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

STUDY OF CLINICAL AND ANGIOGRAPHIC PROFILE OF STROKE IN YOUNG ADULTS

Thesis submitted in partial fulfillment of the rules and regulations for
DM Degree Examination of
Sree Chitra Tirunal Institute for Medical Sciences and Technology

By
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Month and Year of Submission: October 2016

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Thiruvananthapuram
2014-2016
DECLARATION

I, Dr. Sakale Tejas Ulhas, hereby declare that this project was undertaken by me under the supervision of the faculty, Department of Neurology, Sree Chitra Tirunal Institute for Medical Sciences and Technology.

Thiruvananthapuram

Dr. Sakale Tejas Ulhas

Date:
Forwarded

The candidate, Dr Sakale Tejas Ulhas, has completed the project under my guidance.

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Date:

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The candidate, Dr Sakale Tejas Ulhas, has completed the project under my co guidance.

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Date:

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Forwarded

The candidate, Dr. Sakale Tejas Ulhas, has carried out the minimum required project.

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Date: 

Dr. Muralidharan Nair,
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Department of Neurology
SCTIMST.
ACKNOWLEDGEMENT

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I extend my gratitude to all my patients and their caregivers.

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INTRODUCTION

Few authors have reported a higher frequency of young stroke patients in India and in south Asia than in western countries.\(^1\) Patients from India and South Asia were also found to be younger than the stroke patients in western countries.\(^2\). Understanding the exact cause of stroke in the young has great relevance to its prevention and management. Recent advances in the surgical and interventional management of extracranial and intracranial vascular diseases have made it necessary to correctly identify the causative as well as contributory factors of stroke.

A change in lifestyle pattern has led to epidemic of traditional risk factors in younger population, and although large vessel extra and intracranial atherosclerotic disease, small-vessel atherosclerosis, and atrial fibrillation have a major role in cases of stroke in older adults, these disorders are comparatively less frequent in young adults. It is well established that incidence of risk factors and aetiology in young adults differ notably from older patients.

Though many studies have been done about the relationship between various vascular risk factors and young stroke, very few studies from India and south Asia have studied the angiographic profile of patients with young stroke. The study group of acute ischemic stroke in young patients in a tertiary care hospital provides an ideal population to comprehensively study the angiographic and clinical profile as they are comprehensively evaluated in stroke unit.
REVIEW OF LITERATURE

Demographics

Comparison of incidence of young stroke is difficult to predict because of different methods of reporting it in different studies and from different populations. Some population-based studies report rates for all stroke combined (ischemic and haemorrhagic, including subarachnoid haemorrhage), while few other report only ischemic stroke. Referral bias is an important factor in hospital-based registries as opposed to community-based studies. Moreover, in different studies the incidence has been examined at different time points over several decades and incidence rates may change over time making comparisons difficult.

About two thirds of the global burden of stroke is borne by those in developing countries. In India young adults account for approximately 10%-30% of all stroke patients, as opposed to 3%-8.5% in Western countries. Additionally, there is growing evidence for an increasing trend in the incidence of stroke in young adults.

In a systematic review of 15 population based stroke incidence studies, the rate of total stroke for aged less than 45 years was 0.1–0.3 per 1000 person years, while for those aged 75–84 years, the range was 12–20 per 1000 person years in most studies. However, the impact of young stroke is strongest in the individual family and society.

The incidence of young stroke is higher in developing countries than in developed countries because of the higher incidence of strokes related to infections, rheumatic heart disease, and undetected or uncontrolled vascular risk factors.

With regard to sex differences, few studies have shown the predominance of stroke in females
with age group below 35 than males, while no such findings were reported in South Asian studies.\textsuperscript{13,14}

Age limit of young stroke was found different in different studies, and was usually specified below 45 or 50 years in most of the literature.

**Risk factors**

Understanding of risk factors for ischaemic stroke in young adults is based mainly on hospital-based case-control studies and less often on population-based studies. The proportion of young stroke in patients with classical risk factors increases with age\textsuperscript{15, 16, 17}

Traditional risk factors of stroke are hypertension, diabetes, atrial fibrillation, smoking and dyslipidemia. Smoking, trauma, oral contraceptives, migraine, drug abuse, obesity, sedentary lifestyle and pregnancy are modifiable risk factors occurring more frequently in young.\textsuperscript{18} Race, ethnicity, family history of stroke or transient ischemic attack, and low birth weight were identified as other important non-modifiable risk factors of young stroke which are more prevalent in South Asian population.\textsuperscript{19} Risk of stroke is higher when associated with multiple risk factors, still in many cases there may be no identified risk factor.\textsuperscript{10}

**Hypertension**

The most common risk factor of young stroke was hypertension in many South Asian studies. \textsuperscript{20,21,22, 23,24} It was also related with increased risk of stroke death.\textsuperscript{25} The prevalence of hypertension is higher in South Asian population due to changing lifestyle and is predominant in urban areas. This is an important modifiable risk factor in primary as well as secondary prevention.
Dyslipidemia

High levels of total cholesterol or low density lipoprotein and low levels of high density lipoprotein were associated with ischemic stroke. A more consistent association has been noted with low HDL cholesterol and high total cholesterol to HDL cholesterol ratio than with total cholesterol, low density lipoprotein cholesterol and triglycerides. Hossain et al and Lipska et al reported significant number of dyslipidemic young strokes, 38% and 29% respectively. A comparative study of ethnic South Asians and Whites in United Kingdom reported that the percentage of hyperlipidemia was significantly higher among young South Asians. An Indian study reported young stroke in 9 patients with Familial hyperlipidemia, a rarely reported condition in other studies.

Diabetes Mellitus

Diabetes mellitus is a well known risk factor of stroke and its prevalence is increasing in young age population worldwide. Worse prognosis and severe disability was found in stroke patients with diabetes. In India, reported young cases of diabetes patients were high and its association with young stroke similarly showed higher trend. In South Asia, prevalence of diabetes mellitus was found comparatively less among ischemic young strokes than other traditional risk factors. Lipska et al. have in fact reported that diabetes is not a risk factor for young stroke when compared with hospital-based controls.

Smoking

Cigarette smoking is a major independent risk factor for young ischemic stroke. Relative risk may increase with the rate of smoking per day and also with the total
duration of smoking.\textsuperscript{32} Strong association between smoking and young ischemic stroke has also been reported from India.\textsuperscript{9,33}

**Obesity**

Incidence of obesity among stroke patients was reported significantly in Studies from India and also from Pakistan.\textsuperscript{34,35} The major cardiometabolic risk factors are low Basal metabolic index and higher amount of central obesity.\textsuperscript{36} Abdominal obesity which is more associated with atherosclerosis, hypertension and diabetes, is found more common in young South Asians population than western population. Obesity is neglected in most of the Indian studies on young stroke. So, a further epidemiological study on obesity related to young stroke is needed.

**Migraine**

A meta-analyses\textsuperscript{37} showed that the risk of ischemic stroke doubled in people who had migraine with aura than in people without migraine. An age of less than 45 years, smoking, and oral contraceptive use further raised the risk. However, migraine without aura did not seem to affect the risk. The mechanism by which migraine with aura increases the risk of ischaemic stroke is unknown. They mostly affect the posterior cerebral artery territory, but single or multiple infarcts of any size and location have been reported. The incidence of migrainous stroke is too low to explain the increased risk of stroke in people with migraine. Other potential mechanisms include association of migraine with known or unknown causes or risk factors for stroke (e.g. PFO, dissection). Other proposed mechanisms include increased platelet activation, release of serotonin and increased adhesion of platelet during acute attack.\textsuperscript{37,38} Additionally infarcts induced by drugs (e.g. ergotamine) and RCVS might also be a contributing factor. Several disorders such as mitochondrial encephalopathy with
lactic acidosis and stroke-like episodes (MELAS), cerebral autosomal dominant arteriopathy with subcortical ischaemic strokes and leucoencephalopathy (CADASIL), or essential thrombocythaemia can cause stroke and are also associated with migraine. Cerebral infarcts in patients with migraine should be investigated in the same way as any cerebral infarcts in young people and, the label of migrainous stroke is a diagnosis of exclusion.

**Pregnancy and puerperium**

The risk of ischemic stroke for pregnant women is highest in last trimester, and the 6 weeks post-partum but overall pregnancy-related stroke is rare. Although some disorders can be triggered by pregnancy (eg, peripartum cardiomyopathy), in many patients, the cause of the stroke cannot be identified. Whether a hyper-coagulable state and changes in vessel walls associated with pregnancy have a role in the occurrence of these otherwise unexplained ischaemic strokes is still debated.

Eclampsia is the main pregnancy-specific disorder that might be associated with reversible cerebral vasoconstriction syndrome (RCVS) and with non-haemorrhagic stroke-like episodes.

The diagnostic approaches to stroke during pregnancy should proceed as in the non-pregnant state, while taking into account the welfare of the fetus and a history of pregnancy related stroke should not be a contraindication for subsequent pregnancy.


**Oral contraceptives**

The role of OCPs as a risk factor for ischemic stroke remains controversial. According to the results of a meta-analysis\textsuperscript{43}, the risk of stroke is increased by about four times for women who take pills with a high content of oestrogen, and is doubled for those who take pills with low oestrogen content. Pills composed of progesterone alone do not seem to increase the risk of stroke.\textsuperscript{44}

Overall, the excess risk due to oral contraceptives is low (four incident strokes per 100 000 women per year of oral contraceptive use).\textsuperscript{45}, however, in women with migraine, oral contraceptives are associated with an increased risk of ischaemic stroke\textsuperscript{46}.\textsuperscript{47} Women who have prothrombotic genetic variants are also at increased risk.\textsuperscript{48}

**Etiology of young stroke**

Trial of Org 10172 in Acute Stroke Treatment (TOAST) is commonly used to classify strokes The major subtypes according to this classification system are: 1. Large artery atherosclerosis (LAA), 2. Cardio embolism, 3. Small vessel atherosclerosis (SAA), 4. Other determined aetiology, and 5. Undetermined aetiology.

The predominant cause described in the previous Indian studies differs depending on how extensively the patient was evaluated and also on the delay in evaluation.

In a case controlled study of 214 first-occurrence ischemic strokes in young adults from South India, Lipska et al.\textsuperscript{9} reported that cardioembolic stroke (25.2%) was the most common stroke subtype, followed by large artery atherosclerosis (12.6%). They reported that 11.2% of patients had stroke due to other determined cause. In another retrospective study of 177 young adult ischemic stroke patients from South India, the
most common etiologic subtype was atherothrombotic stroke (24%), followed by cardioembolic stroke (17%).\textsuperscript{8} In contrast to the results of the study by Dash et al\textsuperscript{24} where the most common sub type was stroke due to undetermined cause followed by of other determined aetiology. The previous studies reported a low proportion of patients with other determined causes of young stroke. This difference may be because of the increasing availability and use of newer imaging techniques and diagnostic facilities.

**Large and small artery atherosclerosis**

The proportion of young patients with large artery atherosclerosis has traditionally been low in studies from Western countries.\textsuperscript{50,15}

Small arterial atherosclerosis is a common finding in young adults with history of diabetes and hypertension, however atherosclerosis was found to be less common in most of the Indian studies. This may be due to lack of use of vascular imaging applications in hospitals due to cost concerns and unavailability.

Concerning stroke subtype, large vessel atherosclerotic disease and small vessel atherosclerotic disease are rare in younger patients. Atherosclerosis (including both large-vessel and small-vessel atherosclerosis) has been associated with stroke more often in patients over 40 years of age. There are important differences in the distribution of occlusive vascular disease between races: atherosclerosis of large extracranial arteries is more prevalent among Caucasians whereas occlusive disease of the intracranial arteries more often develops in Blacks and Orientals\textsuperscript{17}.

Also the significant increase in large vessel atherosclerotic disease and small vessel atherosclerotic disease observed in the 40- to 49-year age group and the frequency of
risk factors suggests that arterial degenerative alterations occur earlier than expected in patients with a ‘high-risk’ vascular profile. Also, though hypertension is a major risk factor for cerebrovascular disease, its role is strongly preponderant in small vessel atherosclerotic disease.\textsuperscript{17}

In a recent study from north India\textsuperscript{24} only 4.7\% of patients were found to have large artery disease. This could be due to the fact that only 38.4\% of their patients underwent intracranial vessel imaging. In a previous and the only available dedicated angiographic study of young stroke from India, atherosclerosis of large vessels, especially internal carotid artery, was the major finding.

**Cardioembolism**

Cardioembolism is a cause for about 20\% of ischemic stroke in young adults.\textsuperscript{31} Valvular heart diseases, including congenital and acquired, were the major findings in many south Asian studies.\textsuperscript{22,9,20,23,24}. In the Indian scenario, Rheumatic valvular heart disease still remains a major cause, though the incidence has now significantly reduced. Another common cause young stroke with rheumatic heart disease is inadequate anticoagulation after valve replacement or atrial fibrillation. This is in part contributed by poor education and socioeconomic status. Other common sources of cardioembolism in young stroke were infective endocarditis, cardiomyopathy, myxoma, acute myocardial infarction, akinetic ventricular segment, etc.

South Asian studies have shown that Transesophageal echocardiography (TEE) has an important role to diagnose varieties of causes of cardioembolism among young stroke.\textsuperscript{51, 31} TEE was also found to be superior to Transthoracic echocardiography (TTE) in detecting mitral valve prolapse and other cardiac abnormalities.\textsuperscript{52}
The increasing use of 24 hour Holter and longer duration ECG monitoring is expected to help identify and pick up more cases of paroxysmal AF and other arrhythmias.

**Other determined causes**

Stroke of other determined etiology is an important finding in young strokes. The determination of these causes requires special investigations like vasculitis profile, APLA antibodies, CT Angiogram /MR angiogram and DSA. Many of these investigations are not routinely performed and many times the patients cannot afford these investigations, hence it is believed that the incidence of young strokes due to these causes is often underestimated.

Arterial dissection is an important cause of stroke among young adults in western countries and the prevalence in young stroke patients has been reported to be between (10-20%) \(^{53}\). Lipska\(^9\) et al have reported about 7% cases of arterial dissection in their study, whereas Dash\(^{24}\) et al have reported 8.8% of their cases. It is an important cause in young stroke and was the most common cause of stroke due to other determined aetiology in the study by Dash.et.al.\(^{24}\)

The number of dissections could be even higher using the current neuroradiological techniques (axial neck MRI, contrast MR angiography, digital subtraction angiography). Vertebral dissections may be under diagnosed due to the small diameter of the artery, and the difficulty to distinguish between dissection and congenital dysplasia. Thus making it imperative to look for the clinical manifestation of vertebral dissection which may be represented by a cervicocephalic pain without other signs. The importance of a distinction between the two arterial pathologies, atherosclerotic disease v/s arterial dissection lies in the fact that they have different therapeutic and prognostic implications.
Stroke in APLA syndrome, diseases associated with increased lipoprotein and homocysteine or protein S deficiency or antithrombin III deficiency, have also been reported from various Indian studies.\textsuperscript{54-57}

Other causes include systemic vasculitis like SLE and Takayasu’s disease in which stroke can be seen and might even be the presenting manifestation. Other rare vasculitic causes of stroke include Churg-Strauss, Wegener’s vasculitis, polyarteritis nodosa, cryoglobulinaemia, and Behçet’s disease, vasculitis associated with inflammatory bowel disease, and sarcoidosis. Stroke may be a manifestation in patients with primary angiitis of the CNS. Other rare non-inflammatory arteriopathies include radiation arteriopathy, fibromuscular dysplasia, and moyamoya syndrome.

Hematological disorders are an important cause. Sickle-cell anaemia which is fairly common in some communities is an important preventable cause if appropriately managed. Other haematological diseases affecting young adults can be occasionally complicated by arterial stroke. Examples are paroxysmal nocturnal haemoglobinuria, thrombotic thrombocytopenic purpura, erythrocytosis, leukaemias, and intravascular lymphoma.

Strokes due to infectious diseases are also an important cause considering the high prevalence of infectious diseases like TB, HIV and bacterial meningitis. Other infections like meningitis, syphilis, malaria, borreliosis, varicella-zoster vasculopathy and cerebral vasculopathy due to HIV are the well-known causes of stroke, but are unusual findings in most studies.\textsuperscript{58, 59} This may be due to under reporting and reporting bias.
Undetermined causes

In the Indian studies by Lipska et al.\textsuperscript{9} and Dash et al.\textsuperscript{24} 43.5% and 57% of the strokes were classified as undetermined cause and was observed at a steeply higher rate than that reported in previous studies of ischemic stroke in young adults (24%-36%).\textsuperscript{60-63} This may be due to the fact that a significant number of their patient could not undergo complete evaluation. Delayed evaluation is another most important cause for the stroke being mislabelled as ‘cryptogenic’. Reasons for incomplete evaluation are manifold ranging from financial constraints to lack of availability or education.

In the study by Cerrato et al. the vascular risk profile of stroke patients with undetermined cause was similar to that of those with large vessel and small vessel atherosclerotic disease. They suggested that this may be because of an occult arteriopathy, which is affecting many of the patients.\textsuperscript{17}

Lesion pattern and angiographic profile

Improvements and widespread use of neuroimaging techniques such as Diffusion weighted imaging (DWI) and magnetic resonance angiography (MRA), CT Angiography, DSA has increased the reliability and sensitivity of diagnosis of acute ischemic infarction in young patients. A more accurate study of lesion pattern and vessel wall status is now possible.

Studies about the topography of brain infarcts in the young, have found that anterior circulation infarcts found to predominate (46% to 29%)\textsuperscript{60,64,65,66} The wide variation may be attributable to frequent use of MRI in the newer studies which helped in documentation of posterior circulation strokes. Also with the advent of newer
neuroradiological techniques more vertebral artery dissections are being diagnosed which are a common cause of the brain infarcts in this age group.

It has been observed that symptomatic infarcts are more common in the left hemisphere than right. The hemispheric asymmetry of infarcts is an important finding and suggests difficulties in recognition of right hemispheric stroke symptoms.\textsuperscript{67,68} Additionally, it has been hypothesized that because of hemodynamic differences, there may exist a selectivity favoring a cardiac embolus entry into the left common carotid artery or that atherosclerosis might be more frequent in left carotid artery\textsuperscript{68}

The number of patients who underwent intracranial and extracranial vessel status evaluation varied widely from 37-92\% between studies.\textsuperscript{15, 24} Modalities commonly employed included CT Angio, MR Angio and Neck vessel Doppler. DSA based studies are also available but as it is a comparatively invasive procedure it is not performed that frequently. As discussed previously, studies have suggested a greater prevalence of intracranial large artery disease among the South Asians. Among major intracranial vessels, middle cerebral artery is the commonest site of stenosis in young patients.\textsuperscript{54} Ethnic South Asians in England reported higher frequency of lacunar infarction in younger age-group.\textsuperscript{2} A study from Sri Lanka,\textsuperscript{20} also reported majority of cases to be of lacunar infarcts and partial anterior circulation infarcts.

The identification of involved vessel assumes significance as the management strategies in large vessel atherosclerotic disease (extracranial as well intracranial) are different and fast evolving especially with respect to more widespread use of carotid endarterectomy and stenting procedures.
AIMS AND OBJECTIVES

To study the clinical and angiographic profile of patients with ischemic stroke in the age group 15-50 years.
MATERIALS AND METHODS

SUBJECT SELECTION
All consecutive patients admitted in the stroke unit, aged 15 to 50 years with ischemic stroke and who have undergone at least one standard vessel imaging procedure within 2 weeks of stroke onset. Study period Jan 2011 to June 2015

INCLUSION CRITERIA
- Age 15-50 year old
- Consecutive acute ischemic stroke patients.
- Digital Subtraction Angiography /CT Angiography/ MR Angiography (TOF or CE)/ Neck Vessel Doppler completed within 2 weeks of stroke onset.

EXCLUSION CRITERIA:
- Patients who do not meet the inclusion criteria
- Hemorrhagic stroke
- Subarachnoid hemorrhage
- Venous sinus thrombosis.

METHODS
All patients who fulfil the inclusion criteria were included in the study. All patients provided serum samples on hospital admission. The clinical and sociodemographical data, National Institutes of Health Stroke Scale scores, and Modified Rankin Scale scores, as well as data on vascular risk factors and treatment were obtained from the case records.
The assessment of imaging data was performed with the assistance of neuroradiologist.
The stroke subtype was categorized for every patient using Trial of ORG 10172 in Acute Stroke Treatment (TOAST) classification into either of the 5 diagnostic subtypes of ischaemic stroke:

1. Large artery atherosclerosis
2. Cardioembolism
3. Small vessel occlusion (lacunar)
4. Other determined aetiology
5. Undetermined aetiology

**DESIGN**

Cross section observational study

**STATISTICAL ANALYSIS**

We performed a descriptive analysis of the demographic, clinical and angiographic characteristics. Also an inter modality comparison between the various angiographic imaging modalities was attempted. The data was analysed using statistics software (SPSS Inc., Illinois, Chicago). The statistical analysis was be done with the help of the Medical Statistics Expert of the Institute. We summarized the quantitative data with the mean, median, mode and standard deviation measurements whereas the qualitative data or categorical variables will be summarized using percentages. To determine whether the angiographic profile is associated with certain clinical features/demographical features, we used tests for statistical significance, like the Chi square test for comparing percentages and the T test for comparing mean value.
RESULTS

Demography and risk factors

Total patients enrolled were 310 (213 males and 97 females)

Table I

Gender distribution in young stroke patients (N=310)

<table>
<thead>
<tr>
<th>Sex</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>213</td>
<td>68.7</td>
</tr>
<tr>
<td>Female</td>
<td>97</td>
<td>31.3</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Figure 1: Gender distribution in young stroke patients
Table IIa

Age Distribution of the patients (N=310)

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;= 20.0</td>
<td>11</td>
<td>3.5</td>
</tr>
<tr>
<td>21.0 - 25.0</td>
<td>19</td>
<td>6.1</td>
</tr>
<tr>
<td>26.0 - 30.0</td>
<td>25</td>
<td>8.1</td>
</tr>
<tr>
<td>31.0 - 35.0</td>
<td>38</td>
<td>12.3</td>
</tr>
<tr>
<td>36.0 - 40.0</td>
<td>59</td>
<td>19.0</td>
</tr>
<tr>
<td>41.0 - 45.0</td>
<td>84</td>
<td>27.1</td>
</tr>
<tr>
<td>46.0 - 50.0</td>
<td>74</td>
<td>23.9</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The mean age of study population is 38.7 years and the youngest patient being 16 year old and eldest 50 years old.

Figure 2a: Distribution of age of patients
Table IIb

Age-specific group distribution of patients (N=310)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-35</td>
<td>93.00</td>
<td>30.00</td>
</tr>
<tr>
<td>35-50</td>
<td>217.00</td>
<td>70.00</td>
</tr>
<tr>
<td>Total</td>
<td>310.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

The population for the purpose of further analysis was classified into 2 age groups 16-35 and 36-50 years. The number of patients in the 16-35 year age groups was 30% whereas the number of patients in the 36-50 age group were 70%.

Figure 2b: Age-specific group distribution of patients
Table III

Gender distribution according to age-specific groups (N=310)

<table>
<thead>
<tr>
<th></th>
<th>Age ≤35</th>
<th></th>
<th>Age &gt;35</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>53</td>
<td>57.0</td>
<td>160</td>
<td>73.7</td>
</tr>
<tr>
<td>Female</td>
<td>40</td>
<td>43.0</td>
<td>57</td>
<td>26.3</td>
</tr>
<tr>
<td>Total</td>
<td>93</td>
<td>100.0</td>
<td>217</td>
<td>100.0</td>
</tr>
</tbody>
</table>

As can be seen from the table, in the 16-35 year age group 43% were females whereas in the 36-50 years age group it was 26.3%.

Figure 3: Gender distribution according to age-specific groups
Previously described vascular risk factors for stroke in young were studied in the patient population which included diabetes mellitus, hypertension, dyslipidemia, smoking, prior history of CAD, valvular heart disease, past strokes/TIA and migraine. The following tables summarises the relative frequency of these risk factors.

Hypertension and smoking were the most common vascular risk factor noted occurring in more than one fourth of the patients.

Diabetes mellitus and alcoholism was also noted in a significant proportion of patients.

It is noteworthy that the number of patients who had a prior vascular event (stroke/ TIA) was 88. (62 + 26). Thus, almost 28% patients had a history of past stroke/TIA before presentation.

**Table IV**

Risk factor profile of patients

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>85</td>
<td>27.4</td>
</tr>
<tr>
<td>Diabetes</td>
<td>53</td>
<td>17.1</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>23</td>
<td>7.4</td>
</tr>
<tr>
<td>Smoking</td>
<td>85</td>
<td>27.4</td>
</tr>
<tr>
<td>Alcoholism</td>
<td>67</td>
<td>21.6</td>
</tr>
<tr>
<td>Prior stroke</td>
<td>62</td>
<td>20</td>
</tr>
<tr>
<td>H/o prior TIA</td>
<td>26</td>
<td>8.4</td>
</tr>
<tr>
<td>Prior stroke/TIA</td>
<td>88</td>
<td>28.4</td>
</tr>
</tbody>
</table>
Figure 4: Risk factor profile of patients

Around 15% of the patients had history of valvular heart disease and 6.1% had a prosthetic valve. Around 5.8 percent patients had atrial fibrillation. 9% patients had coronary artery disease.

Table V
Risk factor profile of patients

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD</td>
<td>28</td>
<td>9</td>
</tr>
<tr>
<td>Valvular heart disease</td>
<td>46</td>
<td>14.8</td>
</tr>
<tr>
<td>Prosthetic valve</td>
<td>19</td>
<td>6.1</td>
</tr>
<tr>
<td>AF</td>
<td>18</td>
<td>5.8</td>
</tr>
</tbody>
</table>
History of migraine considered by many as a risk factor for young stroke was noted in 13.5% of the patients; however data regarding the history of migraine was not available in about 50% of the patient population.

Table VI

Distribution of history of migraine in patients (N=310)

<table>
<thead>
<tr>
<th>History of Migraine</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>42</td>
<td>13.5</td>
</tr>
<tr>
<td>Not present</td>
<td>104</td>
<td>33.5</td>
</tr>
<tr>
<td>Unknown</td>
<td>164</td>
<td>52.9</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Figure 6: Distribution of history of migraine in patients

Age wise distribution of risk factors

An age wise analysis of the presence of the risk factors is shown in table 7. The proportion of diabetes mellitus, hypertension, dyslipidemia, and smoking was significantly higher in the older age group, whereas the valvular heart disease was significantly more common in the younger age group. The number of patients with history of prior stroke/ TIA was not significantly different between the two age groups.

The following table and figure shows the presence of these risk factors according to age groups
### Table VII

Age wise distribution of risk factors

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>≤35 (N=93)</th>
<th>&gt;35 (N=217)</th>
<th>Total</th>
<th>$\chi^2$</th>
<th>df</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>7 7.5%</td>
<td>78 35.9%</td>
<td>85 27.4%</td>
<td>26.417</td>
<td>1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diabetes</td>
<td>4 4.3%</td>
<td>49 22.6%</td>
<td>53 17.1%</td>
<td>15.347</td>
<td>1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Current smoking</td>
<td>12 12.9%</td>
<td>61 28.4%</td>
<td>73 23.7%</td>
<td>8.590</td>
<td>1</td>
<td>0.003</td>
</tr>
<tr>
<td>Valvular heart disease</td>
<td>20 21.5%</td>
<td>26 12%</td>
<td>46 14.8%</td>
<td>4.673</td>
<td>1</td>
<td>0.031</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>2 2.2%</td>
<td>21 9.7%</td>
<td>23 7.4%</td>
<td>5.369</td>
<td>1</td>
<td>0.020</td>
</tr>
<tr>
<td>AF</td>
<td>2 2.2%</td>
<td>16 7.4%</td>
<td>18 5.8%</td>
<td>3.247</td>
<td>1</td>
<td>0.072</td>
</tr>
<tr>
<td>Prior stroke (Y/N)</td>
<td>15 16.2%</td>
<td>52 24%</td>
<td>67 21.6%</td>
<td>2.358</td>
<td>1</td>
<td>0.125</td>
</tr>
<tr>
<td>H/o prior TIA (Y/N)</td>
<td>9 9.7%</td>
<td>18 8.3%</td>
<td>27 8.7%</td>
<td>0.692</td>
<td>2</td>
<td>0.156</td>
</tr>
</tbody>
</table>

![Age wise distribution of risk factors](image)

**Figure 7:** Age wise distribution of risk factors
Clinical features and stroke severity

Clinical presentation

18 patients (5.8%) had irregularity in pulse rate at presentation which provided an useful and direct clue to etiology at presentation.

No patient presented in hypotension and BP was >140/90mm of Hg in 156 (50.3%) patients on presentation.

3 patients (1%) had neck bruit at presentation, again providing an important clue for further etiologic work up.

32 patients (10.3%) were noted to have a blood glucose level more than 200mg% on admission. No patient had hypoglycaemia on presentation.

Based on the clinical presentation patients were classified as right hemispheric/left hemispheric/ posterior circulation or undetermined territory.

Clinical suspicion of left hemispheric strokes was noted in most of the patients and in about 20% presented with clinical picture suggestive of a posterior circulation involvement as shown in the following table.

Table VIII

Final clinical impression (N=310)

<table>
<thead>
<tr>
<th>Final impression</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right hemispheric</td>
<td>104</td>
<td>33.5</td>
</tr>
<tr>
<td>Left hemispheric</td>
<td>125</td>
<td>40.3</td>
</tr>
<tr>
<td>Posterior circulation</td>
<td>65</td>
<td>21</td>
</tr>
<tr>
<td>Undetermined</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100</td>
</tr>
</tbody>
</table>
NIHSS at admission and discharge was recorded for all the patients (or in few cases calculated retrospectively from case record). Stroke severity was rated on the basis of NIHSS scores. Minor, moderate and severe based on NIHSS score of <6, 6-15 and >15 respectively. Majority of the strokes were minor to moderate. At discharge less than 10% of the patients had a NIHSS score of >12.

**Table IX**

Severity of NIHSS in patients on admission and at discharge (N=310)

<table>
<thead>
<tr>
<th>NIHSS</th>
<th>On admission</th>
<th>At discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Minor</td>
<td>142</td>
<td>45.8</td>
</tr>
<tr>
<td>Moderate</td>
<td>116</td>
<td>37.4</td>
</tr>
<tr>
<td>Severe</td>
<td>52</td>
<td>16.8</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Figure 9: Severity of NIHSS in patients on admission and at discharge

**Etiologic subtypes and work up**

**Etiology**

The TOAST classification system for etiologic stroke subtype classification was used as shown in the following table.

Undetermined aetiology was the most common etiological classification, noted in about 33% patients. Of the patients with determined causes the most common category noted was that of stroke due to other determined causes (26.5%).

Cardio embolism was the next common cause occurring in more than 20% of the patients.

Small vessel disease was the least common aetiology noted.
Table X

Stroke subtype (N=310)

<table>
<thead>
<tr>
<th>Stroke subtype</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large artery atherosclerosis</td>
<td>38</td>
<td>12.3</td>
</tr>
<tr>
<td>Cardio embolism</td>
<td>66</td>
<td>21.3</td>
</tr>
<tr>
<td>Other determined causes</td>
<td>82</td>
<td>26.5</td>
</tr>
<tr>
<td>Undetermined aetiology</td>
<td>103</td>
<td>33.2</td>
</tr>
<tr>
<td>Small vessel disease</td>
<td>21</td>
<td>6.8</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 10: Stroke subtype

Further age wise analysis of the aetiology was done in two groups, and the findings are summarised in the table.

Age wise distribution analysis of the stroke sub types revealed significantly higher proportion of strokes due to small vessel atherosclerosis and large vessel atherosclerosis in the older age group whereas in the younger age group the
predominant causes were other determined aetiologies and cardio embolism.

**Table XI**

Age wise distribution of stroke subtype (N=310)

<table>
<thead>
<tr>
<th>Stroke subtypes</th>
<th>≤35 (N=93)</th>
<th>&gt;35 (N=217)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Large artery atherosclerosis</td>
<td>2</td>
<td>2.2</td>
<td>36</td>
</tr>
<tr>
<td>Cardio embolism</td>
<td>27</td>
<td>29</td>
<td>39</td>
</tr>
<tr>
<td>Other determined causes</td>
<td>30</td>
<td>32.3</td>
<td>52</td>
</tr>
<tr>
<td>Undetermined aetiology</td>
<td>33</td>
<td>35.5</td>
<td>70</td>
</tr>
<tr>
<td>Small vessel disease</td>
<td>1</td>
<td>1.1</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>93</td>
<td>100</td>
<td>217</td>
</tr>
</tbody>
</table>

**Figure 11: Age wise distribution of stroke subtype**

**Other determined causes:**

The most frequent determined etiologic subtype was strokes due to other determined causes and a further analysis of the causes revealed arterial dissection to be the most
common cause. Of the total number of patients dissection was noted in 16.7% of the patients.

Other causes which were commonly identified included vasculitis, Moya Moya disease and procoagulant states. Rare cases of CADASIL, mitochondrial cytopathy and Takayasu’s disease were also seen.

**Table XII**

Distribution of other determined causes (N=85)

<table>
<thead>
<tr>
<th>Other determined causes</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissection</td>
<td>52</td>
<td>61.2</td>
</tr>
<tr>
<td>Pro thrombotic</td>
<td>8</td>
<td>9.4</td>
</tr>
<tr>
<td>Vasculitis</td>
<td>17</td>
<td>20.0</td>
</tr>
<tr>
<td>Moya Moya</td>
<td>4</td>
<td>4.7</td>
</tr>
<tr>
<td>CADASIL</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>Mitochondrial cytopathy</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>Takayasu</td>
<td>2</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>85</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

**Figure 12: Distribution of other determined causes**
Cardio embolism

Cardio embolism was the second most frequent category of determined cause and when causes of cardioembolic strokes were further analysed, majority of the strokes occurred in the setting of a rheumatic valvular heart disease (63.6%), with mitral valve disease being the most frequent association.

Other aetiologies responsible for cardio embolism were paroxysmal AF, PFO and cardiomyopathies.

Table XIII

Cardioembolic specific causes (N=66)

<table>
<thead>
<tr>
<th>Cardioembolic causes</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rheumatic heart disease</td>
<td>42</td>
<td>63.6</td>
</tr>
<tr>
<td>Mitral valve disease</td>
<td>21</td>
<td>50.0</td>
</tr>
<tr>
<td>Aortic valve disease</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Dual valve disease</td>
<td>10</td>
<td>23.8</td>
</tr>
<tr>
<td>Prosthetic valve</td>
<td>11</td>
<td>26.2</td>
</tr>
<tr>
<td><strong>Congenital heart disease</strong></td>
<td><strong>7</strong></td>
<td><strong>10.6</strong></td>
</tr>
<tr>
<td>ASD</td>
<td>1</td>
<td>14.3</td>
</tr>
<tr>
<td>PFO</td>
<td>6</td>
<td>85.7</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td><strong>17</strong></td>
<td><strong>25.8</strong></td>
</tr>
<tr>
<td>LV thrombus</td>
<td>3</td>
<td>17.6</td>
</tr>
<tr>
<td>Paroxysmal AF</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td>Cardiomyopathy</td>
<td>8</td>
<td>47.0</td>
</tr>
<tr>
<td>Infective endocarditis</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td>Others</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>66</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Cardiologic work up

All patients underwent basic cardiology work up with ECG and ECHO. Further evaluation with TEE and Holter study was pursued if clinically indicated.

The ECG findings are summarised in the following table. Almost 80% of patients
had normal ECG whereas 20% of the patients had an ECG abnormality which helped in detecting the aetiology.

**Table XIV**

ECG findings (N=310)

<table>
<thead>
<tr>
<th>ECG findings</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>247</td>
<td>79.7</td>
</tr>
<tr>
<td>LVH</td>
<td>13</td>
<td>4.2</td>
</tr>
<tr>
<td>AF</td>
<td>20</td>
<td>6.5</td>
</tr>
<tr>
<td>Ischemic changes</td>
<td>30</td>
<td>9.6</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100</td>
</tr>
</tbody>
</table>

**ECHO**

The ECHO findings are summarised in the following table. 70% of patients of patients had normal ECHO and the most frequent etiologic abnormality detected was valvular heart disease.

**Table XV**

Echo findings (N=310)

<table>
<thead>
<tr>
<th>ECHO</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>217</td>
<td>70</td>
</tr>
<tr>
<td>LV dysfunction</td>
<td>25</td>
<td>8.1</td>
</tr>
<tr>
<td>Mural thrombus</td>
<td>8</td>
<td>2.6</td>
</tr>
<tr>
<td>Valve disease</td>
<td>44</td>
<td>14.2</td>
</tr>
<tr>
<td>PFO</td>
<td>14</td>
<td>4.5</td>
</tr>
<tr>
<td>Infective endocarditis</td>
<td>2</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100</td>
</tr>
</tbody>
</table>

**Holter study**

Holter study was done in 156 patients. The yield of Holter monitoring was 6.3%.
**Table XVI**

Holter findings (N=156)

<table>
<thead>
<tr>
<th>Holter findings</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>146</td>
<td>93.6</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>3</td>
<td>1.9</td>
</tr>
<tr>
<td>Atrial flutter</td>
<td>6</td>
<td>3.8</td>
</tr>
<tr>
<td>Heart block</td>
<td>1</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>156</td>
<td>100</td>
</tr>
</tbody>
</table>

**Other work up**

Of the 310 patients some patients underwent further testing with ANA profile, RA factor, APLA profile and prothrombotic screening work up as indicated.

The overall yield of these investigations was low and findings are summarised in the table as shown below.

**Table XVII**

Other work up profile

<table>
<thead>
<tr>
<th></th>
<th>ANA</th>
<th>RA factor</th>
<th>APLA profile</th>
<th>Prothrombotic work up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Positive</td>
<td>7</td>
<td>2.3</td>
<td>4</td>
<td>1.3</td>
</tr>
<tr>
<td>Negative</td>
<td>206</td>
<td>66.5</td>
<td>208</td>
<td>67.1</td>
</tr>
<tr>
<td>Not done</td>
<td>97</td>
<td>31.3</td>
<td>98</td>
<td>31.6</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100</td>
<td>310</td>
<td>100</td>
</tr>
</tbody>
</table>
More than 80% (n=269) patients underwent CT Scan and MRI was done in 180 patients. 139 patients underwent both CT as well as MRI. MRI as the only parenchymal imaging modality was done in 13.2% patients only.

The use of parenchymal imaging is summarised in the following table.

**Table XVIII**

<table>
<thead>
<tr>
<th>Imaging</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI only</td>
<td>41</td>
<td>13.2</td>
</tr>
<tr>
<td>CT only</td>
<td>130</td>
<td>41.9</td>
</tr>
<tr>
<td>Both</td>
<td>139</td>
<td>44.8</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100</td>
</tr>
</tbody>
</table>

**Figure 13: Work up for rare causes**

**Imaging and angiographic features**

More than 80% (n=269) patients underwent CT Scan and MRI was done in 180 patients. 139 patients underwent both CT as well as MRI. MRI as the only parenchymal imaging modality was done in 13.2% patients only.
Figure 14: Parenchymal imaging

CT Brain

Of the 269 patients who underwent CT Brain, a new infarct was picked up in about 82% of the patients.

However CT Brain was normal in about 10% of the patients.

Table XIX

CT Brain findings at presentation

<table>
<thead>
<tr>
<th>CT Brain</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>33</td>
</tr>
<tr>
<td>New infarct</td>
<td>221</td>
</tr>
<tr>
<td>Old infarct</td>
<td>11</td>
</tr>
<tr>
<td>Small vessel ischemic changes</td>
<td>4</td>
</tr>
</tbody>
</table>

In patients who had a new infarct on CT scan, the territorial distribution of the infarcts was as summarised in the following table.
Anterior circulation strokes were more common than posterior circulation and the MCA territory was most commonly involved in > 70% of the patients, with complete MCA territory involvement being most common. 15.8% patients had posterior circulation involvement and 6.7% patients had a multi territory involvement.

**Table XX:** Territorial distribution of the infarcts on CT Brain (N=240)

<table>
<thead>
<tr>
<th>CT territory</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICA</td>
<td>7</td>
<td>2.9</td>
</tr>
<tr>
<td>ACA</td>
<td>5</td>
<td>2.1</td>
</tr>
<tr>
<td>MCA</td>
<td>85</td>
<td>35.4</td>
</tr>
<tr>
<td>MCA inferior division</td>
<td>16</td>
<td>6.7</td>
</tr>
<tr>
<td>MCA superior division</td>
<td>27</td>
<td>11.3</td>
</tr>
<tr>
<td>MCA subcortical</td>
<td>46</td>
<td>19.2</td>
</tr>
<tr>
<td>Post circulation</td>
<td>38</td>
<td>15.8</td>
</tr>
<tr>
<td>Multi territory</td>
<td>16</td>
<td>6.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>240</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Figure 15:** Territorial distribution of the infarcts on CT Brain
MRI

MRI was done in 180 patients and about 55.6 percent patients had multiple DWI restricting lesions on MRI. The MRI findings are summarised below in table.

Table XXI

MRI Brain findings at presentation

<table>
<thead>
<tr>
<th>MRI</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWI positive single</td>
<td>80</td>
<td>44.4</td>
</tr>
<tr>
<td>DWI positive multiple</td>
<td>100</td>
<td>55.6</td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>100</td>
</tr>
</tbody>
</table>

In patients who had new infarcts on MRI, the territorial distribution of the infarcts was as summarised in following table.

MCA was the most commonly involved territory and posterior circulation strokes were noted in 31.1% of the patients, which was as expected much higher than the posterior circulation strokes picked up on CT Scans.

Table XXII

Territorial distribution of the infarcts on MRI Brain (N=189)

<table>
<thead>
<tr>
<th>MRI territory</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICA</td>
<td>3</td>
<td>1.6</td>
</tr>
<tr>
<td>ACA</td>
<td>5</td>
<td>2.6</td>
</tr>
<tr>
<td>MCA</td>
<td>51</td>
<td>27.0</td>
</tr>
<tr>
<td>MCA inferior division</td>
<td>11</td>
<td>5.9</td>
</tr>
<tr>
<td>MCA superior division</td>
<td>15</td>
<td>7.9</td>
</tr>
<tr>
<td>MCA sub cortical</td>
<td>30</td>
<td>15.9</td>
</tr>
<tr>
<td>Posterior circulation</td>
<td>59</td>
<td>31.2</td>
</tr>
<tr>
<td>Multiterritory</td>
<td>15</td>
<td>7.9</td>
</tr>
<tr>
<td>Total</td>
<td>189</td>
<td>100</td>
</tr>
</tbody>
</table>
Figure 16: Territorial distribution of the infarcts on MRI Brain

Angiographic profile

All the patients underwent at least one of the following angiographic tests, CT Angiography, MR Angiography (TOF or CE), DSA or neck vessel Doppler.

The most commonly performed angiographic procedure was CT angiogram. TOF MRA was the next most commonly performed angiographic procedure. The least commonly performed procedure was contrast enhanced MR angiography.

Carotid Doppler was done in 9.4% patients but it was never done as a sole angiographic test.

The use of imaging modalities and their positivity has been summarised in the following table. The highest yield for picking up abnormalities was noted in the CT Angiography. The yield of CT angiography was 35.4% and 37.7% for extracranial
and intracranial vasculature respectively, whereas that of MRA TOF was 23.6% and 28.6% respectively.

**Table XXIII**

Vascular imaging modalities (N=310)

<table>
<thead>
<tr>
<th>Vascular imaging modalities</th>
<th>Normal</th>
<th>Abnormal</th>
<th>Not done</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT angio Neck</td>
<td>135</td>
<td>74</td>
<td>101</td>
<td>310</td>
</tr>
<tr>
<td>CT angio Intracranial</td>
<td>132</td>
<td>80</td>
<td>98</td>
<td>310</td>
</tr>
<tr>
<td>MRA (TOF) Neck</td>
<td>94</td>
<td>29</td>
<td>187</td>
<td>310</td>
</tr>
<tr>
<td>MRA (TOF) Intracranial</td>
<td>90</td>
<td>36</td>
<td>184</td>
<td>310</td>
</tr>
<tr>
<td>DSA</td>
<td>20</td>
<td>33</td>
<td>257</td>
<td>310</td>
</tr>
<tr>
<td>Carotid Doppler</td>
<td>12</td>
<td>17</td>
<td>281</td>
<td>310</td>
</tr>
<tr>
<td>MRA (CE) Neck</td>
<td>1</td>
<td>5</td>
<td>304</td>
<td>310</td>
</tr>
<tr>
<td>MRA (CE) Intracranial</td>
<td>1</td>
<td>3</td>
<td>306</td>
<td>310</td>
</tr>
</tbody>
</table>

**Figure 17: Vascular imaging modalities**
Of the 310, 53 patients underwent DSA and it was normal in 20 patients. 33 patients had abnormal DSA, thus the yield of DSA (in carefully selected patients) was more than 60%. The common abnormalities detected on DSA are summarised in the following table.

Table XXIV

**DSA findings (N=53)**

<table>
<thead>
<tr>
<th>DSA Findings</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atherosclerotic disease</td>
<td>11</td>
<td>20.8</td>
</tr>
<tr>
<td>Dissection</td>
<td>8</td>
<td>15.1</td>
</tr>
<tr>
<td>Vasculitis</td>
<td>7</td>
<td>13.2</td>
</tr>
<tr>
<td>Moya Moya</td>
<td>6</td>
<td>11.3</td>
</tr>
<tr>
<td>Takayasu</td>
<td>1</td>
<td>1.9</td>
</tr>
<tr>
<td>Normal</td>
<td>20</td>
<td>37.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>53</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

![Figure 18: DSA findings](image-url)
As far as the atherosclerotic disease and arterial dissections were considered, there was a stark difference in the involvement pattern of the intracranial and extracranial vasculature as shown in the table. Intracranial vasculature was more frequently involved in the patients with atherosclerotic disease whereas arterial dissections occurred more frequently in the extracranial vasculature.

**Table XXV**

Pattern of involvement in atherosclerotic disease and arterial dissections in DSA

<table>
<thead>
<tr>
<th></th>
<th>Intracranial</th>
<th>Extracranial</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Atherosclerotic</td>
<td>10</td>
<td>90.9</td>
<td>1</td>
</tr>
<tr>
<td>disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissection</td>
<td>3</td>
<td>37.5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 19: Pattern of involvement in atherosclerotic disease and arterial dissections in DSA**
Final vessel status:

The final impression regarding the vessel status at the end of angiographic evaluation was as show in the table. Of the 310 patients, 42% patients (n=130) had a normal angiography.

Stroke of undetermined aetiology was noted to be the most frequent cause in patients with a normal angiography (50.8%). Cardio embolism was the next most frequent cause. (25.4%)

The abnormality most commonly encountered was vessel occlusion in 30.6% of the patients. The next most common abnormality noted was dissection which was seen in 16.8 % of the patients. A small percent of the patients i.e. 3.9% had a clinically significant stenosis (>70%).

Table XXVI

Final vessel status (N=310)

<table>
<thead>
<tr>
<th>Final vessel status</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;50% stenosis</td>
<td>5</td>
<td>1.6</td>
</tr>
<tr>
<td>50-69% stenosis</td>
<td>16</td>
<td>5.2</td>
</tr>
<tr>
<td>&gt;70% stenosis</td>
<td>12</td>
<td>3.9</td>
</tr>
<tr>
<td>Dissection</td>
<td>52</td>
<td>16.8</td>
</tr>
<tr>
<td>Occlusion</td>
<td>95</td>
<td>30.6</td>
</tr>
<tr>
<td>Normal</td>
<td>130</td>
<td>41.9</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100</td>
</tr>
</tbody>
</table>
Figure 20: Final vessel status

Pattern of vessel involvement

Extracranial vasculature as a group was involved in more than 40% of patients with abnormal vessel status. Extracranial ICA was involved in 33.7% of the patients and was the most common extracranial vessel involved. Intracranial vasculature involvement was slightly more frequent than extracranial involvement. The intracranial vessel most commonly involved was M1 branch of MCA.

As can be seen from the table there was no particular side predilection for the vessel involvement and about 20% of the patients had bilateral abnormalities.
### Table XXVII

Vessel involvement (N=187)

<table>
<thead>
<tr>
<th>Vessel involved</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extracranial ICA</td>
<td>63</td>
<td>33.7</td>
</tr>
<tr>
<td>VA</td>
<td>17</td>
<td>9.1</td>
</tr>
<tr>
<td>Intracranial ICA</td>
<td>12</td>
<td>6.4</td>
</tr>
<tr>
<td>MCA M1</td>
<td>43</td>
<td>23</td>
</tr>
<tr>
<td>MCA M2</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>ACA</td>
<td>6</td>
<td>3.2</td>
</tr>
<tr>
<td>BA</td>
<td>7</td>
<td>3.7</td>
</tr>
<tr>
<td>PCA</td>
<td>6</td>
<td>3.2</td>
</tr>
<tr>
<td>SCA</td>
<td>2</td>
<td>1.1</td>
</tr>
<tr>
<td>PICA</td>
<td>3</td>
<td>1.6</td>
</tr>
<tr>
<td>Multi vessel</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>187</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

![Vessels Involved Diagram](image)

**Figure 21: Vessels involved**
Outcomes and Treatment:

Of the 310 patients, 8 patients expired (mRS-6). More than 60 percent patients at the time of discharge had a mRS of ≤3, indicating an overall good recovery and lesser disability.

Table XXVIII

mRS at discharge (N=310)

<table>
<thead>
<tr>
<th>mRS at discharge</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>33</td>
<td>10.6</td>
</tr>
<tr>
<td>1</td>
<td>42</td>
<td>13.5</td>
</tr>
<tr>
<td>2</td>
<td>67</td>
<td>21.6</td>
</tr>
<tr>
<td>3</td>
<td>62</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>89</td>
<td>28.7</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>2.9</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>2.6</td>
</tr>
<tr>
<td>Total</td>
<td>310</td>
<td>100</td>
</tr>
</tbody>
</table>

Treatment at discharge:

Most commonly patients were discharged on a combination of Ecosprin and Statins (more than 80% of patients). Dual antiplatelets (Ecosprin + Clopidrogel) were prescribed to 38.4% patients on discharge. Around 20% of the patients were initiated on anticoagulation at discharge and antihypertensives were required for more than 40% of the patients.

<table>
<thead>
<tr>
<th>Discharge medications</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosprin</td>
<td>253</td>
<td>81.6</td>
</tr>
<tr>
<td>Clopidrogel</td>
<td>122</td>
<td>39.4</td>
</tr>
<tr>
<td>Warfarin or Acitrom</td>
<td>67</td>
<td>21.6</td>
</tr>
<tr>
<td>Statin</td>
<td>248</td>
<td>80</td>
</tr>
<tr>
<td>Antihypertensives</td>
<td>129</td>
<td>41.6</td>
</tr>
<tr>
<td>Ecosprin + Clopidrogel</td>
<td>119</td>
<td>38.4</td>
</tr>
</tbody>
</table>
DISCUSSION

Considering the ever increasing burden of stroke and the profound economic and social consequences in young population it is essential that etiological diagnosis and risk factor evaluation is complete. This helps not only in planning treatment and secondary prevention strategies but also assumes significance for rehabilitation. There are very few studies from India focussing on the risk factors and angiographic profile of stroke in young adults and we report one of the largest of such studies.

As has been noted in previous studies from the subcontinent a higher male predominance was observed in our study. Similar findings have been noted in previous studies\textsuperscript{9, 23, 24} and is probably also related to referral bias related to the social and cultural factors.

The number of patients who were more than 35 years of age constituted almost 70% of the total patients highlighting the age related increase in incidence of stroke. Also the gender differences were less prominent at younger age groups than in the older age groups. This is consistent with the previous studies some of which have described even higher incidence of stroke in females\textsuperscript{65, 63}

Of the commonly studied vascular risk factors hypertension, smoking, diabetes, dyslipidemia and CAD the risk factors most commonly noted were smoking and hypertension.

The age wise analysis of the vascular risk factors revealed statistically significant higher occurrence of diabetes mellitus, hypertension, dyslipidemia and smoking in patients $>$35 years of age.

Valvular heart disease was also noted in higher proportion of patients as
compared to other studies and this may be because of referral bias as our hospital also serves as a major tertiary referral centre for cardiology services.

More than 25% patients had a history of past stroke/TIA. This high proportion highlights the importance of proper initial evaluation in young patients with first ever ischemic event. Proper etiological work up and stringent secondary prophylaxis strategies are essential.

Small proportion of patients had findings like irregularly irregular pulse and arterial bruit on general examination which provided a direct clue to the underlying aetiology of stroke.

Anterior circulation strokes predominated in our study which was consistent with results from other young stroke studies. The proportion of left hemispheric strokes was higher than right as has been previously noted by many authors.\textsuperscript{65, 67} This may be because of the difficulty in identifying right hemispheric deficits.\textsuperscript{65, 67}

The strength of our study is that all patients underwent at least the basic etiologic work up in the form of ECG, ECHO and vessel imaging.

The commonest etiologic subtype according to TOAST etiological classification was stroke due to undetermined causes. The next common cause was stroke due to other determined causes. Similar findings were noted in a recent study by dash et.al\textsuperscript{24} in which 17.4\% of their patients had stroke due to other determined causes, arterial dissection being the commonest. Similar trend was observed in our study also in where we noted arterial dissections in 16.7\% of our patients. The higher proportion of patients in our study as well as in the study by Das et.al is probably related to increased and early availability of radiological investigations like CT
angiogram.

This finding also highlights the importance of early and through evaluation of the vascular tree of all young stroke patients.

Cardio embolic strokes were the next common cause. Valvular heart was the most common cause of cardio embolic strokes. Lipska et. al have also previously noted cardio embolic strokes as the most common aetiology with valvular rheumatic heart diseases being the commonest cause for cardio embolic strokes. Various studies have previously reported the incidence of cardio embolic young strokes to be between 14-47%. However the common causes of cardio embolic strokes in studies from the west were congenital heart diseases like PFO/ ASD.

All patients underwent ECG and ECHO and this should be considered as one of the strengths of the current study. ECG provided a direct etiologic clue in about 6% of the patients whereas ECHO in about 20% of the patients. Holter was done in selected patients in whom the initial work up (Angiographic evaluation, ECG, ECHO) was negative and clinical suspicion of a cardio embolic aetiology was high. The yield of Holter was about 6 percent. Thus a thorough cardiac evaluation is necessary in all young stroke patients.

Large vessel atherosclerotic disease was noted as aetiology in 12.3% of the patients and these patients were noted to have statistically significant presence of diabetes mellitus, hypertension, and smoking. The number of patients with atherosclerotic disease increases with age as is expected from previous stroke studies.

CT Brain was the most commonly used parenchymal imaging procedure and more than 40% of the patients underwent MRI as well as CT Brain. This underscores
the difficulties in identifying infarcts in acute settings, especially in cases with posterior circulation strokes or acute on chronic infarcts. MRI as expected was more sensitive in detecting the posterior circulation strokes.\textsuperscript{69}

All the patients underwent at least one of the following angiographic tests CT Angiography, MR Angiography (TOF or CE), DSA or neck vessel Doppler.

The most commonly performed angiographic procedure was CT angiogram followed by TOF MRA. The least commonly performed procedure was contrast enhanced MR angiography.

Carotid Doppler was done in 9.4% patients but it was never done as a sole angiographic test.

These findings highlight the easy availability, speed, good sensitivity and specificity of CT angiogram which has led to its widespread use in stroke setting. Contrast enhanced MRI was sparingly used and this probably reflects the limited resources.

Though considered gold standard DSA was performed in <20\% of the patients. The yield of DSA (in these carefully selected patients) was more than 60\%. With the advent of CT scanners with better resolution the use of DSA has declined however it is still very important in certain settings like Vasculitis, Moya moya disease (especially when planning revascularisation procedure), dissections and in acute settings when mechanical thrombectomy is planned.

>40\% of the patients had normal vessel imaging and the abnormality which was most commonly identified was vessel occlusion. However vessel occlusion might not always provide a clue to the aetiology of stroke. It was also noted that a
significant number of patients had dissections, whereas the number of patients with atherosclerotic disease was small. The management of these two conditions is different thus emphasizing the need for proper angiographic evaluation. When dissections were considered the involvement of extracranial vessels was more frequent whereas in patients with atherosclerotic involvement intracranial vasculature was more frequently involved. Similar results have been obtained previously from South Asia by Deidre A et al.70

Overall, the difference between intracranial and extracranial vasculature involvement was slight.

Majority of the events were strokes of minor to moderate severity and of the 310 patients 8 patients expired during the hospital stay and less than 10% of patients had NIHSS >15 at discharge. This is consistent with most of the other young stroke studies from the western as well as the Indian literature.15, 24, 60

Almost one fifth of the patients were discharged on anticoagulation and more than 40% patients were discharged on antihypertensives. This emphasises the role of regular follow up and monitoring of patients with young stroke after discharge.

The main drawback is referral bias due to recruitment of patients from a referral institute. Also being a hospital based study admission bias is also one limitation. The fact that a very limited number of patients underwent a further detailed work up for rarer causes like prothrombotic states can also be considered as a limitation.

This is one of the largest studies from the subcontinent which focuses on the angiographic profile in young stroke. The main strength lies in the fact that all 310
patients underwent some form of angiographic assessment of the intracranial as well as extracranial vasculature and basic cardiology work up in the form of ECG and ECHO.
CONCLUSIONS

The high proportion of patients with past history of stroke/TIA highlights the need for better secondary prevention strategies. The conventional vascular risk factors shifts towards the ‘older population’ pattern after 35-50 years of age and patients who are <35 years of age should be actively evaluated for even the rare causes of stroke in young.

Arterial dissections are fairly common in young population and should be considered in appropriate clinical setting and all patients should have a good and timely angiographic assessment to rule out dissections. Revascularisation strategies (like carotid endartrectomy/stenting) are now easily available for extracranial large vessel atherosclerotic disease and patient eligibility should be screened for.

Thus, this study highlights the importance of risk factor evaluation, and control, complete etiological evaluation including angiographic assessment in the diagnosis, management and planning of secondary prevention strategies in young patients with stroke.
REFERENCES


ANNEXURES
Annexure I

Pro forma for study of clinical and angiographic profile of stroke in young adults

1.1 Study code no---------

1.2. Age -------------- years

1.3 Sex -------------- 1.Male 2.female

1.4. Date of admission. ----------- Time --------------

1.5. Date of symptom onset--------- Time---------

1.6 Phone No 1:------------------------

1.7 Phone No2:------------------------

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

2.1. Hypertension------------- Duration in years -----------

2.2. Diabetes mellitus------------- Duration in years -----------

2.3. Current smoking------------- pack years -----------

2.3a Ex smoker………………Stopped -------------------years back

2.3. b. Drug addiction ----------------

2.3. c. Alcoholism------------------

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

2.5. Valvular heart disease------ Duration in years -----------

2.5. a. if yes, Specify -----------

2.5. b. Prosthetic valve -----------

2.5. c. Sick sinus syndrome -----------
2.6. Congestive heart failure ---------------- Duration in years ----------------

2.7. Peripheral vascular disease---------

2.8. Hyperlipidaemia------------------- Duration in years---------------------

2.9. Atrial fibrillation------------------ Duration in years------------------

2.9.1. If patient on pacemaker ---------------

2.1.1. History of prior stroke --------- 2.1.1.a. Date of ictus------------

2.1.2. History of prior TIA---------- 2.1.2.b. Date of ictus------------

2.1.3. History of migraine ---------------

2.1.4. Known carotid disease---------

2.1.5. Patient on treatment ---------------

2.1.6. If yes, Type of treatment 1.ASA 2.Clopidroge 3.Aggrenox
4.Coumadin 5.statins

2.1.7. History of DVT -----------

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

2.1.8. Comments----------------------------------------

3. Symptoms (1=yes, 2=No)

Blurring of vision 6. None

3.2. Weakness 1. facealone 2.arm 3.leg 4.arm and leg 5. Face arm and leg

6. None

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

3.5. Vertigo

3.6. Ataxia

3.7. Confusion 3.7.a. Loss of consciousness

3.8. Headache

3.9. Seizures

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

4.9a. Central retinal artery occlusion

4.9.1. Hemispatial neglect

4.9.2. Final impression

1. Right hemispheric 2. Left hemispheric 3. Posterior circulation 4. undetermined

4.9.3 NIHSS at admission

4.9.4 GCS on admission

5. Investigations

5.1. Blood glucose in ER
FBS-

PPBS

RBS

HbA1c

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

5.3. LDL--------

5.4. HDL--------

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


If valve disease, specify -----------------


5.1.3. Homocysteine -----------------

5.1.4. APLA ------------------- 1. Positive 2. Negative 3. Not done


5.1.5.a. If done, specify -----------------------------

6. Diagnostic imaging

Ischaemic changes

6.1. A Territory

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 lesion 3. DWI-Multiple lesions 4. Not done

6.3.1. Arterial territory of acute infarct

6.3.1. a. Describe the MRI findings (acute and old lesions)

FLAIR –

Fazeka Grading

6.3.3. SWI
1. microbleeds 2. hemorrhagic transformation of infarct 3. negative 4. Not done

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. Extracranial ICA
2. Intracranial ICA
3. MCA M1
4. M2
5. ACA
6. BA
7. VA
8. PCA
9. SCA
10. PICA

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

6.7. Stroke subtype----------
1. Large artery atherosclerosis
2. Cardioembolic
3. Other specific causes
4. Undetermined
5. Lacunar

6.7. a. If cardioembolic, mention cause ---------------------

6.7. b. If specific cause ----------------------
1. Dissection
2. Prothrombotic
3. Vasculitis
4. MoyaMoya

6.8. Arterial territory -------------------
1. ACA
2. MCA
3. PCA
4. VA
5. BA
6. ICA
7. SCA
8. PICA

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

7.1. Aspirin----------

7.2. Clopidogrel--------

7.3. Aggrenox---------

7.4. Warfarin ----------

7.5. Statins ------------

7.6. Antihypertensives ---------

8. Outcome

8.1. Date of discharge------------------

8.2. Final diagnosis --------------
1. Definite TIA
2. Probable TIA
3. Ischemic stroke
8.4.1 NIHSS at discharge

8.4.2 Modified Rankin Scale at discharge
ANNEXURE –II

NIHSS (National institute of health stroke scale)

1a. Level of Consciousness:
0 = Alert; keenly responsive.
1 = Not alert; but arousable by minor stimulation to obey, answer, or respond. 2
   = Not alert; requires repeated stimulation to attend.
3 = Responds only with reflex motor or autonomic effects or totally unresponsive,
   flaccid, and areflexic.

1b. LOC Questions:
0 = Answers both questions correctly.
1 = Answers one question correctly.
2 = Answers neither question correctly.

1c. LOC Commands:
0 = Performs both tasks correctly.
1 = Performs one task correctly.
2 = Performs neither task correctly.

2. Best Gaze:
0 = Normal.
1 = Partial gaze palsy;
2 = Forced deviation,

3. Visual:
0 = No visual loss.
1 = Partial hemianopia.
2 = Complete hemianopia.
3 = Bilateral hemianopia (blind including cortical blindness).

4. Facial Palsy:
0 = Normal symmetrical movements.
1 = Minor paralysis (flattened nasolabial fold, asymmetry on smiling).
2 = Partial paralysis (total or near-total paralysis of lower face).
3 = Complete paralysis.

5. Motor Arm:
0 = No drift;
1 = Drift;
2 = Some effort against gravity;
3 = No effort against gravity;
4 = No movement.
UN = Amputation or joint fusion

6. Motor Leg:
0 = No drift;
1 = Drift;
2 = Some effort against gravity;
3 = No effort against gravity;
4 = No movement.
UN = Amputation or joint fusion

7. Limb Ataxia:
0 = Absent.
1 = Present in one limb.
2 = Present in two limbs.

8. Sensory:
0 = Normal; no sensory loss.
1 = Mild-to-moderate sensory loss;
2 = Severe to total sensory loss;

9. Best Language:
0 = No aphasia; normal.
1 = Mild-to-moderate aphasia;
2 = Severe aphasia;
3 = Mute, global aphasia;

10. Dysarthria:
0 = Normal.
1 = Mild-to-moderate dysarthria;
2 = Severe dysarthria;

11. Extinction and Inattention (formerly Neglect):
0 = No abnormality.
1 = Visual, tactile, auditory, spatial, or personal inattention
2 = Profound hemi-inattention or extinction to more than one modality
ANNEXURE –III
MODIFIED RANKIN SCALE (mRS)

Score Description

0 = No symptoms at all
1 = No significant disability despite symptoms; able to carry out all usual duties and activities
2 = Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance
3 = Moderate disability; requiring some help, but able to walk without assistance
4 = Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance
5 = Severe disability; bedridden, incontinent and requiring constant nursing care and attention
6 = Dead
ANNEXURE –IV

TOAST Classification of Subtypes of Acute Ischemic Stroke

(TOAST, Trial of Org 10172 in Acute Stroke Treatment.)

1. Large-artery atherosclerosis
2. Cardioembolism
3. Lacunar
4. Stroke of other determined etiology
5. Stroke of undetermined etiology
ANNEXURE –V

APLA: Antiphospholipid antibody syndrome  
CT: Computed Tomography  
CTA: CT Angiogram  
DM: Diabetes Mellitus  
DSA: Digital Subtraction Angiogram  
HTN: Hypertension  
m-RS: Modified Rankins Scale  
MRI: Magnetic Resonance Imaging  
MRA: MR Angiogram  
NIHSS: National institute of Health Stroke  
OCPs: Oral contraceptive pills  
RHD: Rheumatic Heart Disease  
SLE: Systemic Lupus Erythematosus  
TCD: Transcranial Doppler  
TIA: Transient Ischemic Attack  
TOAST: Trial of Org 10172 in Acute Stroke Treatment  
TOF: Time of flight sequence
Institutional Ethics Committee
(IEC Regn No. ECR/189/Inst/KL/2013)

SCT/IEC/773/JUNE-2015

Dr. Sakale Tejas Ulhas
Resident
Department of Neurology
SCTIMST, Thiruvananthapuram

Dear Dr. Sakale Tejas Ulhas,

The Institutional Ethics Committee reviewed and discussed your application to conduct the study entitled "STUDY OF CLINICAL AND ANGIOGRAPHIC PROFILE OF STROKE IN YOUNG ADULTS (IEC/773)" on 12th June, 2015.

The following documents were reviewed:

Original submission

1. Covering letter addressed to the Chairperson, IEC, SCTIMST dated 25.05.2015
2. TAC Approval Letter.
3. IEC Application form.
4. Study proposal.
5. Proforma.
6. Short CVs of PI and Co-PI's

Revised submission

1. Covering letter addressed to the Chairperson, IEC, SCTIMST dated 18.08.2015.
2. Modified IEC Application form was submitted.
3. Modified Project proposal.
4. Modified proforma was submitted.
5. CV of PI, and Co-PI's.
The following members of the Ethics Committee were present at the meeting held on 12th June, 2015 at G. Parthasarathi Board Room, AMCHSS, SCTIMST.

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>Member Name</th>
<th>Highest Degree</th>
<th>Gender</th>
<th>Scientific /Non Scientific</th>
<th>Affiliation with Institution(s)</th>
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<tr>
<td>1.</td>
<td>Justice Gopinathan. P.S</td>
<td>BSc. LLB</td>
<td>Male</td>
<td>Legal Expert (Chairperson)</td>
<td>No</td>
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<tr>
<td>2.</td>
<td>Dr. J. M. Tharakan</td>
<td>MD</td>
<td>Male</td>
<td>Clinician (Cardiologist)</td>
<td>Yes</td>
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<tr>
<td>3.</td>
<td>Shri. O.S. Neelakandan Nair</td>
<td>BE</td>
<td>Male</td>
<td>Engineer</td>
<td>Yes</td>
</tr>
<tr>
<td>4.</td>
<td>Dr. R V G Menon</td>
<td>PhD</td>
<td>Male</td>
<td>Lay Person</td>
<td>No</td>
</tr>
<tr>
<td>5.</td>
<td>Dr. Meenu Hariharan</td>
<td>DM</td>
<td>Female</td>
<td>Clinician (Gastro-Enterologist)</td>
<td>No</td>
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<tr>
<td>6.</td>
<td>Dr. Rema M. N</td>
<td>MD</td>
<td>Female</td>
<td>Pharmacologist</td>
<td>No</td>
</tr>
<tr>
<td>7.</td>
<td>Smt. Sathi Nair</td>
<td>MA</td>
<td>Female</td>
<td>Lay Person</td>
<td>No</td>
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<tr>
<td>8.</td>
<td>Dr. Kala Kesavan. P</td>
<td>MD</td>
<td>Female</td>
<td>Pharmacologist</td>
<td>No</td>
</tr>
<tr>
<td>9.</td>
<td>Dr. K R S Krishnan</td>
<td>ME, PhD</td>
<td>Male</td>
<td>Biomedical Scientist/Engineer</td>
<td>No</td>
</tr>
<tr>
<td>10.</td>
<td>Dr. K. Jayakumar</td>
<td>MS, MCh</td>
<td>Male</td>
<td>Clinician (Surgeon)</td>
<td>Yes</td>
</tr>
<tr>
<td>11.</td>
<td>Dr. Mala Ramanathan</td>
<td>MSc, PhD, MA</td>
<td>Female</td>
<td>Ethicist/Social Scientist</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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,

Mala Ramanathan
Member Secretary, IEC

Jayakumar, P.N.. "Angiographic profile of ischaemic stroke in the young - Study of 143 cases", Clinical Radiology, 199110