,RanganathaS,Kesavadas C.Self regulation of language areas using real time functional MRI in stroke patients with expressive aphasia.Brain imaging and behavior.2019 doi: 10.1007/s11682-019-00106-7.
37. Kesav P, Krishnavadana B, Kesavadas C, Sreedharan SE, Rajendran A, Sukumaran S, Sylaja PN. Utility of intracranial high-resolution vessel wall magnetic resonance imaging in differentiating intracranial vasculopathic diseases causing ischemic stroke. Neuroradiology. 2019 ;61(4):389-396.
38. Vishnu VY,BhatiaR,PandainJ,KhuranaD,KaulS,SylajaPN,AroraD,Khatter H,MV Padma,SinghalAB.Regional Differences in ischemic stroke in India (North vs South).Int J Stroke.2019 ;14:706-714.
39. Vineetha VS,SreedharanSE,Sarma S,PN Sylaja.Antiplatelets versus anticoagulants in the treatment of extracranial carotid and vertebral artery dissection.Neurol India 2019;67:1056-59.
40. Sundaram S,P N Sylaja, Menon D, Sreedharan, SEJayadevan ER, SarmaS.Primaryangitis of central nervous system.Clinical profile and outcome of 45 patients.Neurol India 2019;67:105-112.
41. Li Z, Pandian J, Sylaja PN, Wang Y, Zhao X, Liu L, Wang C, Khurana D, Srivastava MVP, Kaul S, Arora D, Schwamm LH, Wang Y, Singhal AB. Quality of care for ischemic stroke in China vs India: Findings from national clinical registries. Neurology. 2018;91(14):e1348-e1354.
42. Adithyan Rajendran,PraveenKesav,Bejoy Thomas, PN Sylaja, C Kesavadas . MRVessel wall imaging in cerebrovascular diseases – a review. Neurol India 2018;66:1124-1132.
43. Sylaja PN, Pandian J, Kaul S, Srivastava P, Khurana D, Schwamm L H, Kesav P, Arora D, Pannu A, Thankachan T, Singhal AB Ischemic stroke profile, risk factors and outcomes in India; the Indo-US Collaborative Stroke Project. Stroke 2018;49:219-222.
44. Kesav P, Vrinda SL, Sukumaran S ,Sarma PS , Sylaja PN .Effectiveness of speech language therapy either alone or in combination with computer based language therapy software (Malayalam version) for post stroke patients with aphasia. J Neurol Sci 2017;380:137-141.
45. Anderson CS, Arima H, Lavados P, Billot L, Hackett ML, Olavarria VV, Muñoz Venturelli P, Brunser A, Peng B, Cui L, Song L, Rogers K, Middleton S, Lim JY, Forshaw D, Lightbody CE, Woodward M, Pontes-Neto O, De Silva HA, Lin RT, Lee TH, Pandian JD, Mead GE, Robinson T, Watkins C; HeadPoST Investigators and Coordinators. Cluster-Randomized, Crossover Trial of Head Positioning in Acute Stroke. N Engl J Med. 2017;376(25):2437-2447.
46. ATTEND Collaborative Group. Family-led rehabilitation after stroke in India (ATTEND): a randomised controlled trial. Lancet. 2017 ;390(10094):588-599.
47. Janet Bettger,ChelseaLiu,DorcasGandhi,NithaJayaram,PN Sylaja,Jeyaraj Pandian.Emerging areas of stroke rehabilitation research in low and middle income countries – A scoping review. Stroke 2019 doi: 10.1161/STROKEAHA.119.023565.
48. Iyer GK, Mekala S, Paplikara, Sharma M, Tripathi M, Ghosh A, Menon R, Ellajosyula R, SarojaAO, Kaul S, Nehra A, Dutt A, Sylaja PN, NarayananJ,VarmaRP, Padma MV, MathuranathPS, Shah U, Pauranik A, Mathew R, Divyaraj G, Nandi R, Sarath L, Verma M, Varghese F, Kandukuri R, Justus S, Khan AB, Hooda R, Alladi S. Standardising dementia diagnosis across linguistic and educational diversity: Study design of the Indian Council of Medical Research-Neurocognitive Tool Box (ICMR-NTB) project.JINS J Int Neuropsychol Soc. 2020 ;26(2):172-186.
49. Vinny WP, VishnuV,GuptaA,ModiM,PadmaMV,Lal V, Sylaja PN, NarasimhanN, DwivediS, NairP, Iype. Head to head comparison between neurology residents and a mobilemedical application for diagnostic accuracy in cognitive neurology. Quarterly journal of Medicine 2019 ;112:591-598.
50. Global , regional and national burden of neurological disorders 1990- 2016:a systematic analysis for Global

Burden of Disease Study 2016.GBD 2016 Neurology Colloborators.Lancet Neurol 2019;18:459-480.
51. Global , regional and national burden of Stroke 1990- 2016:a systematic analysis for Global Burden of Disease Study 2016.GBD 2016 Neurology Colloborators.Lancet Neurol 2019;18:439-58.
52. Bashiya J,KesavP,SreedharanSE,SylajaPN.Extensiveextrapulvinar calcification in Fabrysdisease.Ann Indian Acad Neurol 2018;21:309-310.
53. GBD 2017 SDG Collaborators. Measuring progress from 1990 to 2017 and projecting attainment to 2030 of the health-related Sustainable Development Goals for 195 countries and territories: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018 ;392(10159):2091-2138.
54. GBD 2017 Population and Fertility Collaborators. Population and fertility by age and sex for 195 countries and territories, 1950-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018 ;392(10159):1995-2051.
55. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018;392:1736-1788.
56. Global, regional, and national age-sex-specific mortality and life expectancy, 1950-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018;392:1684-1735.
57. Global, regional, and national disability – adjusted life – years (DALYs) for 359 disease and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018; 392: 1859-1922.
58. Global,regional and national disability adjusted life years (DALYs)for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories 1990-2017- a systematic analysis for Global Burden of Disease Study 2017. Lancet 2018;392:1859-1922.
59. The changing patterns of cardiovascular diseases and their risk factors in the states of India.the Global burden of Disease Study 1990-2016.Lancet Glob Health.2018;6:e1339-51.

Signature: SylajaPN	Date: **26-08-2021** Place: **Trivandrum**

CV Dr.Jayadevan

Last Name: ER	First Name: Jayadevan	Middle Name: -
Date of Birth (dd/mm/yy): 31.05.1974		Sex:M
Study Site Affiliation: Co -Investigator		
Professional Mailing Address: (Include Institution name)		Study Site Address (Include Institution name)
Dept of Imaging Sciences and Interventional Radiology, SCTIMST, Trivandrum		SCTIMST
Telephone (Office): 0471-2524217		Mobile Number: 9287912484
Telephone (Residence): 0471-2382133		Email: drjayadevan@gmail.com

Academic Qualifications (Most recent qualification first)		
Degree/Certificate	Year	Institution, Country
DM Neuroradiology	2005	SCTIMST. Trivandrum
DNB Radiodiagnosis	2002	Govt medical college , Trivandrum
MD Radiodiagnosis	2001	Govt medical college , Trivandrum
Diploma in radiodiagnosis	2000	Govt medical college , Trivandrum
MBBS	Medicine	Govt medical college , Trivandrum

Details of professional registration : (MCI/State Registration/Bar Council/DCI/etc including Registration Number and Year of Registration 26135, dated 13.3.1998 TC medical council Kerala

Current and previous positions (most recent position first)		
Month and Year	Title	Institution/Company, Country
2016 July - Continuing	Additional Professor	SCTIMST, Trivandrum
2013July – 2016 July	Associate professor	SCTIMST, Trivandrum
2010 Nov- 2013 July	Assistant professor	SCTIMST, Trivandrum
2006 Feb to 2010 Nov	Associate professor	MOSC medical college Keolenchery, Kerala

Brief summary of relevant research experience:
Published 23 papers in various peer reviewed journals

Current project/s at hand:

Project title	Funding source	Amount in Rupees
Development of a prototype Flow Diversion Intracranial Stent for the treatment of Complex Intracranial Aneurysms	Technology development fund (TDF, SCTIMST)	5,49,920
Development of novel prototype mechanical clot retriever for the treatment of acute cerebral ischemic stroke	Department of biotechnology (DBT)	16,18,200
Development of Aortic Stent Graft for treatment of thoracic aortic aneurysm	Technical Research centre (TRC, SCTIMST)	1,090,000
Radiopaque liquid embolization device by chemical grafting of Iodinated compounds onto the ethylene vinyl alcohol co-polymer	Technical Research centre (TRC, SCTIMST)	66,40,000
Virtual reality-based solution for effective neuroanatomy teaching	SERB	2.5 Crores

Jayadevan ER

Date: Place:Trivandrum, 30/6/2019

CV – Dr. Chandrasekharan Kesavadas

Chandrasekharan	Kesavadas	
Last Name	First Name	Middle Name
Date of Birth (dd/mm/yy) 29/10/1965		Sex Male
Study Site Affiliation (e.g. Principal Investigator, Co-Investigator, Coordinator) SCTIMST, Trivandrum		
Professional Mailing Address (Include Institution name)		Study Site Address (Include Institution name)
Professor of Radiology, SCTIMST, Trivandrum-11		Professor of Radiology, SCTIMST, Trivandrum-11
Telephone (Office): 04712524220		Mobile Number:9447047002
Telephone (Residence):04712447002		Email : kesav@sctimst.ac.in

Academic Qualifications (Most recent qualification first)

Degree/Certificate	Year	Institution, Country
MBBS	1989	Calicut Medical College
DMRD	1993	GMC, Trivandrum
MD	1994	GMC, Trivandrum
Fellowship : Neuroradiology	2001	St.Raffaele Hospital, Milan

Details of professional registration : (MCI/State Registration/Bar Council/DCI/etc including Registration Number and Year of Registration : 18279, TC Medical Council, 1990

Current and previous positions (most recent position first)

Month and Year	Title	Institution/Company, Country
14.03.2012	Professor, Radiology	SCTIMST
19.08.2007	Additional Professor, Radiology	SCTIMST
19.08.2002	Associate Professor	SCTIMST
19.08.98	Assistant Professor	SCTIMST

Brief summary of relevant research experience: **Areas of research**: Magnetic Resonance Imaging (including Functional MRI , resting state fMRI, SWI, Diffusion/Perfusion Imaging MR spectroscopy ,), Functional near infra red spectroscopy
Neuroradiology (Especially Neuroimaging in Epilepsy, Neurodegenerative diseases, Brain tumor, Stroke, Movement disorders),
Medical Imaging Informatics & Brain Computer interface

Current project/s at hand: Virtual teaching of Neuroanatomy, Resting state fMRI in epilepsy, Functional near infra red spectroscopy in post stroke recovery

Signature:	Date: 8.5.2020 Place:Trivandrum

Supplementary table 1

PROFORMA

Sree Chitra Tirunal Institute for Medical Sciences and Technology
Thiruvananthapuram, Kerala-695011

Title of the study:

Comparative analysis of Computed Tomography Angiography (CTA) with Digital Subtraction Angiography (DSA) for collateral status (CS)in patients with acute large vessel ischemic stroke and to correlate the collateral status with clinical outcome

1. Personal data

1.3. Age ---------- years

1.4 Sex ---------- -- 1.Male 2.female

1.5. Date of admission. ----------

1.6. Date of symptom onset----------

1.7 Phone No : .....

2. Risk factors (1=yes, 2=No)

1. Hypertension---------- Duration in years ----------

2. Diabetes mellitus---------- Duration in years ---------

3. Current smoking---------- pack years ----------

4 Ex smoker……Stopped ---------- years back

5. Drug addiction ----------

6. Alcoholism .....

7. Coronary artery disease-------- Duration in years ----------

8 Valvular heart disease--------- Duration in years ----------

9Congestive heart failure ---------- Duration in years ----------

10. Peripheral vascular disease--------

11. Hyperlipidaemia---------- Duration in years----------

12. Atrial fibrillation---------- Duration in years----------

13. Known carotid disease----------

14 Patients on treatment ----------

. If yes, Type of treatment ----------

2.1.8. Family history of stroke/CAD (first degree relatives) ----------1.Yes.2.No (male<55yrs and female <65 years of age)

3. <u>Symptoms</u> (1=yes, 2=No)

3.1. Visual disturbances ---------- --1.Amaurosis fugax 3.Hemianopia 4.Diplopia 5. Blurring of

vision 6. None

3.2. Weakness ---------- 1. face alone 2.arm 3.leg 4.arm and leg 5. Face arm and leg

6.None

3.3. Numbness/paresthesia ----------

3.4. Speech disturbances ---------- --1.Aphasia 2.Dysarthria3. Both 4.None

3.5. Vertigo----------

3.6. Ataxia .....

3.7. Confusion---------- 3.7.a. Loss of consciousness ----------

3.8. Headache ----------3.8.a.Neck pain ----------

3.9. Seizures .....

3.9.1 Duration of symptoms if TIA ---------- minutes

3.9.2 Number of TIAs before admission----------

3.1.3. Symptoms if present on arrival (in patients with TIA) ----------

4. Clinical Examination (1=yes, 2=No)

4.1. Pulse rate---------- (If Regular =1, Atrial fibrillation =2)

4.2. Blood pressure at ER Systolic---------- diastolic --------- (first documented BP)

4.3. Bruit .....

4.4. Weakness ----------

4.5. Numbness----------

4.6. Cerebellar signs----------

4.7. Aphasia----------

4.8. Dysarthria ----------

4.9. Hemianopia----------

4.9 a. Central retinal artery occlusion----------

4.9.1. Hemispatial neglect ----------

4.9.2. Final impression----------

1. Right hemispheric 2.Left hemispheric 3.Posterior circulation4.undetermined

4.9.3 NIHSS at admission ----------

4.9.4. NIHSS at 24hours (if admitted on day of stroke or TIA onset) ----------

4.9.5. GCS on admission ----------

4.9.6. MRS prior to stroke ----------

4.9.6a.mRS at stroke onset----------

5. Investigations

5.1. Blood glucose in ER----------

5.2. Serum cholesterol----------

5.3. LDL--------

5.4. HDL----------

5.5. Serum triglycerides----------

5.6. ECG---------- 1.Normal 2.LVH 3.AF 4 Ischemic changes 4. Not done

5.7. Echo-trans thoracic ---------- 1.Normal 2.LV dysfunction 3.Mural thrombus 4.

Valve disease 5.PFO 6.infective endocarditis 7.Not done.5.7a.If valve disease, specify ----------

6. Diagnostic imaging

6.1. CT scan ---------- 1.Normal.2. New infarct 3. Old infarct 4.Small vessel

Ischaemic changes 5.Not done

6.1. A Territory ---------- 1. ICA 2.ACA 3.MCA-complete 4 MCA-Inf div 5 MCA sup div 6MCA subcortical

6.1.B Dense artery sign -------1. MCA 2. PCA 3. Basilar 4.ACA.5.ICA 6.absent

6.2. CT angio neck---------- 1.Normal 2.abnormal 3.not done

6.2.1. If abnormal, specify ----------

6.2.2. CT angio intracranial----------1.Normal 2.abnormal 3.not done

6.2.3. If abnormal, specify----------

6.3. MRI scan---------- - 1. DWI negative 2.DWI positive single lesion3.DWI –

Multiple lesions 4.Not done

6.3.1. Arterial territory of acute infarct ---------- - 1.ICA 2.ACA 3.MCA-complete 4.

MCA-Inf div 5. MCA sup div 6. MCA subcortical

6.4. MRA neck ----------1.normal 2.abnormal 3.Not done

6.4.1. If abnormal specify----------

6.4.2. MRA intracranial ---------- --1.normal 2.abnormal 3.Not done

6.4.3. If abnormal, specify ----------

6.5. Carotid Doppler ---------- --1.normal 2.abnormal 3.Not done

6.5.1. If abnormal, specify ----------

6.6. DSA---------- 1.normal 2.abnormal 3.Not done

6.6.1. If abnormal specify ----------

6.7. Final impression on vessel status (symptomatic vessel) ---------- 1. <50% stenosis 2.Moderate stenosis (50-69%) 3.severe stenosis 4.arterial dissection 5.vessel occlusion 6.Normal

6.7.1. Vessel involved ---------- 1.MCA M1 2. MCA M2. -

6.7.2. Side of involvement of vessel ---------- --1.Right 2.Left 3.Bilateral

6.8 MR Vessel wall imaging ----------Findings

6.8.1 Wall remodeling------ 1. Positive 2. Negative

6.8.2 Wall thickening and enhancement 1. Concentric 2. Eccentric 3. No enhancement

6.8.3 Intimal flap 1. Present 2. Absent

6.9 Stroke subtype ---------- --1.large artery atherosclerosis 2.Cardioembolic.3Other Specific causes.4.Undetermined 5.lacunar

7. Thrombolysis

7.1. If thrombolysed ---------- --1.Yes 2.No

7.2. If yes ---------- --1.intravenous 2intraarterial 3.Bridging

8. Treatment at discharge (1=yes, 2= No)

8.1. Aspirin----------

8.2. Clopidogrel----------

8.3. Warfarin ----------

8.4. Statins .....

8.5. Antihypertensives ----------

8.6. Newer Anticoagulant----------

8.7. Carotid endarterectomy---------- Date of surgery----------

8.8. Carotid stenting----------Date of stenting----------

9. Outcome at discharge:

Any periprocedural stroke -Yes / NO Any periprocedural TIA Yes/ No Any other vascular events Yes/ No

9.5. If stroke arterial territory -----1. ICA 2.MCA-M1 3.MCA-M2.4.ACA

9.6. NIHSS at discharge----------

9.7. mRS at discharge----------

9.8. If died, cause of death----------1.Vascular 2.Non vascular. Specify----------

10. Three month outcome:

10.1. Outcome at 3 month ---- --1.Normal 2.Ischaemic stroke3.Haemorrhagic stroke 4.MI

5.CCF 6.

Recurrent TIA 7. Death

10.2. Date of event .....

10.3. m RS at 3 months----------

10.4. NIHSS at 3 months----------

10.5. If died, cause of death------1.Vascular 2.Non vascular.

Supplementary table 2

SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND TECHNOLOGY, THIRUVANANTHAPURAM, KERALA - 695011

COMPREHENSIVE STROKE CARE PROGRAM INFORMED CONSENT FORM

Title of Study:

Comparative analysis of Computed Tomography Angiography (CTA) with Digital Subtraction Angiography (DSA) for collateral status (CS)in patients with acute large vessel ischemic strokeand to correlate the collateral status with clinical outcome

Principal Investigator:

Dr. Hari Kishore K, Senior Resident, Department of IS & IR, SCTIMST

Co-Principal Investigator:

Dr. Santhosh Kumar K, Additional Professor, Department of IS & IR, SCTIMST

Please tick the following points:

(i) I agree to participate as a participant in the study described in the ParticipantInformation Sheet attached to this form.	[ ]
(ii) I acknowledge that I have read the Participant Information Sheet, which explains why I have been selected, the aims of the study and the nature and the possible risks of the investigation, and the information sheet has been explained to me to my satisfaction.	[ ]
(iii) Before signing this consent form, I have been given the opportunity of asking any questions relating to any possible physical and mental harm I might suffer as a result of my participation and I have received satisfactoryanswers.	[ ]
(iv) I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical careor legal rights being affected.	[ ]

(v) I agree that research data gathered from the results of the study may bepublished, provided that I cannot be identified.	[ ]
(vi) I understand that if I have any questions relating to my participation in thisresearch, I may contact my doctor, who will be happy to answer them.	[ ]
(vii) I acknowledge receipt of a copy of this Consent Form and the Participant	[ ]
Information Sheet attached to this form	

Name of Participant

Signature of Participant Date

Time

_____

Name of Caretaker or Next of Kin

(If patient not directly consented)

_____

Relationship with the patient

Signature of Caretaker or Next of Kin Date

Time

_____

Name of Witness

Signature of Witness Date

Time

_____

Name of Person conducting Informed Consent discussion

_____

Signature of Person conducting Informed Consent discussion Date

Time

Supplementary table 3

ശ്രീചിത്ര തിരുനാൾ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഫോർമെഡിക്കൽ സയൻസസ് ആന്റ്ടെക്നോളജി ,
തിരുവനന്തപുരം 695011

കാര്യബോധത്തോടെയുള്ള സമ്മതപത്രം

പഠനശീർഷകം

സമാന്തര രക്തചംക്രമണ നിലയുടെ കമ്പ്യൂട്ടഡ് ടോമോഗ്രഫി ആൻജിയോഗ്രഫി (സിറ്റിഎ) ഡിജിറ്റൽ സബ്ട്രാക്ഷൻ ആൻജിയോഗ്രഫി (ഡിഎസ്എ)യിലേതുമായി താരതമ്യം ചെയ്തതും വലിയ രക്തധമനിയിലെ ഗുരുതരമായ ഈഷ്മിക് മസ്തിഷ്ക്കാഘാത രോഗികളിലെ സമാന്തരമായ രക്തചംക്രമണ നിലയും ക്ലിനിക്കൽ നേട്ടങ്ങളും തമ്മിലുള്ള പാരസ്പര്യം

പ്രധാന ഗവേഷകൻ

ഡോ. ഹരി കിഷോർ കെ,

സീനിയർ റെസിഡന്റ്, ഐഎസ് & ഐആർ ഡിപ്പാർട്ട്മെന്റ്, SCTIMST

സഹപ്രധാനഗവേഷകൻ

ഡോ. സന്തോഷ് കുമാർ കെ,

അഡീഷണൽ പ്രൊഫസർ, ഐഎസ് & ഐആർ ഡിപ്പാർട്ട്മെന്റ്, SCTIMST

(കോളങ്ങളിൽ അടയാളപ്പെടുത്തുക)

ഈ പത്രികയോടൊപ്പമുള്ള, പങ്കെടുക്കുന്നവർക്കുള്ള കാര്യവിവരണപത്രത്തിൽ വിശദീകരിക്കുന്ന പഠനത്തിൽ പങ്കെടുക്കാൻ ഞാൻ സമ്മതിക്കുന്നു.	[ ]
എന്നെ എന്തുകൊണ്ട് തിരഞ്ഞെടുത്തു, പഠനത്തിന്റെ ഉദ്ദേശം, സ്വഭാവം, പരിശോധനയിൽ ഉണ്ടാവാനിടയുള്ള അപായങ്ങൾ എന്നിവ വിവരിക്കുന്ന പങ്കെടുക്കുന്നവർക്കുള്ള കാര്യവിവരണപത്രം വായിച്ചതായും എന്റെ തൃപ്തിയ്ക്കനുസരിച്ച് വിശദീകരിച്ചുതന്നതായും ഞാൻ സമ്മതിക്കുന്നു.	[ ]
സമ്മതപത്രത്തിൽ ഒപ്പു വയ്ക്കുന്നതിനുമുമ്പ്, ഈ പഠനത്തിൽ പങ്കെടുക്കുന്നതുകൊണ്ട് ശാരീരികവും മാനസികവുമായ എന്തെങ്കിലും ഹാനി എനിക്ക് ഉണ്ടാകാൻ സാദ്ധ്യതയുണ്ടോ എന്നതുമായി ബന്ധപ്പെട്ട ചോദ്യങ്ങൾ ചോദിക്കാൻ എനിക്ക് അവസരം ഉണ്ടാവുകയും തൃപ്തികരമായ മറുപടി ലഭിക്കുകയും ചെയ്തു	[ ]
എന്റെ പങ്കാളിത്തം സ്വമേധയായാണെന്നും, കാരണമൊന്നും നൽകാതെയും എന്റെ വൈദ്യപരിചരണത്തെ ബാധിക്കാതെയും ഏതു സമയത്തും എനിക്ക് പിൻമാറാൻ സ്വാതന്ത്ര്യമുണ്ടെന്നും മനസ്സിലാക്കുന്നു.	[ ]
പഠനഫലമായി ശേഖരിച്ച വിവരങ്ങൾ പ്രസിദ്ധീകരിക്കുമ്പോൾ എന്നെ തിരിച്ചറിയാനിടയാകുന്നതൊന്നും വെളിപ്പെടുത്തുകയില്ലെന്ന് ഞാൻ മനസ്സിലാക്കുന്നു.	[ ]
ഗവേഷണത്തിൽ പങ്കെടുക്കുന്നതുമായി ബന്ധപ്പെട്ട് എനിക്ക് ചോദ്യങ്ങളുണ്ടെങ്കിൽ എനിക്ക് ഡോക്ടറെ ബന്ധപ്പെടാമെന്നും ഉത്തരം തരുന്നതിൽ അദ്ദേഹത്തിന് സന്തോഷമേയുള്ളെന്നും ഞാൻ മനസ്സിലാക്കുന്നു.	[ ]
ഈ പത്രികയോടൊപ്പം നൽകിയിട്ടുള്ള പങ്കാളികൾക്കുള്ള വിവരണപത്രവും സമ്മതപത്രവും കിട്ടിയതായി ഞാൻ അറിയിക്കുന്നു.	[ ]

പങ്കെടുക്കുന്നയാളുടെ പേര്

പങ്കെടുക്കുന്നയാളുടെ ഒപ്പ് തീയതി സമയം

പരിചരിക്കുന്നയാളുടെ അല്ലെങ്കിൽ അടുത്തബന്ധുവിന്റെ പേര്
(രോഗി നേരിട്ടല്ല സമ്മതം തരുന്നതെങ്കിൽ)

രോഗിയുമായുള്ള ബന്ധം

പരിചരിക്കുന്നയാളുടെ അല്ലെങ്കിൽ അടുത്തബന്ധുവിന്റെ ഒപ്പ് തീയതി സമയം

സാക്ഷിയുടെ പേര്

സാക്ഷിയുടെ ഒപ്പ് തീയതി സമയം

സമ്മതപത്രത്തെപ്പറ്റി ചർച്ച ചെയ്തയാളുടെ പേര്

സമ്മതപത്രത്തെപ്പറ്റി ചർച്ച ചെയ്തയാളുടെ ഒപ്പ് തീയതി സമയം

Supplementary table 4

SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND TECHNOLOGY, THIRUVANANTHAPURAM, KERALA - 695011

PATIENT INFORMATION SHEET

Title of the study:

Comparative analysis of Computed Tomography Angiography (CTA) with Digital Subtraction Angiography (DSA) for collateral status (CS)in patients with acute large vesselischemic stroke and to correlate the collateral status with clinical outcome

Principal Investigator:

Dr. Hari Kishore K, Senior Resident, Department of IS & IR, SCTIMST

Co-Principal Investigator:

Dr. Santhosh Kumar K, Additional Professor, Department of IS & IR, SCTIMST

Sir/ Madam,

We invite you/bystanders to take part in our study titled *"Comparative analysis of Computed Tomography Angiography (CTA) with Digital Subtraction Angiography (DSA) for collateralstatus (CS)in patients with acute large vessel ischemic stroke and to correlate the collateral status with clinical outcome"* an observational study. Before you/bystanders agree to participate in this research study, it is important that you/bystanders read and understand this information sheet which will provide you/bystanders with all the information needed for participation in this study so that you can make a well informed and considered decision about participation. In addition, should you/bystanders have any questions, the investigator and his team members will be happy to answer them and explain to you more about this research study, the procedure involved and the related issues. You/bystanders may ask them any questions you/bystanders may have regarding the study, or ask them to explain any wordor information that you/bystanders don't clearly understand.

Study Overview

Retrospective and prospective acute ischemic stroke patients who underwent both CTA andDSA before endovascular treatment (EVT) for occlusion of intracranial ICA, M1 and/or M2segments will be included. The collateral status will be evaluated from CTA and will be compared with DSA and the collateral status will be correlated to clinical outcome.

Purpose of this study

To correlate CTA and DSA collateral status in acute ischemic stroke secondary to intracranial large vessel occlusion with the 90-day functional outcome

Study Procedures

If you/bystanders are willing to participate, then you/bystanders will be interviewed and examined and the clinical findings will be noted. As a part of your management plan youwill have to undergo CT imaging & DSA +/- Mechanical Thrombectomy as per standard protocol, data of which will be used in this study.

Risks and Discomfort

This study involves only a structured interview along with CT imaging and DSA +/- Mechanical Thrombectomy done as part of standard management protocol. There are noadditional risks or costs associated with the study.

Benefits

Taking part in this research study may not benefit you. However, the clinical outcome of acute ischemic stroke (AIS) patients is associated with the grade of collateral filling. By comparing various CT angiography techniques with DSA for collateral status and by correlating this collateral status with functional outcome, we may know the better imaging technique that correlates with functional outcome of the patient so that proper patient selection can be done as well as better prognostication can be done simultaneously. If imaging cognates of good collateral status gleaned from DSA could be elucidated from CT,better prognostication could be performed without the need of invasive imaging study

Confidentiality

Your privacy is very important to us and the results of the tests performed on you will be treated as highly confidential, and nobody other than the investigators listed above will be knowing the test results. Your name or any other identifiable details will not be published inany research paper or scientific presentation arising out of the study.

Rights

Your participation in the trial is voluntary. You do not have to take part in this study if you are unwilling and you will not be losing any of your rights as a patient if you choose not to participate. You will also be at the liberty to withdraw from the study at any stage (even after signing this consent form) of the study in case you want to withdraw.

Contact Information

- When you read this information, your treating doctor will be available to discuss andanswer any questions you may have. If you have any queries please contact:

Dr Hari Kishore K

Senior Resident, Department of IS & IR,

Sree Chitra Tirunal Institute for Medical Sciences and Technology Tel: +91 9141633728, Email: haki.kamepalli@sctimst.ac.in

- If you have any questions, concerns or complaints about the research please contact:

Dr. Srinivas G

Member Secretary, Institutional Ethics Committee,

Sree Chitra Tirunal Institute for Medical Sciences and Technology Tel: 0471-2524689, Email: iec.mem.sec@sctimst.ac.in

Supplementary table 5

PATIENT INFORMATION SHEET – MALAYALAM

ശ്രീചിത്ര തിരുനാൾ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഫോർമെഡിക്കൽ സയൻസസ് ആന്റ്ടെക്നോളജി ,
തിരുവനന്തപുരം 695011

കാര്യബോധത്തോടെയുള്ള സമ്മതപത്രം

പഠനശീർഷകം കമ്പ്യൂട്ടഡ് ടോമോഗ്രഫി ആൻജിയോഗ്രഫി (സിറ്റിഎ) യിലെയും ഡിജിറ്റൽ സബ്ട്രാക്ഷൻ ആൻജിയോഗ്രഫി (ഡിഎസ്എ)യിലേയും സമാന്തര രക്തചംക്രമണ നിലകളും, ഗുരുതരമായ ഈഷ്മിക് മസ്തിഷ്ക്കാഘാത രോഗികളിലെ വലിയ രക്തധമനിയിലെ സമാന്തരമായ രക്തചംക്രമണ നിലയും ക്ലിനിക്കൽ നേട്ടങ്ങളും തമ്മിലുള്ള പാരസ്പര്യം

പ്രധാന ഗവേഷകൻ
ഡോ. ഹരി കിഷോർ കെ,
സീനിയർ റെസിഡന്റ്, ഐഎസ് & ഐആർ ഡിപ്പാർട്ട്മെന്റ്, SCTIMST
സഹപ്രധാനഗവേഷകൻ
ഡോ. സന്തോഷ് കുമാർ കെ,
അഡീഷണൽ പ്രൊഫസർ, ഐഎസ് & ഐആർ ഡിപ്പാർട്ട്മെന്റ്, SCTIMST
(കോളങ്ങളിൽ അടയാളപ്പെടുത്തുക)

ഈ പത്രികയോടൊപ്പമുള്ള, പങ്കെടുക്കുന്നവർക്കുള്ള കാര്യവിവരണപത്രത്തിൽ വിശദീകരിക്കുന്ന പഠനത്തിൽ പങ്കെടുക്കാൻ ഞാൻ സമ്മതിക്കുന്നു.	[ ]
എന്നെ എന്തുകൊണ്ട് തിരഞ്ഞെടുത്തു, പഠനത്തിന്റെ ഉദ്ദേശം, സ്വഭാവം, പരിശോധനയിൽ ഉണ്ടാവാനിടയുള്ള അപായങ്ങൾ എന്നിവ വിവരിക്കുന്ന പങ്കെടുക്കുന്നവർക്കുള്ള കാര്യവിവരണപത്രം വായിച്ചതായും എന്റെ തൃപ്തിയ്ക്കനുസരിച്ച് വിശദീകരിച്ചുതന്നതായും ഞാൻ സമ്മതിക്കുന്നു.	[ ]
സമ്മതപത്രത്തിൽ ഒപ്പു വയ്ക്കുന്നതിനുമുമ്പ്, ഈ പഠനത്തിൽ പങ്കെടുക്കുന്നതുകൊണ്ട് ശാരീരികവും മാനസികവുമായ എന്തെങ്കിലും ഹാനി എനിക്ക് ഉണ്ടാകാൻ സാദ്ധ്യതയുണ്ടോ എന്നതുമായി ബന്ധപ്പെട്ട ചോദ്യങ്ങൾ ചോദിക്കാൻ എനിക്ക് അവസരം ഉണ്ടാവുകയും തൃപ്തികരമായ മറുപടി ലഭിക്കുകയും ചെയ്തു	[ ]
എന്റെ പങ്കാളിത്തം സ്വമേധയായാണെന്നും, കാരണമൊന്നും നൽകാതെയും എന്റെ വൈദ്യപരിചരണത്തെ ബാധിക്കാതെയും ഏതു സമയത്തും എനിക്ക് പിൻമാറാൻ സ്വാതന്ത്ര്യമുണ്ടെന്നും മനസ്സിലാക്കുന്നു.	[ ]
പഠനഫലമായി ശേഖരിച്ച വിവരങ്ങൾ പ്രസിദ്ധീകരിക്കുമ്പോൾ എന്നെ തിരിച്ചറിയാനിടയാകുന്നതൊന്നും വെളിപ്പെടുത്തുകയില്ലെന്ന് ഞാൻ മനസ്സിലാക്കുന്നു.	[ ]
ഗവേഷണത്തിൽ പങ്കെടുക്കുന്നതുമായി ബന്ധപ്പെട്ട് എനിക്ക് ചോദ്യങ്ങളുണ്ടെങ്കിൽ എനിക്ക് ഡോക്ടറെ ബന്ധപ്പെടാമെന്നും ഉത്തരം തരുന്നതിൽ അദ്ദേഹത്തിന് സന്തോഷമേയുള്ളൂന്നും ഞാൻ മനസ്സിലാക്കുന്നു.	[ ]
ഈ പത്രികയോടൊപ്പം നൽകിയിട്ടുള്ള പങ്കാളികൾക്കുള്ള വിവരണപത്രവും സമ്മതപത്രവും കിട്ടിയതായി ഞാൻ അറിയിക്കുന്നു.	[ ]

പങ്കെടുക്കുന്നയാളുടെ പേര്

പങ്കെടുക്കുന്നയാളുടെ ഒപ്പ് തീയതി സമയം

പരിചരിക്കുന്നയാളുടെ അല്ലെങ്കിൽ അടുത്തബന്ധുവിന്റെ പേര്
(രോഗി നേരിട്ടല്ല സമ്മതം തരുന്നതെങ്കിൽ)

രോഗിയുമായുള്ള ബന്ധം

പരിചരിക്കുന്നയാളുടെ അല്ലെങ്കിൽ അടുത്തബന്ധുവിന്റെ ഒപ്പ് തീയതി സമയം

സാക്ഷിയുടെ പേര്

സാക്ഷിയുടെ ഒപ്പ് തീയതി സമയം

സമ്മതപത്രത്തെപ്പറ്റി ചർച്ച ചെയ്തയാളുടെ പേര്

സമ്മതപത്രത്തെപ്പറ്റി ചർച്ച ചെയ്തയാളുടെ ഒപ്പ് തീയതി സമയം

Abbreviations

Acom - Anterior communicating artery

ASPECTS - Alberta stroke programme early computed tomography score

ACA – Anterior cerebral artery

ASL – Arterial spin labelling

CT – Computed tomography

CTA – Computed tomographic angiography

CS – Collateral score

CTP – Computed tomographic perfusion

CBD – Clot burden score

CAD – Coronary artery disease

DSA – Digital subtraction angiography

EVT – Endovascular therapy

ECASS – European co-operative acute stroke study

HI – Hemorrhagic infarction

ICA – Internal carotid artery

IVT – Intravenous thrombolysis

mCTA – multi-phasic computed tomographic angiography

mRS – modified Rankin score

MT – Mechanical thrombectomy

mASITN/SIR – modified American society of intervention and therapeutic

neuroradiology/society of interventional neuroradiology

MCA – Middle cerebral artery

mTICI – modified Thrombolytic treatment in cerebral ischemia score

NIHSS – National institute of health stroke scale

NPV – Negative predictive value

PPV – Positive predictive value

Pcom – Posterior communicating artery

PH – Parenchymal hematoma

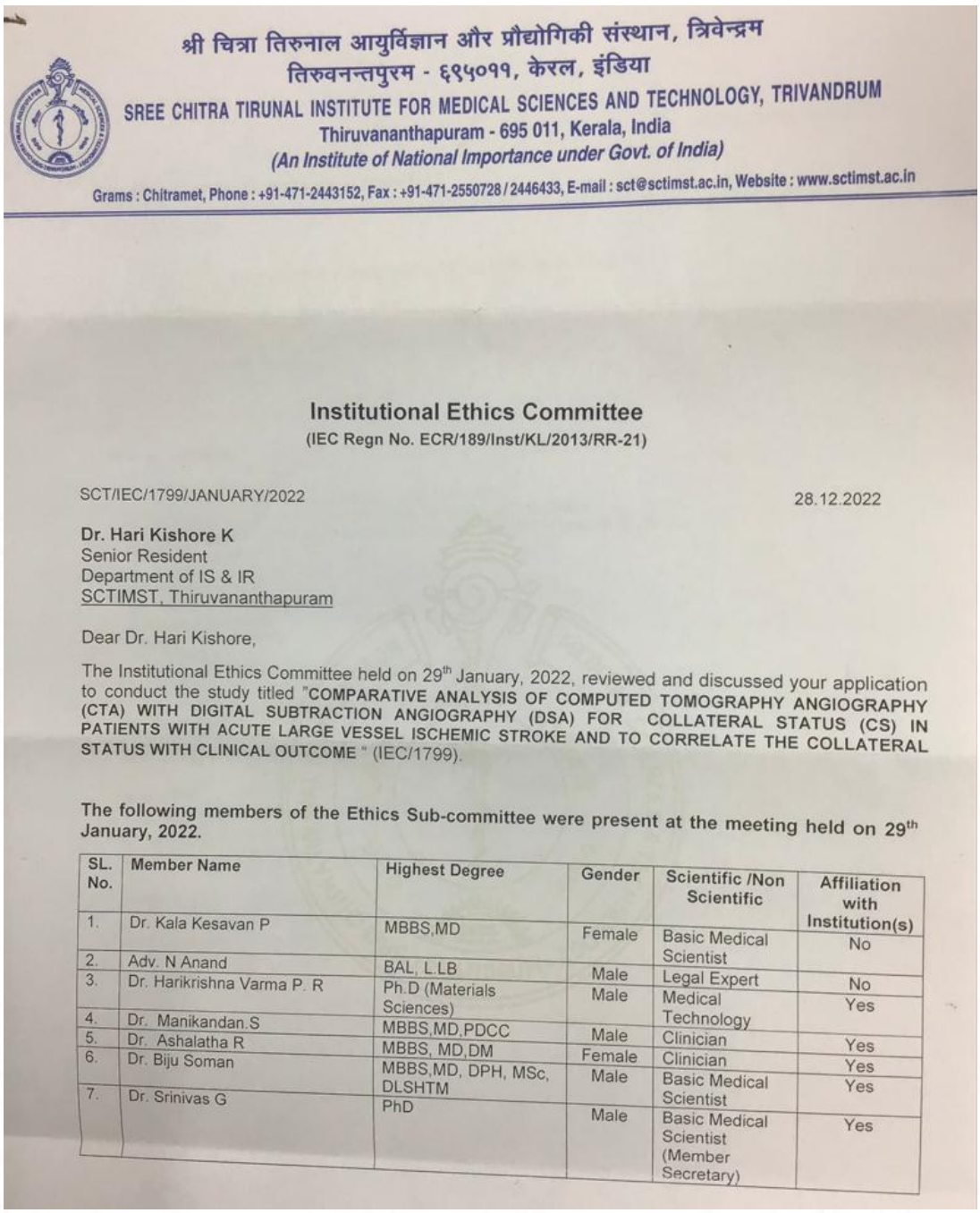
rLMC – regional leptomeningeal score

RHD – Rheumatic heart disease

sCTA – Single phase computed tomographic angiography

TCD – Transcranial doppler

APPENDIX A - IEC Approval form



श्री चित्रा तिरुनाल आयुर्विज्ञान और प्रौद्योगिकी संस्थान, त्रिवेन्द्रम
तिरुवनन्तपुरम - ६९५०११, केरल, इंडिया
SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND TECHNOLOGY, TRIVANDRUM
Thiruvananthapuram - 695 011, Kerala, India
(An Institute of National Importance under Govt. of India)
Grams : Chitramet, Phone : +91-471-2443152, Fax : +91-471-2550728 / 2446433, E-mail : sct@sctimst.ac.in, Website : www.sctimst.ac.in

Institutional Ethics Committee
(IEC Regn No. ECR/189/Inst/KL/2013/RR-21)

SCT/IEC/1799/JANUARY/2022 28.12.2022

Dr. Hari Kishore K
Senior Resident
Department of IS & IR
SCTIMST, Thiruvananthapuram

Dear Dr. Hari Kishore,

The Institutional Ethics Committee held on 29th January, 2022, reviewed and discussed your application to conduct the study titled "**COMPARATIVE ANALYSIS OF COMPUTED TOMOGRAPHY ANGIOGRAPHY (CTA) WITH DIGITAL SUBTRACTION ANGIOGRAPHY (DSA) FOR COLLATERAL STATUS (CS) IN PATIENTS WITH ACUTE LARGE VESSEL ISCHEMIC STROKE AND TO CORRELATE THE COLLATERAL STATUS WITH CLINICAL OUTCOME** " (IEC/1799).

The following members of the Ethics Sub-committee were present at the meeting held on 29th January, 2022.

SL. No.	Member Name	Highest Degree	Gender	Scientific /Non Scientific	Affiliation with Institution(s)
1.	Dr. Kala Kesavan P	MBBS,MD	Female	Basic Medical Scientist	No
2.	Adv. N Anand	BAL, L.LB	Male	Legal Expert	No
3.	Dr. Harikrishna Varma P. R	Ph.D (Materials Sciences)	Male	Medical Technology	Yes
4.	Dr. Manikandan.S	MBBS,MD,PDCC	Male	Clinician	Yes
5.	Dr. Ashalatha R	MBBS, MD,DM	Female	Clinician	Yes
6.	Dr. Biju Soman	MBBS,MD, DPH, MSc, DLSHTM	Male	Basic Medical Scientist	Yes
7.	Dr. Srinivas G	PhD	Male	Basic Medical Scientist (Member Secretary)	Yes

The following documents were reviewed:

Original submission

1. *Checklist Form*
2. *Covering letter addressed to the Chairperson, IEC, SCTIMST dated 08.10.2021*
3. *IEC Application Form*
4. *Study Proposal*
5. *Declaration form*
6. *Informed Consent Form in English and Malayalam*
7. *Patient Information Sheet*
8. *CV of PI and Co-PIs*
9. *Proforma*
10. *SRC Recommendation*

Revised submission

1. *Checklist Form*
2. *Copy of IEC Recommendation letter dated 21.01.2022*
3. *Covering letter addressed to the Member Secretary, IEC, SCTIMST*
4. *Covering letter addressed to the Chairperson, IEC, SCTIMST dated 08.10.2021*
5. *IEC Application Form*
6. *Study Proposal*
7. *Declaration form*
8. *Informed Consent Form in English and Malayalam*
9. *Patient Information Sheet in English and Malayalam*
10. *CV of PI and Co-PIs*
11. *Proforma*
12. *Copy of TCMC Registraion certificate*

IEC Decision

The IEC approved the conduct of the study in the present form.

Remarks:
The Institutional Ethics Committee expects to be informed about the progress of the study, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent and asks to be provided a copy of the final report.

There was no member of the study team who participated in voting / decision making process. The ethics committee is organized and operated according to the requirements of Good Clinical Practice and the requirements of the Indian Council of Medical Research (ICMR).

Sincerely,

Dr. G. Srinivas
Member Secretary, IEC

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE (IEC)
SCTIMST, THIRUVANANTHAPURAM

SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES & TECHNOLOGY
INSTITUTIONAL ETHICS COMMITTEE (IEC)
SCTIMST
THIRUVANANTHAPURAM

APPENDIX B- Thesis data Excel sheet

Hosp No	Age	Sex	NIHSS - Admission	MRS - Admission	Hypertension	Diabetes	Smoking	CAD	RHD	Dyslipidaemia	Past stroke	Carotid disease	Stroke etiology	Bridging therapy	CT ASPECTS - Admission	Hemorragic transformation	Intracra. ICA	M1 MCA	ACA A1	Clot burden score	CTA Single phase (Tan grading)	CTA Multi phase (Modified ASITN/SIR)	DSA (ASITN/SIR)	Final TICI Score	24 H CT ASPECTS	MRS - 3 months	Clot histology
16798	41	Male	16	4	No	No	No	No	No	No	No	No	Cardioembolic	Yes	8	No	Yes	Yes	Yes	2	1	Not available	2	3	7	0	
24488	58	Female	19	4	No	No	No	Yes	Yes	No	No	No	Cardioembolic	No	8	No	No	Yes	No	6	2	4	2	2B	9	0	Equal
196942	46	Female	10	4	No	No	No	No	Yes	No	No	No	Cardioembolic	No	6	No	Yes	Yes	Yes	4	2	3	2	3	6	2	
216151	61	Male	21	4	Yes	Yes	No	Yes	No	Yes	Yes	No	Cardioembolic	Yes	5	Yes (PH 2)	No	Yes	No	4	0	1	3	2C	3	6	
222899	64	Female	13	4	No	No	No	No	Yes	No	No	No	Cardioembolic	No	7	No	No	Yes	No	6	2	3	3	2A	5	3	Fibrin rich
245480	39	Male	15	4	Yes	No	Yes	No	Yes	No	No	No	Cardioembolic	No	5	No	Yes	Yes	Yes	3	2	2	2	3	5	1	
265222	56	Male	20	4	No	No	No	No	Yes	No	Yes	No	Cardioembolic	No	5	No	No	Yes	No	6	1	2	3	3	1	3	
266477	54	Male	21	4	Yes	No	Yes	Yes	No	No	No	No	Atherosclerosis	Yes	10	No	No	Yes	No	8	1	3	3	2C	5	3	
285875	56	Male	18	4	Yes	Yes	No	Yes	No	Yes	Yes	No	Cardioembolic	Yes	6	No	No	Yes	No	6	1	2	3	2A	6	3	
299618	64	Female	19	4	Yes	Yes	No	Yes	No	Yes	No	No	Cardioembolic	No	10	No	No	Yes	No	7	1	1	1	1	2	6	
304748	41	Female	18	4	No	No	No	No	Yes	No	No	Yes	Cardioembolic	No	8	Yes (HI 2)	Yes	Yes	Yes	3	2	Not available	2	3	8	6	
329017	50	Male	14	3	No	Yes	No	Yes	No	No	No	No	Undetermined	No	9	No	No	Yes	No	7	2	Not available	1	3	9	0	
360591	82	Male	7	4	Yes	No	No	No	No	No	No	No	Cardioembolic	Yes	9	No	No	Yes	No	6	1	Not available	2	2B	9	0	
379557	44	Female	14	4	No	Yes	No	No	No	Yes	No	No	Undetermined	Yes	7	No	No	Yes	No	5	1	Not available	3	3	5	2	
385115	43	Male	21	4	No	Yes	No	No	Yes	No	No	No	Cardioembolic	No	6	Yes (HI 1)	No	Yes	No	6	2	1	2	3	8	6	
395900	53	Male	19	5	Yes	No	No	No	No	No	No	No	Undetermined	No	6	Yes (PH 2)	No	Yes	No	8	2	Not available	2	3	6	1	
397050	61	Male	11	4	No	No	Yes	No	No	No	No	No	Cardioembolic	Yes	6	Yes (HI 1)	No	Yes	No	7	2	Not available	3	2C	5	3	
403856	60	Female	21	4	No	Yes	No	Yes	No	No	No	No	Cardioembolic	No	5	No	No	Yes	No	4	2	Not available	2	2B	5	1	
404644	52	Male	21	4	No	No	Yes	No	No	No	No	No	Undetermined	Yes	7	No	No	Yes	No	5	1	Not available	4	2C	6	0	
408551	65	Female	13	4	Yes	No	No	No	No	Yes	No	No	Atherosclerosis	Yes	6	No	No	Yes	No	6	2	Not available	3	2B	6	4	
411721	69	Female	16	4	No	Yes	No	No	No	No	No	No	Undetermined	No	9	No	No	Yes	No	6	2	Not available	1	2C	4	2	
416251	48	Female	13	4	No	No	No	No	Yes	No	No	No	Cardioembolic	Yes	10	No	No	Yes	No	7	2	Not available	1	3	7	2	
419196	74	Male	14	4	No	No	No	Yes	No	No	No	No	Cardioembolic	No	6	Yes (PH 2)	No	Yes	No	5	1	Not available	2	2B	6	0	
421436	60	Male	19	4	Yes	No	No	Yes	No	No	Yes	No	Undetermined	Yes	5	Yes (PH 1)	No	Yes	No	4	1	Not available	3	2A	5	3	
423211	65	Male	16	4	No	No	No	No	No	No	No	No	Atherosclerosis	No	9	No	Yes	Yes	No	1	1	Not available	2	2B	9	2	
427446	68	Female	17	4	Yes	No	No	Yes	No	Yes	No	No	Cardioembolic	No	6	Yes (HI 2)	No	Yes	No	7	1	3	1	3	6	2	
429711	65	Female	14	4	Yes	Yes	No	No	No	Yes	No	No	Cardioembolic	Yes	6	No	No	Yes	No	6	2	1	3	3	5	4	

430068	86	Male	12	4	Yes	No	No	No	No	No	No	No	Cardioembolic	No	7	No	No	Yes	No	4	2	3	1	2B	6	2	
431044	60	Female	10	4	Yes	Yes	No	No	No	Yes	No	No	Cardioembolic	No	8	No	No	Yes	No	6	1	2	2	3	8	1	
431632	67	Male	8	4	Yes	Yes	Yes	Yes	No	Yes	No	No	Undetermined	Yes	9	No	No	Yes	No	8	2	4	3	2A	6	0	
431883	70	Male	17	4	Yes	No	No	No	No	Yes	No	No	Cardioembolic	Yes	8	No	No	Yes	No	6	2	3	2	2B	9	2	
432898	75	Female	23	4	Yes	Yes	No	No	No	No	No	No	Undetermined	Yes	6	No	No	Yes	No	6	2	3	1	2B	6	2	
433853	60	Male	23	4	Yes	No	No	No	No	No	No	No	Cardioembolic	No	6	No	No	Yes	No	4	1	2	3	2C	6	3	
435540	74	Male	16	4	Yes	Yes	No	Yes	No	No	No	No	Cardioembolic	No	5	No	No	Yes	No	6	1	1	2	2B	6	6	
437247	48	Female	26	5	No	No	No	No	No	No	No	No	Undetermined	Yes	8	No	No	Yes	No	4	1	0	1	2c	4	6	
437250	63	Male	18	5	No	Yes	Yes	No	No	No	No	No	Atherosclerosis	No	5	No	Yes	Yes	No	3	1	3	1	2B	5	2	
438048	64	Female	24	5	Yes	Yes	No	No	No	Yes	No	No	Undetermined	No	5	No	No	Yes	No	6	2	1	3	1	0	6	
440137	42	Male	6	3	No	Yes	Yes	No	No	No	No	No	Undetermined	No	6	Yes (HI 1)	No	Yes	No	6	3	4	2	3	6	1	
441106	61	Female	12	4	No	No	No	No	Yes	No	No	No	Cardioembolic	No	7	No	Yes	Yes	Yes	5	1	3	3	3	7	0	
442247	68	Male	15	4	Yes	Yes	No	No	No	No	Yes	No	Cardioembolic	No	6	No	No	Yes	No	5	1	1	3	2b	6	3	
442457	67	Female	17	4	No	No	No	No	No	No	No	No	Cardioembolic	No	7	Yes (HI 1)	No	Yes	No	6	1	3	2	2B	7	1	
444876	63	Male	16	4	No	No	Yes	No	No	No	No	No	Cardioembolic	No	6	No	Yes	Yes	Yes	2	1	1	3	2A	6	4	
445009	54	Male	13	4	Yes	No	Yes	No	No	No	No	No	Undetermined	No	7	No	No	Yes	No	8	2	2	2	2C	4	3	
446169	50	Female	19	4	No	No	No	No	No	No	No	No	Cardioembolic	No	8	No	Yes	Yes	Yes	3	1	3	2	2B	9	0	
447508	58	Male	15	4	No	No	No	Yes	No	No	No	No	Cardioembolic	No	5	Yes (HI 1)	No	Yes	No	6	1	1	3	3	5	4	
450351	64	Female	22	4	Yes	Yes	No	No	No	No	No	No	Undetermined	No	4	No	No	Yes	No	6	1	Not available	4	3	5	3	
451581	49	Female	11	4	Yes	No	No	No	No	No	No	No	Undetermined	No	7	No	Yes	Yes	Yes	1	1	1	1	3	5	6	
452312	51	Male	24	5	Yes	No	No	No	No	No	No	No	Atherosclerosis	No	7	No	No	Yes	No	6	1	4	2	2B	6	0	
453423	81	Male	18	4	Yes	Yes	No	No	No	No	No	No	Atherosclerosis	Yes	6	Yes (PH 1)	No	Yes	No	5	0	1	2	2B	0	4	
453642	78	Male	16	5	Yes	Yes	No	No	No	No	Yes	No	Cardioembolic	No	8	No	No	Yes	No	5	1	2	1	3	6	2	
457230	82	Male	5	3	Yes	Yes	No	No	No	No	No	No	Cardioembolic	No	8	No	No	Yes	No	8	2	Not available	2	2B	8	0	
458196	40	Male	10	4	Yes	No	Yes	No	No	No	No	No	Atherosclerosis	No	7	No	No	Yes	No	8	3	1	3	2A	4	3	
458547	47	Female	15	4	Yes	No	No	No	No	No	No	No	Undetermined	No	4	Yes (HI 2)	No	Yes	No	6	1	1	4	2B	4	3	
461569	88	Male	12	4	Yes	No	No	No	No	No	No	No	Atherosclerosis	No	8	No	No	Yes	No	6	2	2	3	2B	8	3	
462084	61	Female	20	5	Yes	No	No	No	No	Yes	No	No	Undetermined	No	6	No	No	Yes	No	6	2	2	1	3	6	2	
463221	70	Male	11	5	Yes	No	No	No	No	No	No	No	Atherosclerosis	No	9	No	Yes	No	No	8	2	3	2	3	9	1	
467219	64	Male	12	4	Yes	No	No	No	No	No	No	No	Cardioembolic	No	6	No	No	Yes	No	6	2	3	1	2B	8	0	
468846	46	Female	11	4	No	No	No	No	No	No	No	No	Undetermined	No	7	Yes (HI 1)	No	Yes	No	8	2	1	2	1	1	4	
469144	59	Male	21	5	Yes	No	Yes	No	No	No	No	No	Atherosclerosis	No	6	No	No	Yes	No	6	1	1	1	2C	6	2	
469500	65	Male	5	5	No	Yes	Yes	No	No	No	No	No	Atherosclerosis	No	8	No	Yes	No	No	5	2	2	2	2B	1	4	
470872	72	Female	20	5	No	No	No	No	No	No	No	No	Undetermined	No	5	No	No	Yes	No	6	2	3	3	3	7	1	
472193	42	Female	18	4	No	No	No	No	No	No	No	No	Specific Causes	No	4	No	No	Yes	No	6	2	3	2	2b	4	2	
474401	64	Male	20	5	Yes	No	Yes	No	No	No	No	No	Atherosclerosis	No	5	No	Yes	Yes	Yes	4	1	2	2	2a	5	2	
476726	68	Male	4	3	Yes	Yes	No	Yes	No	No	No	No	Atherosclerosis	No	8	No	Yes	Yes	No	6	2	3	3	2C	8	3	
477058	78	Male	19	4	No	No	No	No	No	No	No	No	Undetermined	No	7	No	No	Yes	No	6	1	1	2	2B	5	3	
477063	78	Male	23	4	No	No	No	No	No	No	No	No	Cardioembolic	No	6	Yes (PH 2)	No	Yes	No	6	1	1	3	3	6	5	
477517	46	Male	17	5	No	No	No	No	No	No	No	No	Undetermined	No	7	No	No	Yes	No	7	1	4	1	3	8	2	
477770	51	Male	1	4	No	Yes	No	No	No	No	No	No	Atherosclerosis	Yes	7	No	No	Yes	No	7	2	2	3	2B	5	0	

478333	60	Male	16	4	Yes	Yes	Yes	No	No	No	No	No	Cardioembolic,ICAD	No	5	Yes (HI 2)	No	Yes	No	5	2	2	3	2b	3	3	
478490	58	Female	12	4	No	No	No	No	No	No	No	No	Undetermined	No	6	No	No	Yes	No	6	2	1	2	3	6	3	
479110	70	Male	22	5	Yes	Yes	Yes	No	No	No	No	No	Undetermined	No	7	No	No	Yes	No	7	2	3	2	2a	5	4	
479320	75	Female	8	4	Yes	No	No	No	No	Yes	No	No	Undetermined	Yes	7	No	No	Yes	No	7	2	2	2	3	7	1	
480560	68	Male	23	5	Yes	No	No	No	No	No	No	No	Cardioembolic	Yes	6	No	No	No	No	8	1	2	1	1	6	5	
481237	62	Female	22	5	Yes	Yes	No	No	No	No	No	No	Undetermined	No	6	Yes (HI 1)	No	Yes	No	6	2	1	2	3	4	4	
481822	71	Male	11	4	Yes	No	Yes	No	No	Yes	No	No	Atherosclerosis	No	3	Yes (HI 1)	No	Yes	No	4	2	3	2	0	4	4	
482239	46	Male	11	4	Yes	Yes	Yes	No	No	Yes	No	No	Atherosclerosis	No	6	No	No	Yes	No	4	2	1	3	0	7	3	
482607	71	Male	15	4	Yes	No	Yes	No	No	No	No	No	Cardioembolic	No	5	No	No	Yes	No	4	2	3	4	2B	5	1	
482612	67	Male	23	4	Yes	Yes	No	No	No	No	No	No	Undetermined	No	5	No	Yes	Yes	Yes	0	1	Not available	1	3	4	2	
484209	70	Male	17	4	Yes	No	No	No	No	Yes	Yes	No	Cardioembolic	No	7	Yes (HI 1)	No	Yes	No	4	2	2	2	2b	6	3	
484606	62	Female	17	5	Yes	Yes	No	Yes	No	No	No	No	Atherosclerosis	Yes	8	No	No	Yes	No	6	3	1	3	3	0	4	
487575	41	Female	11	4	No	No	No	No	No	No	No	No	Cardioembolic	No	4	Yes (HI 1)	No	Yes	No	5	2	3	1	3	4	0	
489405	40	Male	13	4	No	Yes	No	No	No	No	Yes	No	Undetermined	Yes	7	Yes (HI 2)	No	Yes	No	8	2	1	1	2C	6	3	
489834	60	Male	8	3	Yes	Yes	Yes	Yes	No	Yes	No	No	Atherosclerosis	Yes	9	No	No	Yes	No	5	2	4	3	2b	9	0	
491075	60	Male	23	4	No	Yes	No	No	No	No	No	No	Undetermined	No	6	No	No	No	No	9	1	1	2	3	6	4	
492198	76	Male	22	4	No	No	Yes	No	No	Yes	No	No	Cardioembolic	Yes	6	Yes (HI 1)	No	Yes	No	6	2	3	2	2b	8	2	
493146	65	Female	18	5	Yes	Yes	No	Yes	No	No	Yes	No	Undetermined	No	5	Yes (HI 1)	No	Yes	No	5	1	1	1	3	2	6	
494599	65	Female	9	4	Yes	No	No	No	No	No	No	No	Undetermined	Yes	4	Yes (HI 1)	No	Yes	No	5	2	3	3	3	4	3	
497091	61	Male	12	4	Yes	Yes	No	Yes	No	No	No	No	Undetermined	No	5	Yes (HI 1)	No	Yes	No	5	2	4	1	3	4	1	
497401	45	Female	19	4	No	No	No	No	Yes	No	No	No	Cardioembolic	Yes	4	Yes (HI 1)	No	Yes	No	7	2	1	3	3	4	4	
8804890	51	Female	10	4	No	No	No	No	Yes	No	Yes	No	Cardioembolic	No	8	No	No	Yes	No	6	1	1	1	2B	4	6	
9304814	51	Male	14	5	No	No	No	Yes	Yes	No	No	No	Cardioembolic	Yes	5	Yes (HI 2)	No	Yes	No	6	1	Not available	2	2C	5	0	
9508269	62	Female	21	5	No	No	No	No	No	No	No	No	Cardioembolic	No	6	No	No	Yes	No	6	1	1	3	2b	4	4	
9600315	48	Male	24	5	No	No	No	No	Yes	No	Yes	No	Cardioembolic	Yes	8	No	No	Yes	No	6	1	3	3	2A	8	3	
9604388	72	Female	21	5	No	No	No	No	No	Yes	Yes	No	Cardioembolic	Yes	5	No	No	Yes	No	7	2	Not available	1	2B	4	6	
9702382	66	Male	16	4	Yes	Yes	No	No	No	Yes	Yes	No	Cardioembolic	Yes	10	No	No	Yes	No	6	1	3	2	3	10	0	
9603602	47	Female	22	5	No	No	No	No	Yes	No	No	No	Cardioembolic	No	5	No	Yes	Yes	Yes	2	1	3	3	3	7	0	
380146	62	Male	14	4	Yes	No	Yes	No	No	No	Yes	No	Cardioembolic	Yes	4	No	No	Yes	No	6	1	Not available	2	3	2	3	
497774	78	Female	11	4	Yes	No	No	No	No	No	No	No	Cardioembolic	Yes	8	No	Yes	Yes	Yes	5	1	1	1	2B	5	4	
499710	73	Male	10	3	Yes	Yes	No	No	No	No	No	No	Atherosclerosis	No	9	No	No	Yes	No	8	3	2	2	2B	9	1	
499404	43	Female	11	4	No	Yes	No	No	No	No	No	No	Undetermined	Yes	6	No	Yes	Yes	Yes	3	2	0	2	3	2	6	
499243	40	Female	16	4	Yes	No	No	No	Yes	No	No	No	Cardioembolic	Yes	7	No	Yes	Yes	Yes	3	1	3	2	2B	9	0	
499172	68	Female	19	4	Yes	Yes	No	No	No	No	No	No	Cardioembolic	No	5	No	No	Yes	No	4	2	4	3	3	5	1	
451663	76	M	21	4	Yes	No	Yes	No	No	No	No	Yes	Atherosclerosis	No	7	No	No	Yes	No	9	1	1	3	2C	7	3	
279546	74	F	14	4	Yes	No	No	No	Yes	No	No	No	Cardioembolic	Yes	3	No	No	Yes	No	9	2	Not available	3	3	7	3	
409048	64	F	21	4	Yes	No	Yes	Yes	No	No	No	Yes	Cardioembolic	Yes	10	No	Yes	Yes	No	6	1	3	3	3	8	3	
477062	42	M	24	5	No	No	No	No	No	Yes	No	No	Cardioembolic	No	5	No	No	Yes	No	9	1	1	2	3	6	6	
477517	50	F	6	3	No	No	Yes	No	No	No	No	No	Cardioembolic	No	6	Yes (HI 1)	No	Yes	No	6	2	2	1	2B	8	1	
478490	52	F	19	4	No	No	NO	No	Yes	No	No	Yes	Cardioembolic	No	10	No	Yes	Yes	No	5	2	3	1	3	6	0	
480560	78	F	19	5	Yes	Yes	No	No	No	Yes	Yes	No	Cardioembolic	Yes	6	Yes (HI 1)	No	Yes	No	8	2	1	1	2B	7	4	

487881	60	F	10	4	Yes	No	Yes	No	No	Yes	No	Yes	Atherosclerosis	No	7	No	No	Yes	No	8	2	2	3	2B	8	3	
487915	59	F	11	4	Yes	Yes	No	No	Yes	No	No	No	Cardioembolic	No	7	No	No	Yes	No	6	2	3	2	3	6	1	
299618	42	F	12	4	No	No	No	No	No	No	No	No	Cardioembolic	No	8	No	No	Yes	No	8	2	1	3	3	2	3	
374330	62	M	18	4	Yes	No	No	No	No	No	No	Yes	Cardioembolic	No	5	No	Yes	Yes	Yes	2	1	2	1	2C	9	2	
412525	58	F	17	5	No	No	Yes	No	No	Yes	No	No	Cardioembolic	No	7	No	No	Yes	No	6	2	3	1	3	8	2	
415566	70	M	12	4	Yes	Yes	No	No	No	Yes	No	No	Cardioembolic	No	7	No	No	Yes	No	8	2	Not available	3	3	7	3	
420057	68	M	22	5	Yes	No	Yes	No	No	Yes	No	No	Cardioembolic	No	6	No	No	Yes	No	6	1	3	3	2B	7	4	
423509	68	M	23	5	Yes	Yes	No	No	No	No	No	Yes	Cardioembolic	Yes	6	N	No	Yes	No	8	2	1	1	3	6	5	
447508	58	Male	15	4	No	No	No	Yes	No	No	No	No	Cardioembolic	No	5	Yes (PI 1)	No	Yes	No	6	1	1	3	3	5	4	
458342	64	Female	22	4	Yes	Yes	No	No	No	No	No	No	Undetermined	No	4	No	No	Yes	No	6	1	Not available	3	3	5	3	
451342	49	Female	11	4	Yes	No	No	No	No	No	No	No	Specific Causes	No	7	No	Yes	Yes	Yes	1	1	2	1	3	5	6	
452399	51	Male	24	5	Yes	No	No	No	No	No	No	No	Atherosclerosis	No	7	No	No	Yes	No	6	1	3	3	2B	6	0	
453581	81	Male	18	4	Yes	Yes	No	No	No	No	No	No	Atherosclerosis	Yes	6	Yes (HI 1)	No	Yes	No	5	0	1	3	2B	0	4	
450523	78	Male	16	5	Yes	Yes	No	No	No	No	Yes	No	Cardioembolic	No	8	No	No	Yes	No	5	1	2	2	3	6	2	
488650	82	Male	5	3	Yes	Yes	No	No	No	No	No	No	Cardioembolic	No	8	No	No	Yes	No	8	2	Not available	2	2B	8	0	
512627	40	Male	10	4	Yes	No	Yes	No	No	No	No	No	Atherosclerosis	No	7	No	No	Yes	No	8	3	3	3	2A	4	3	
455605	47	Female	15	4	Yes	No	No	No	No	No	No	No	Undetermined	No	4	Yes (HI 1)	No	Yes	No	6	1	1	3	2B	4	3	
481215	88	Male	12	4	Yes	No	No	No	No	No	No	No	Atherosclerosis	No	8	No	No	Yes	No	6	2	1	2	2B	8	3	
523187	61	Female	20	5	Yes	No	No	No	No	Yes	No	No	Undetermined	No	6	No	No	Yes	No	6	2	2	1	3	6	2	
488127	70	Male	11	5	Yes	No	No	No	No	No	No	No	Atherosclerosis	No	9	No	Yes	No	No	8	2	3	1	3	9	1	
486321	64	Male	12	4	Yes	No	No	No	No	No	No	No	Cardioembolic	No	6	No	No	Yes	No	6	2	3	2	2B	8	0	
462247	46	Female	11	4	No	No	No	No	No	No	No	No	Undetermined	No	7	Yes (PH 2)	No	Yes	No	8	2	1	3	1	1	4	
498632	59	Male	21	5	Yes	No	Yes	No	No	No	No	No	Atherosclerosis	No	6	No	No	Yes	No	6	1	3	1	2C	6	2	
482621	65	Male	5	5	No	Yes	Yes	No	No	No	No	No	Atherosclerosis	No	8	NO	Yes	No	No	5	2	1	3	2B	1	4	
467624	72	Female	20	5	No	No	No	No	No	No	No	No	Undetermined	No	5	No	No	Yes	No	6	2	2	3	3	7	1	
422981	42	Female	18	4	No	No	No	No	No	No	No	No	Specific Causes	No	4	No	No	Yes	No	6	2	3	2	2b	4	2	
481621	64	Male	20	5	Yes	No	Yes	No	No	No	No	No	Atherosclerosis	No	5	No	Yes	Yes	Yes	4	1	4	2	2a	5	2	
442367	68	Male	4	3	Yes	Yes	No	Yes	No	No	No	No	Atherosclerosis	No	8	No	Yes	Yes	No	6	2	1	3	2C	8	3	
486581	78	Male	19	4	No	No	No	No	No	No	No	No	Undetermined	No	7	No	No	Yes	No	6	1	2	2	2B	5	3	

APPENDIX D - PLAGIARISM CHECK REPORT

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ORIGINALITY REPORT

5%	3%	5%	1%
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5	Frans Kauw, Jan W. Dankbaar, Blake W. Martin, Victoria Y. Ding et al. "Collateral Status in Ischemic Stroke: A Comparison of Computed Tomography Angiography, Computed Tomography Perfusion, and Digital Subtraction Angiography", Journal of Computer Assisted Tomography, 2020 Publication	<1%