Strokes in the Young

BY JACOB ABRAHAM, M.D., G. SHETTY, M.D., AND C. J. JOSE, M.D.

Abstract:

Strokes in the Young

Of 407 consecutive patients with cerebrovascular disease seen from July 1967 to June 1969 in a prospective study of stroke being conducted by the Department of Neurological Sciences at Christian Medical College Hospital, Vellore, South India, 127 (32%) patients were between the ages of 11 and 40. Using the standard criteria for diagnosis, 50% of the patients had cerebral thrombosis, 13% had cerebral embolism, 13% had internal carotid artery thrombosis (a subcategory of cerebral infarction), and the remainder were distributed through the other categories of cerebrovascular disease. Hypertension appeared to be a factor in about 19% of the patients (angiography revealed that the small intracranial vessels were more commonly abnormal than the larger extracranial arteries). Less than 10% of the patients had intracerebral hemorrhage or subarachnoid hemorrhage. The question was raised as to the possible role of arteritis secondary to common tropical diseases in the pathogenesis of these “strokes in the young.”

ADDITIONAL KEY WORDS cerebral infarction cerebral angiography systemic hypertension carotid artery hemiplegia arteritis

Methods

Of 407 consecutive patients with cerebrovascular disease admitted into the “stroke research project” from July 1967 to June 1969, inclusive, 127 were between 11 and 40 years of age. A detailed history was obtained and all patients had a neurological and systemic examination. The physical disability as reflected by the muscle score* and the activities of daily living† were assessed and numerical values given to each patient. A psychological assessment was also made. The laboratory investigations consisted of blood examinations, including hemoglobin, total and differential white cell count, sedimentation rate, VDRL, urea, cholesterol, sugar, L.E. cells, parasites and coagulation studies, and a routine urinalysis and stool examination. Lumbar puncture was made to determine the CSF pressure, and the CSF was examined for cells, biochemistry, VDRL and colloid mastic. An x-ray of the chest, ECG and EEG were done in most cases. Whenever possible, three-vessel angiography was performed under local anesthesia. A right retrograde brachial angiogram and a left carotid angiogram were done routinely. A right carotid angiogram or an aortic arch study or a left vertebral angiogram was done when indicated. General anesthesia was utilized in some cases.

The diagnostic criteria used to classify the patients into the various categories were modified from the ad hoc committee’s classification of cerebrovascular disease (Neurology 1958), in conjunction with the available angiographical data.

*The activities of daily living were also graded from zero to five. The percentage of the total grade for the tests performed was judged as above average for those with more than 66.6%. A percentage below 66.6 was considered as below average.

†The activities of daily living were assessed and numerical values given to each patient. A psychological assessment was also made. The laboratory investigations consisted of blood examinations, including hemoglobin, total and differential white cell count, sedimentation rate, VDRL, urea, cholesterol, sugar, L.E. cells, parasites and coagulation studies, and a routine urinalysis and stool examination. Lumbar puncture was made to determine the CSF pressure, and the CSF was examined for cells, biochemistry, VDRL and colloid mastic. An x-ray of the chest, ECG and EEG were done in most cases. Whenever possible, three-vessel angiography was performed under local anesthesia. A right retrograde brachial angiogram and a left carotid angiogram were done routinely. A right carotid angiogram or an aortic arch study or a left vertebral angiogram was done when indicated. General anesthesia was utilized in some cases.

The diagnostic criteria used to classify the patients into the various categories were modified from the ad hoc committee’s classification of cerebrovascular disease (Neurology 1958), in conjunction with the available angiographical data.
The data thus collected were then coded and transferred to 80 column punch cards and processed by the International Computers Ltd. data processing equipment.

**Results**

The diagnosis and distribution by age and sex of the 127 cases are given in table 1.

Cerebral infarction was diagnosed in 44.9%, followed by embolism 13.4%, internal carotid artery thrombosis 12.6%, infantile hemiplegia 7.9%, cortical venous thrombosis 7.1%, subarachnoid hemorrhage 3.9%, arteriovenous malformation 3.1%, aneurysm 1.6%. Hemorrhagic and possible hemorrhage-producing lesions were or made up 8.6% of all the cases. Aortic arch syndrome was seen in 3.1%.

**Cerebral Infarction**

A total of 57 patients were diagnosed as suffering from cerebral ischemia as a result of cerebral arterial thrombosis; 42 were men and 15 were women. The right side was paralyzed in 47.4% and the left side in 52.6%. The maximum number of patients were in the fourth decade (55.1%).

The onset of the ictus was acute in 87.5%; 59.5% of the patients were engaged in some activity, while 40.5% were resting. A stuttering onset was found in 8.9% and a gradually progressive onset in 3.6%. A non-specific prodrome, such as malaise, feeling out of sorts and giddiness, was found in 43.9% of the cases. Loss of consciousness at the onset of the ictus occurred in 40.7% and did not last more than an hour in most cases. Fits of a focal or generalized nature occurred at the onset in 12.3% of cases.

The nutritional status of all the patients assessed except one was judged to be fair to good. There was no apparent correlation between cerebral infarction and socioeconomic status. A positive serological test for syphilis was found in 11%. Diabetes mellitus* did not exist without associated hypertension and was found in 8.8% of the cases. Hypertension† was present in 19.3%, of which 8.8% was associated with diabetes, and in 10.5% hypertension was an isolated finding. The serum cholesterol‡ level was borderline to high in 26.7%.

Forty-nine of the 57 patients had an ECG with standard chest and limb leads, which revealed abnormality in 12 (24.5%), eight of which were directly related to hypertension. There was associated diabetes in one and diabetes with a high cholesterol in another. Three of the 12 patients had definite evidence of an ischemic lesion in the heart (infarct). In one case with evidence of an infarct the cholesterol level was high. In cerebral infarction in the younger age group, about 16% had evidence of an ischemic lesion of the heart not associated with hypertension, diabetes or a high blood cholesterol. All the patients with ischemic lesions were in the fourth decade.

Fifty-four of 57 patients had an EEG examination performed. Abnormalities in the wake record were detected in 55.6% (31). The abnormalities are summarized in table 2.

Focal abnormalities in the appropriate cerebral hemisphere were seen in 84%. Abnormal EEGs associated with hypertension alone were seen in 13.3% and in 10% of the abnormal EEGs hypertension and diabetes were also found. In patients without diabetes or hypertension, 76.7% of the abnormal EEGs were found.

Forty-three of the patients with cerebral infarction had a total of 72 angiograms performed. The types of study done were 41 carotid angiograms, 28 right retrograde brachial angiograms, one arch aortogram and one left vertebral angiogram. Of the 43 patients studied, 24 had normal angiograms and 19 had abnormal angiograms. The abnormalities in the territory of the neurological deficit are shown in table 3.

In this group, 10% had extracranial abnormalities and 90% had intracranial abnormalities. The most common lesion was middle cerebral artery occlusion, which was present in 42%.

Out of four with hypertension as the only additional abnormality, one showed a tortuous internal carotid artery in the neck and another had stenosis of the middle cerebral artery. It is interesting to note that in two cases with

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*Criterion for diabetes—fasting blood sugar above 120 mg %.
†Criterion for hypertension—readings above 150/100.
‡Criterion for cholesterol increase—above 250 mg %.
TABLE 1

Diagnosis and Distribution by Age and Sex of 127 Young Strokes

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Age in years</th>
<th>Sex</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
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<tr>
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<td>11-20</td>
<td>18</td>
<td>36</td>
<td>42</td>
</tr>
<tr>
<td>Cerebral embolism</td>
<td>21-30</td>
<td>3</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Internal carotid artery thrombosis</td>
<td>31-40</td>
<td>1</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Infantile hemiplegia</td>
<td></td>
<td>9</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Cortical venous thrombosis (postpartum)</td>
<td></td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage (without demonstrable abnormality)</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Aortic arch syndrome</td>
<td></td>
<td>1</td>
<td>—</td>
<td>3</td>
</tr>
<tr>
<td>A.V. malformations</td>
<td></td>
<td>2</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>Hypertensive encephalopathy</td>
<td></td>
<td>—</td>
<td>—</td>
<td>3</td>
</tr>
<tr>
<td>Intracranial aneurysm</td>
<td></td>
<td>2</td>
<td>—</td>
<td>2</td>
</tr>
</tbody>
</table>

diabetes and hypertension the angiograms were normal.

Eleven cases with focal EEG changes had the following angiographical abnormalities: middle cerebral artery ischemia in eight, and one each of diffuse cerebral arteriosclerosis, infarct and a tortuous internal carotid artery.

CEREBRAL EMBOLISM

Cerebral embolism is the second most common cause of stroke in the young adult. Seventeen of 127 patients were diagnosed as having cerebral embolism; ten were females and seven were males. The maximum incidence was in the fourth decade. The site of origin of the embolus was from the heart in all but two of the cases. The most commonly embolized arterial territory was that of the middle cerebral artery, followed by the internal carotid artery (table 4).

The onset of the embolic phenomenon was acute in 15 of 17 cases. In one, it was stuttering and in another it was unknown. There was loss of consciousness in ten of the 17, and in four the loss of consciousness lasted for more than 24 hours. A nonspecific prodrome was present in 50% of the cases. In four of 17, generalized seizure was associated with the onset.

There was no hypertension in any of the patients, and in 13 of 17 who were examined for diabetes mellitus, none was found. The serological tests for syphilis were negative in all cases. The serum cholesterol level was normal in all cases.

The ECG showed typical changes of mitral stenosis in 13 of 15 cases where it was done. In the two cases who had embolization from the internal carotid artery, one had a normal ECG and another had ischemic changes.

EEG was done in 14 of 17 cases, of which seven had abnormalities. Focal abnormalities on the infarcted side were seen in four cases; in one, focal abnormality was seen on the opposite side. All seven had diffuse abnormalities on the infarcted side of which two had a diffuse abnormality of both cerebral hemispheres.

TABLE 2

Distribution of Age, Sex, Side of Hemiplegia and Type of EEG Abnormality in Cerebral Infarction (Total 31)

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Side of Hemiplegia</th>
<th>Diffuse and Focal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Diffuse Right</td>
</tr>
<tr>
<td>11-20</td>
<td>21-30</td>
<td>31-40</td>
<td>M F</td>
</tr>
<tr>
<td>Left</td>
<td>—</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Right</td>
<td>6</td>
<td>16</td>
<td>10</td>
</tr>
</tbody>
</table>

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TABLE 3

Angiographical Abnormalities in the Territory of Neurological Deficit

<table>
<thead>
<tr>
<th></th>
<th>Left hemiplegia</th>
<th>Right hemiplegia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 11-20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 21-30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 31-40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extracranial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal carotid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenosis</td>
<td>1 F</td>
<td>2M,1F</td>
</tr>
<tr>
<td>Tortuous</td>
<td>4M</td>
<td>5M,1F</td>
</tr>
<tr>
<td>Intracranial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICA</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>O S</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>MCA</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>A. C. A.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>O S</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Infarct with</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Blush + arterio-
| sclerosis       |                 |                 |

Angiograms were done in 14 of the 17 cases of which five were considered normal. The lesion was in the internal carotid artery in four, with occlusion in one and stenosis in three. In the remaining five, the middle cerebral artery was involved with stenosis in two and occlusion in three.

INTERNAL CAROTID ARTERY THROMBOSIS

Internal carotid artery thrombosis was the third most common cause of stroke in the younger age group.*

Of 127 patients, 103 had angiographical studies performed; 16 showed occlusion of the internal carotid artery. In most instances, the arteriographical profile distal to the occlusion of the internal carotid artery was not visualized. There was an occasional cross-filling of the anterior cerebral artery from the contralateral side. The largest number of patients were in the fourth decade. There were 14 males and two females and the right internal carotid artery was thrombosed in ten, while the left was thrombosed in six. The site of thrombosis was extracranial in all but one.

The onset of the ictus was acute in 12, stuttering in three and gradually progressive in one. Five of the 12, with an acute onset, had their stroke while resting. There was loss of consciousness in seven of 16; three were unconscious for more than 24 hours. Generalized fits were associated with the onset in one case. In one case, the carotid artery thrombosis probably developed after fever, vomiting and dehydration.

There were three cases with hypertension and two were borderline hypertensives. One had diabetes while another had an elevated serum cholesterol; in two, serological tests for syphilis were positive.

The ECG was done in 13 cases, five of which were abnormal. There was evidence of left ventricular hypertrophy in two associated with hypertension. Two had evidence of ischemia, and another had sinus bradycardia.

The EEG was abnormal in nine (64.3%); eight of the nine had changes on the ipsilateral side of the thrombosis. The changes were purely focal in two, focal and diffuse in three and diffuse only in four. Only one of the nine had EEG abnormalities in the opposite hemisphere.

Internal carotid artery thrombosis was confirmed by angiography in all cases. The artery was thrombosed on the right side in ten and on the left side in six. In 13 of the 16 cases, bilateral visualization of the carotid system was possible. No abnormalities were found in the opposite carotid tree. In two cases, stenosis of the subclavian and the innominate arteries was also found.

INFANTILE HEMIPLEGIA

Infantile hemiplegia was the fourth largest entity in this series (cases resulting from brain...

TABLE 4

Distribution by Age, Sex, Site of Origin of Embolus and Arterial Territory Embolized

<table>
<thead>
<tr>
<th>Age 11-20</th>
<th>Age 21-30</th>
<th>Age 31-40</th>
<th>Sex M</th>
<th>Sex F</th>
<th>Site of origin of embolus</th>
<th>Arterial territory embolized Right</th>
<th>Arterial territory embolized Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-20</td>
<td>21-30</td>
<td>31-40</td>
<td></td>
<td></td>
<td>Heart</td>
<td>ICA</td>
<td>IC</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>10</td>
<td>15</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

*One with anterior and middle cerebral embolism.
injury have been omitted). Ten of the 127 patients were diagnosed as infantile hemiplegics, of whom four were females and six were males. Angiographical study was done on six cases; all were found to be normal.

The nature of onset was assessed in eight of these cases; five had an acute onset and three had a gradual onset. Of the ten cases, six had fever prior to the onset of the hemiplegia. Loss of consciousness was reported in only one case. In four of the ten cases, seizures were associated with the onset, two were of a focal nature and two were generalized.

All the cases were normotensive. EEG was done in nine of the ten cases. All had focal abnormality originating in the appropriate hemisphere. In addition, four cases had focal abnormality in the opposite hemisphere. Diffuse abnormality on the side of the affected area was seen in four cases. Of these, two had diffuse abnormality on the contralateral side as well.

CORTICAL VENOUS THROMBOSIS
Cortical venous thrombosis is the second largest cause of stroke in young females. Of the 45 young females with stroke, nine (20%) were diagnosed as having cortical venous thrombosis. This constitutes 7.1% of all the young strokes.

The onset was acute in seven, gradual in one and stuttering in another. Prodromes of mild systemic reactions, such as fever and headache, were present in all cases. Five of the nine cases had convulsions associated with the onset; two were of a focal nature and three were of a generalized nature.

Angiograms were performed on six of the nine cases; all were normal. Blood pressure was high in one case. Eight of the nine cases had abnormal EEGs. Focal abnormalities on the infarcted hemisphere were seen in five cases. A focal abnormality on the normal side was seen in one case. Diffuse abnormalities on the ipsilateral and contralateral sides of the infarcted area were seen in six cases and three cases, respectively.

Subarachnoid hemorrhage was the presenting feature in eight of 127 cases. No demonstrable pathology was found in five of these.

INTRACEREBRAL ANEURYSMS
Only one aneurysm was visualized on angiography. Three others may have been aneurysms which leaked, but these were not demonstrated angiographically. All four presented as subarachnoid hemorrhage and all the patients were in the fourth decade. Three were males and one was female. The aneurysm demonstrated by angiography was large, involving the left middle cerebral artery. This case was managed conservatively and at present, 24 months after admission, the patient is back at his job as physical instructor at a college. Another had an associated cirsoid aneurysm of the scalp.

HYPERTENSIVE INTRACEREBRAL HEMORRHAGE
This condition was diagnosed in two cases. Both were known hypertensives on irregular treatment, both were males in the fourth decade, and both presented as subarachnoid hemorrhage with evidence of increasing intracranial tension. One died a few hours after admission.

ARTERIOVENOUS MALFORMATIONS
Four cases had arteriovenous malformations. All were males aged 17, 19, 32 and 32 years, respectively. The 17-year-old had an arteriovenous malformation of the sylvian area with an associated cirsoid aneurysm of the scalp. The 19-year-old presented as a subarachnoid hemorrhage with focal fits involving the right side. Angiography showed a small malformation in the ganglionic area. One of the 32-year-old men presented with an acute attack of left-sided hemiparesis. A right brachial angiogram revealed a malformation in the neck involving the subclavian artery with atherosomatous changes in the right common carotid artery, which probably was the site from where embolization occurred. The other 32-year-old man presented as an infantile hemiplegic with a history of 22 years of hemiplegia of the left side, following a bout of unconsciousness which lasted for one week. Angiography revealed a fairly large arteriovenous malformation of the right hemisphere.

HYPERTENSIVE ENCEPHALOPATHY
There were three cases diagnosed as hypertensive encephalopathy. All were in the fourth decade, two were males and one was female.

AORTIC ARCH SYNDROME
This syndrome was seen in four cases, three females and one male. The youngest female was 14 years old; the other two were in the fourth decade. One male had occlusion of all the major vessels supplying the brain except for

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one vertebral artery; he was in the fourth
decade.

SURVIVAL
From a total of 127 cases included in this
study, 17 died while in the hospital, giving a
mortality rate of 13.4%. Some of these died
within a few hours after admission. The
condition of those discharged was as follows:
11 recovered (8.6%), 78 improved (61.4%),
19 remained the same (15%), and two
became worse (1.6%).

The case survival rate is depicted graphi-
cally (fig. 1). There were 11 deaths in the first
six months, two in the next six months, and a
total of 17 deaths in three years, only six of
which occurred after the first six months of
discharge.

Discussion
The present series of 127 consecutive cases of
cerebrovascular disease seen in patients be-
tween 11 and 40 years in a two-year period
probably constitutes one of the largest single
series of this category.

Stroke in the young adult is rare and in
children rarer still.1,2 Wisoff,3 after excluding
obvious etiological causes for cerebral throm-
bosis in children, found 27 cases reported in the
literature to which they added two of their own.
However, Berlin et al.4 and Sprofkin and
Blakey5 have demonstrated cerebral thrombosis
to be no great rarity in younger age groups.
Wells and Timberger,6 in a study of patients
with cerebral thrombosis under the age of 50
years, found 77 cases in a 28-year period. Pa-
tients below the age of 40 years totaled 22.
Less than 2% of strokes in Sweden7 occur
below the age of 40 years. In Germany, Sinder-
mann et al.8 in a small study found the age
medians of 41.5, 46 and 32.5 "rather low" for
strokes compared to what is usually found
there. Recently, Haerer et al.9 reported on
cerebrovascular disease of young adults in
Mississippi.

The basic diagnostic categories in cere-
brovascular disease applicable to both clinical
and mortality data are contained in the
international statistical classification of cere-
brovascular disease and carry the rubrics 330
to 334. Unfortunately, these categories are not
strictly defined; 332, for example, is for
embolism and thrombosis and for various
equivalents of cerebral and cerebellar "soften-
ing or necrosis and apoplexy." Be that as it
may, for clinical purposes an exhaustive
classification of stroke was drawn up by the ad
hoc committee of the Academy of Neurology
in 1958. We have tried to adhere to the ad hoc
committee's classification coupled with the
angiographical findings.

Much ambiguity and uncertainty still
persists; for example, some cases without an
angiographical study classified under cerebral
infarction in this series may be due to internal
carotid artery thrombosis, embolism or infarc-
tion from some other cause like "small vessel
disease." It is hoped that this does not detract
from the main thesis of this communication,
which is to draw attention to the fact that
cerebrovascular disease is not uncommon in
the young Indian.

It is of the utmost importance, under the
circumstances, to assess the validity of the
findings and the role of possible artifacts. The
first possible source of error would be in the
age of the patient. In countries where more
than one system exists for reckoning months
and years and where birth certificates are not
kept, a certain haphazard, though poetic,
approach to one's age exists. Therefore, it must
be admitted that in spite of strict personal
surveillance the ages of some patients entered
as 40 years could in some instances be a year
or two more.

The second source of error could be that
publicity associated with an ongoing research
project on cerebrovascular disease may draw
patients who ordinarily might not seek hospital treatment. An analysis of vascular lesions affecting the central nervous system for the years from July 1964 to June 1968 showed an average annual incidence of approximately 125, compared to 359 for the year July 1968 to June 1969. The percentage of stroke patients admitted compared to other neurological cases was 14.5% in 1966 to 1967, 18% in 1967 to 1968, and 24% in 1968 to 1969. Whatever the significance of this upward trend, an analysis of vascular lesions affecting the central nervous system (rubrics 330, 331, 332 and 334 for the years 1964 to 1969, both clinical and autopsy combined) from the hospital inpatients 11 to 40 years is given in table 5, which shows that the patients below 40 years constituted 50% of the cerebrovascular disease seen in the hospital. Therefore, the incidence in the young person is the usual rather than an abnormal trend.

In the present series, of 407 consecutive cases of cerebrovascular disease admitted into this study, 127 or 32% were in the 11 to 40-year age group. Of all patients with cerebrovascular disease admitted to the research project, 43.6% were below the age of 45 years. The drop in percentage as compared to the hospital incidence of 50% is perhaps due to stricter criteria and surveillance of diagnosis and age.

No population-based studies of the incidences of cerebrovascular disease are available in India. The authors' epidemiological survey of the prevalence of hemiplegia due to "stroke" in and around Vellore10 gives a rate of 57 per 100,000 population, and 25% of this group were patients below the age of 40 years. The good corroboration between the epidemiological study and the present hospital statistics lends further credence to the reliability of the present figures.

Authors11,12 from other parts of India have also found that between 20% and 25% of all strokes due to thromboembolism occur in the less than 40 year age group and 78.1% and 46.7%14 of cerebrovascular disease occur in patients below the age of 49 years. The high incidence of stroke in the younger age group, therefore, is not peculiar to the South.

In two other series in India, the relative proportion of cerebral thromboembolism comprising cerebrovascular disease was 82%11,12 for all age groups. Osuntokun et al.15 in Nigeria found that thromboembolism was the cause of stroke in 73% in all age groups. It is interesting to compare our figure of 70% to the weighted mean of the population-based studies in America (Eisenberg et al.,16 Kurland et al.17 and Kannel et al.18,19) of 62%. In the present series, cerebral infarction (cerebral atrial thrombosis 44.9%, cerebral embolism 13.4%, internal carotid artery thrombosis 12.6%) accounted for 70% of all cerebrovascular diseases.

The sex ratios (male/female) in thrombosis, embolism and internal carotid artery thrombosis are, respectively, 2.8, 0.7 and 7. The overall male/female ratio of thrombosis and embolism together is 1.9, compared to 1.72 from the cooperative stroke study in seven centers in the U.S.A. for all age groups.20 The relative frequency of cerebral thrombosis versus embolism in this series was 0.23 as compared to 0.07-0.18%21 for all ages from hospital series in the West.

The identifiable factors at play in this group of strokes below the age of 40 years were embolization usually secondary to mitral stenosis, cortical venous thrombosis (postpartum), arteriovenous malformation and subarachnoid hemorrhages. No associated disorder such as hypertension, diabetes or hypercholesterolemia, etc., was found in 73% of the group.

In discussing the etiological mechanisms of cerebral atherosclerosis, Resch and Baker28

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**TABLE 5**

<table>
<thead>
<tr>
<th>Years</th>
<th>330 M</th>
<th>330 F</th>
<th>331 M</th>
<th>331 F</th>
<th>332 M</th>
<th>332 F</th>
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<tbody>
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STROKES IN THE YOUNG

found no atherosclerosis in 71.9% of males and 79.2% of females in the 31 to 40 year age group, while 7.3% of patients had severe atherosclerosis. Baker et al.\textsuperscript{24, 25} states that hypertension and diabetes will produce a definite increase in the appearance and severity of atherosclerosis. It is interesting to note that in Wells\textsuperscript{16} series, 32 of the 77 patients (42\%) suffering from cerebral thrombosis below the age of 50 years were hypertensive. In the present series, 19.3\% with cerebral thrombosis had hypertension. Hypertension with diabetes was seen in only 8.8\%. The serum cholesterol was borderline to high in 26.7\%. A high cholesterol as the only abnormality detected was found in six cases. According to Osuntokun et al.,\textsuperscript{19} except in hypertensive and diabetic patients, nonembolic ischemic cerebrovascular disease from atherosclerotic occlusion is uncommon in Nigerians. This observation is borne out by the findings of Resch et al.,\textsuperscript{26} who found that atherosclerosis was less in the Nigerian population as compared to the Minnesota population and to the ethnologically related American Negroes in Alabama, Maryland and Tennessee.

It is important to note that in this series, 16\% had evidence of ischemic heart disease unrelated to the presence of hypertension or diabetes. The absence of angiographical patterns showing atheroma and the histological evidence of its absence from internal carotid artery biopsies would make us conjecture that there are perhaps some systemic and local factors at work in the production of stroke in the younger age group.

In an earlier analysis of an unpublished group of patients less than 45 years of age with stroke, not including embolism, cortical venous thrombosis, arteriovenous malformations and subarachnoid hemorrhage, it was found that the onset was acute in 80\%, 55\% occurring while at work. There was loss of consciousness at onset in 43\% and fits at onset in 9\%. The blood pressure was found to be abnormal in 23.3\%. The blood cholesterol was above 250 mg % in one patient and the fasting blood sugar above 120 mg % in seven patients. The blood pressure, blood cholesterol and blood sugars were normal in 51.2\% of patients in this group. Postmortem studies of coronary arteries and brain vessels from Madras\textsuperscript{27} indicated that a gradual increase in atheromatous changes occurred in both systems from the second decade onward. However, Mathur et al.\textsuperscript{28} reported a series where no atheromatous changes were found in the cerebral vessels before the fourth decade. Atherosclerosis is probably not a major factor in the etiology.

Large-vessel arteritis producing pulseless disease has been reported in India.\textsuperscript{29, 30} This, however, was an uncommon etiological factor in this series of cases. An auto-immune process affecting vessels of smaller caliber is an interesting possibility. The finding of L.E. cells in the peripheral blood smear, altered albumin-globulin ratios, abnormal serum electrophoretic patterns, coupled with the occasional finding of microfilaria in the blood, tuberculous infection, syphilis, and leprosy in some of our patients, make us speculate as to whether the process affecting the cerebral vascular tree is an allergic manifestation of some of the chronic diseases found in the tropics.

In a comparative study of the pattern of vessel involvement in stroke between a Japanese and a Minnesota population,\textsuperscript{31} it was pointed out that the Japanese predominantly had small-vessel involvement. In the analysis of our angiographical data for the young stroke patients we are also impressed by the very much higher incidence of abnormalities of the small vessels.

Katsuki and Omac,\textsuperscript{32} in their writing of stroke-prone profiles in the Japanese, make the following observation—"Frequency of stenotic lesions in the affected side of the cerebral hemisphere—complete occlusion was more frequently seen in the ages below 40, in which the cases with occlusion due to arteritis or arteriopathy of unknown etiology were included. These findings indicate that a definite occlusive arterial disease is responsible for cerebral infarction in a considerable number of cases below age 40. . . . Complete occlusion was found in 10\% in those above 60 years, compared with 30\% in the ages below 40 years." It seems probable that in some of the Afro-Asian countries and in the Orient arteriopathies of yet unknown etiology are responsible for the fairly widespread occurrence of occlusive vascular disorder in the young adult.

Another factor which merits comment is the relative infrequency of intracranial aneurysms in this series. In an analysis of cerebrovascular disease of young adults in Mississippi, Haerer et al.\textsuperscript{9} found ruptured aneurysms in 27\% of the cases. Our incidence...
of subarachnoid hemorrhage was 3.9% and of demonstrable intracranial aneurysm 1.6%. The relative infrequency of aneurysm in India has been commented on by another author.88 The reasons for the low incidence are not established.

According to Robinson et al.,84 the initial thrombotic episode was fatal in 21%. Fifteen percent died in one year and 50% died in 4.1 years. Lindgren85 found that 34% died in two years. A 28% mortality within three years has been previously reported in patients unselected as to age who survive one episode of cerebral thrombosis.30 Berlin et al.4 reported only one death out of 13 patients under the age of 40 years. We find that the case-fatality rate of the group under 40 years (fig. 1) differs from the figures of stroke survivals of all age groups given by the Western authors.

Summary and Conclusion
One hundred twenty-seven consecutive cases of stroke in the 11 to 40 year age group have been studied clinically and by angiography. Attention has been drawn to the fact that a high incidence below 40 years is seen in other areas in India as well. Hypertension was a factor in about 19% of the cases with no other obvious etiology. Atherosclerosis is probably not an important etiological factor. The smaller intracranial vessels were more involved as shown by angiography. Hemorrhagic and possible hemorrhage-producing lesions constituted only 8.6% of all the cases. It is conjectured that arteritis secondary to common tropical diseases may perhaps play a role in the causation of “stroke in the young adult.”

When large numbers of disabled people survive in a society which is economically far from sound, the problem of ultimate rehabilitation of patients stricken with stroke is further compounded.

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