Prognosis of ischemic stroke patients with or without collateralization after carotid stenosis

Subash Kanti Dey, Md. Shahidullah, Anis Ahmed, Ahsan Habib and Abu Nasar Rizvi

Abstract

The objective of this study was to see the association of the prognosis of ischemic stroke patients with or without collateralization after carotid stenosis. This study was conducted on 36 patients presenting with acute ischemic stroke who were going through digital subtraction angiography from March 2017 to March 2018. Collateralization status after unilateral or bilateral stenosis was evaluated. Modified ranking scale (mRS) score was measured on the first day of the stroke and after three months. The disability of ischemic stroke patients was compared between patients who developed collateralization and who had not. Among them, 61.6% developed collateralization. Among the patients who developed collateralization after three months, 90.9% patients had mRS scale of ≤2 and who not developed collateralization, 85.7% patients had mRS scale of ≤2. In both the groups, the p value was <0.05. It can be concluded that carotid stenosed patients who suffered from ischemic stroke, most of the patients disability improved to some extents whether collateralization developed or not among the major vessels.

Introduction

The cerebral blood flow is supplied through the left and right internal carotid artery and basilar artery to the arterial circle of Willis, and thence to the brain. The collateral potential of the circle of Willis is believed to be dependent on the presence and size of its component vessels. If internal carotid artery in one side is stenosed, the circle of Willis may allow the supply of blood from the contralateral carotid artery or the basilar artery to the territory of the stenotic internal carotid artery. Impaired blood supply to the brain due to internal carotid artery occlusion or enhancing embolic washout in distal territory due to hypoperfusion, in situ thrombosis, artery to artery emboli, perforator vessel occlusion by the atherosclerotic plaque, or combined mechanisms. Collateral circulation may be beneficial by different pathophysiologic mechanisms, by sustaining downstream perfusion or enhancing embolic washout in distal arteries, although such influence may be diminished in perforator occlusion. Predictors of stroke in this condition may also be explained by perfusion and the role of collaterals. Angiographic details such as the relative length and exact percentage of luminal stenosis may impact distal flow and therefore be related to collateral status. Systemic blood pressure may be related to collateralization or arteriogenesis and may also be linked with perfusion of the vascular territory. Even when the recurrent stroke occurs, collateral status may influence the resultant infarct size and clinical severity. Ischemic stroke outcome varies considerably,
from complete recovery to complete loss of tissue and function. This diversity is partly explained by the compensatory ability of the collateral circulation and the ensuing cerebral blood flow. The collaterals are the pial arterioles connecting two major cerebral arteries that supply two different vascular territories. These arteriolar connections contribute to the retrograde filling of pial arteries distal to an occlusion, and they provide alternative routes for blood flow in the setting of acute ischemic stroke. There is a wide interindividual variability in the size, number, and localization of the collaterals. Recent evidence suggests that these collaterals are dynamic, with a time-dependent recruitment of flow to the symptomatic hemisphere, once major occlusion has occurred. Although conventional angiography is considered the gold standard for the collateral flow assessment, there is wide variation in how leptomeningeal collateral grade is graded variables beyond a single measure of percent stenosis and the influence of collateral flow on stroke risk have not been explored. The association of collateral flow with hemodynamic variables and subsequent infarct size or stroke severity are also unknown. We, therefore, studied the potential impact of such extensive variability in collateral status on modifying the stroke risk due to intracranial atherosclerosis and the possible influence on subsequent stroke characteristics.

The objectives of the study was to see the prognosis of ischemic stroke patients due to collateralization after unilateral or bilateral carotid stenosis.

### Materials and Methods

This study was done on the ischemic stroke patients admitted in the inpatient Department from March 2017 to March 2018. Digital subtraction angiography was done in the catheter laboratory. From the report, information regarding completeness of circle of Willis and details of collateralization were obtained according to the specified objectives. The severity of the stroke was assessed by mRS scale first at the time of registration and after three months.

mRS score of the patients of ischemic stroke who had carotid stenosis were compared between the groups with collateralization and without collateralization. mRS scale of <2 was categorized as normal and mRS scale >2 was categorized as disease or disable.

### Statistical analysis

The difference of disability between the groups was tested by McNemar test.

### Results

Table I shows that the most frequent age group was 56-65 years representing 45.5% who developed collateralization after stroke but 57.1% was not developed.

Table I shows that 81.8% stroke patients developed collateralization but 85.7% not, who also suffered from hypertension. It was not statistically significant. But patients who had history of previous stroke, 54.5% patients developed collateralization which was statistically significant (p<0.05).

Table II shows that stroke patients who developed collateralization, 90.9% patients mRS scale improved (<2) after three months. It was statistically significant (p>0.05). The stroke patients who did not develop collateralization, 85.7% mRS scale improved (<2). It was statistically significant.

### Discussion

In this study, the most frequent age group was 56-65 years. Among them, 45.5% developed collateralization after stroke, though it was not statistically significant. One study showed older age group (mean age 66.9 ± 11.6 years) developed less collateral.

![Table I](image1)

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Present (%)</th>
<th>Absent (%)</th>
<th>p value</th>
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<tbody>
<tr>
<td>≤35</td>
<td>9.1</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>36-45</td>
<td>9.1</td>
<td>14.3</td>
<td></td>
</tr>
<tr>
<td>46-55</td>
<td>27.3</td>
<td>14.3</td>
<td></td>
</tr>
<tr>
<td>56-65</td>
<td>45.5</td>
<td>57.1</td>
<td></td>
</tr>
<tr>
<td>&gt;65</td>
<td>9.1</td>
<td>14.3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comorbidity</th>
<th>Present (%)</th>
<th>Absent (%)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>81.8</td>
<td>85.7</td>
<td>0.999</td>
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<tr>
<td>Diabetes mellitus</td>
<td>18.2</td>
<td>0.0</td>
<td>0.141</td>
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<tr>
<td>Ischemic heart disease</td>
<td>9.1</td>
<td>0.0</td>
<td>0.511</td>
</tr>
<tr>
<td>History of previous stroke</td>
<td>54.5</td>
<td>14.3</td>
<td>0.016</td>
</tr>
</tbody>
</table>

![Table II](image2)

<table>
<thead>
<tr>
<th>mRS scale</th>
<th>Collateralization</th>
<th>Without collateralization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1 of stroke</td>
<td>3 months after stroke</td>
</tr>
<tr>
<td>&gt;2</td>
<td>45.5</td>
<td>9.1</td>
</tr>
<tr>
<td>&lt;2</td>
<td>54.5</td>
<td>90.9</td>
</tr>
</tbody>
</table>

*McNemar test was done to measure the level of significance.
collateralization, who also suffered from hypertension. It was not statistically significant. Another study showed 66% developed good collateral who were hypertensive.\cite{11} Previously one study found 64.5% patients who were hypertensive developed collateralization after carotid occlusion.\cite{12} Patients who were previously diabetic and suffered from stroke with carotid stenosis, 18% patients were developed collateralization. One study found, collateralization development was 36%.\cite{11} In this study, patients who had history of previous stroke, 54.5% patients developed collateralization which was statistically significant. One study showed 78% patients developed good collateral who had recurrent stroke.\cite{11}

Circle of Willis was found to be incomplete in 77.8% patients. In a study in Pakistani population found circle of Willis is incomplete in 33.5% of individuals.\cite{13}

Another study previously showed 52% patients had incomplete circle of Willis.\cite{14} This finding was not correlated with the previous study, because in the study cerebral DSA was done only in selected cases who had carotid stenosis. mRS score of the patient of ischemic stroke who had carotid stenosis was compared between groups with collateralization and without collateralization. In this study, mRS scale of <2 was categorized as normal and mRS scale >2 was categorized as diseased or disable. In this study, stroke patients with carotid stenosis, who developed collateralization, 90.9% patients mRS scale improved (<2) after three months. It was statistically significant. Previously one study showed only 12% patients with poor collateral compensation resulting in less favorable outcome.\cite{11}

About 88% patients who had preserved good collateral compensation in patients with compromised antegrade flow was associated with more favorable outcome. This adds to the growing evidence of prognostication role by collateral circulation flow, associated with more favorable outcome (OR 7.50, 95% CI 1.11–50.7, p=0.04).\cite{15,16} This study suggests that composite antegrade and collateral assessment is feasible and useful in the prognostication of patients with chronic carotid stenosis. Some study previously showed leptomeningeal collateral play an important role after ischemic stroke and results in good outcome.\cite{18} Even in acute stroke patients, good outcome was found after revascularization in presence of good collateral.\cite{14} One study found infarct volume was depended on collateral.\cite{18} The effect of corticocortical collateralization was evaluated on the prognosis of stroke. In case of proximal and distal intracranial stenosis of internal carotid artery, outcome depends on collateralizations.\cite{17,18,19,20} Prognosis was not significantly associated with antegrade or collateral grade per se.\cite{11} The favorable neurological outcomes among patients with good collateral compensation could be linked to the neuroplasticity theory. Neuroplasticity in post-stroke by synaptogenesis or dendritic arborization.\cite{22}

An animal model demonstrated restoration of perfusion to ischemic borders by collateral circulation via arterioles and new capillaries in Wistar rats after surgical ligation of MCA branches.\cite{21} Collateral circulation potentially provides blood supply to the perilesional brain parenchyma to facilitate repair and recovery, and may partially explain why patients with good collateral flow had better neurological recovery.\cite{24}

**Conclusion**

Carotid stenosed patients who suffered from ischemic stroke, improved to some extent whether collateralization developed among major vessels or not.

**Ethical Issue**

The study was approved by the institutional review board of Bangabandhu Sheikh Mujib Medical University research grant. Ref No. BSMMU/2017/2618(28). Date: 14.03.2017.

**Acknowledgement**

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**References**

5. Brozici M, van der Zwan A, Hillen B. Anatomy and functionality of leptomeningeal anastomoses: A


