A Review of Cerebrovascular Surgery in The People's Republic of China

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SUMMARY Cerebrovascular disease (CBVD) is very common in the People's Republic of China (PRC). In 8 of 12 large cities in the PRC, CBVD ranked first in frequency as a cause of death. The ratio of aneurysms to arteriovenous malformations (AVMs) was 0.84-2:1, much lower than in the United States (6.5:1). Hypertensive intracerebral hemorrhage (HIH) is the commonest cause of mortality in patients with CBVD; patients with ischemic stroke have been submitted to extracranial-intracranial (EC-IC) arterial anastomosis since 1976. Moyamoya syndrome is not uncommon in the PRC; leptospiral arteritis was one of the major causes in the series that have been reported.

MANY WESTERN neurologists and neurosurgeons are interested in the status of cerebrovascular surgery in the PRC, but little information on this subject is available in the English language. According to the 1976 health statistics from 12 large Chinese cities (fig. 1), the mortality associated with CBVD varied considerably. Beijing, Nanking, Wuhan, and Xian were among the regions with the highest mortality (24.3%-28.6%), while Guangzhou, Harbin, and Chungching had lower rates (12.6%-15.7%). In 8 of 12 cities — Beijing, Tienjin, Nanking, Hangzhou, Kunming, Xian, Guilin, and Wuhan — CBVD ranked first in frequency as a cause of death; in Shanghai, Guangzhou, Chungching, and Harbin it ranked second, following either cancer or heart disease.1 Thus, prevention and treatment of CBVD is an important aspect of health care in the PRC today.

Neurosurgery was first established as a separate specialty in the PRC in Shanghai in 1953. The first direct intracranial clipping of an aneurysm was carried out in Shanghai the same year. Today, every larger city and province has its own neurosurgical center doing clinical and research work on CBVD. Computerized tomography (CT) and microsurgery were not employed widely until after 1978-1979, although the first cases of EC-IC arterial bypass surgery were done under the microscope in 1976 in the Hospital of Zinjiang Medical College.8

This paper reviews some experiences in cerebrovascular disease in the PRC, including 537 cases of aneurysm, 490 cases of AVM, 315 cases of HIH, 66 cases of ischemic stroke, and 142 cases of Moyamoya syndrome. All operations except bypass surgery were being performed before the surgical microscope became available.

Clinical Series

Aneurysm

The aneurysm data reported here are based on 537 cases treated between 1953 and 1979. This period saw the beginning of intracranial-directed surgery in the PRC, but ended before microsurgery and CT scans were widely used. The data were collected from 5 hospitals.9 There were 226 male and 311 female patients. The ages ranged from 7 to 73 years, most patients being middle-aged.

The majority of the 550 aneurysms were located in the internal carotid artery (ICA) (60.9%). They were also found in the middle cerebral artery (MCA) (10.5%), the anterior cerebral artery (ACA) and anterior communicating artery (AcomA) (18.9%), the cavernous sinus (4.4%), the posterior cerebral artery (PCA) (1.4%), the vertebro-basilar artery (BVA) (1.2%), and other areas (2.5%). Only 24 cases were confirmed as multiple aneurysms on angiography. Only 43 cases (8%) did not bleed.

The results of treatment have been reported elsewhere and will not be reported here.4, 5, 7 This series included long-term follow-up (3 months to 17 years) of 91 cases.4 The data show that 82.4% of patients had good or fair results. Of 18 patients treated without operation or only removal of a hematoma, 4 patients (22.2%) died from reblooding compared with only one death in 31 patients (3.2%) treated with direct clipping of the aneurysm.

Arteriovenous Malformation

The incidence of AVMs compared with aneurysms seems much higher in Chinese than in western persons. A statistical analysis based on five studies, including only Chinese patients, reveals that the ratio of aneurysms to AVMs is 0.84-2:1.8, 4, 6, 8, 9, 10, 11 (table 1). In contrast, the Cooperative Study performed in the United States reported a ratio of 6.5:1.12 Whether selection for referral plays a role in this difference remains to be determined.

The data reported here are based on 490 cases of AVM as seen at the following hospitals: Beijing Hsuan Wu Hospital, 265 cases;9 Tienjin Municipal Hospital, 110 cases;9 and Shanghai Hwa Shan Hospital, 54 cases.9 There were 337 male (68.7%) and 153 female (31.3%) patients ranging in age from 5 months to 69 years. The average age was 27.5 years. Three hundred and fifty one patients (71.6%)
presented with SAH, among them 190 patients (38.8%) with complicating intracranial hematoma, and 64 patients (13.3%) presented with epilepsy. The AVMs were located as follows: 390 (80%) were above the tentorium; 55 (11.2%) were below the tentorium (including those in the brain stem); 13 (2.6%) were intra- or paraventricular; 7 (1.4%) were multiple (supra- and infratentorial); and 25 (5.1%) were not localized with certainty.

Two hundred and ten of the 490 collected cases underwent surgery for excision of the AVM, with a mortality of 11.4%. There were 132 cases with follow-up
from 6 months to 22 years (average, more than 7 years). Of the patients in the AVM excision group, 84.5% received a "good" or "fair" clinical grade, and only 3 patients (3.8%) died. In the nonoperated group, only 60.1% received a "good" or "fair" rating, and 8 patients (23.4%) died.

**Hypertensive Intracerebral Hemorrhage**

Two surgical series are available for evaluation: 235 cases recorded at Beijing Hsuan Wu Hospital between 1958 and 1978 and 80 cases reviewed at the First Hospital of Chungching Medical College between 1960 and 1974. All 315 patients were submitted to surgery. Their ages ranged from 29 to 78 years; 243 patients (76.5%) were 40 to 59 years old. There was a predominance of males (199, 63.2%) over females (116, 36.7%).

In 261 cases (83%), carotid angiography was done preoperatively. Angiography located the hematoma in all cases. CT was not utilized in this series.

All the hematomas were in the basal ganglia area, and most could be put into one of two categories: lateral (including external capsule, with or without spread to the surface — 112 cases), or medial (including internal capsule, external capsule with spread to the midline and thalamus — 184 cases). Extension into the ventricular system occurred in 101 cases (85%). Tentorial herniation occurred in 70 (58.8%), and foramen magnum herniation in 79 cases (66.3%). Some patients had both types of herniation. These 119 cases were mainly treated with conservative therapy.

Surgical procedure involved a formal craniotomy (frontal, temporal, or fronto-temporal), puncture of edema was present, the bone flap was not replaced; if the hematoma ruptured into the ventricle, ventricular drainage was used postoperatively. Needle aspiration of the hematoma was performed during the acute phase in only 6 patients in the early 1960s, all with failure. Three hundred and six patients were operated on within 7 days of the hemorrhage, 24 patients more than 7 days after hemorrhage, and in 5 the timing of surgery was unclear from the records. The operative mortality in the 315 patients was 40% (126 cases).

In the Beijing Hsuan Wu Hospital series, clinical grade was closely related to mortality (table 2). If the mortality in the 315 patients was 40% (126 cases).

Autopsy data from HIH patients are helpful in assessing the operative indications. A total of 119 autopsy cases were reported from Beijing Capital Hospital and Shanghia Hwa Shan Hospital. The locations of HIH were as follows: basal ganglia, 97 (81.5%); subcortex, 5 (4.2%); pons, 10 (8.4%); cerebellum, 6 (5%), and primarily in the ventricle, 1 (0.9%). There was secondary hemorrhage into the ventricular system in 101 cases (85%). Tentorial herniation occurred in 70 (58.8%), and foramen magnum herniation in 79 cases (66.3%). Some patients had both types of herniation. These 119 cases were mainly treated with conservative therapy.

Surgical procedure involved a formal craniotomy (frontal, temporal, or fronto-temporal), puncture of the brain for confirmation of the diagnosis followed by a small corticotomy, evacuation of the clot, and coagulation of the bleeding point. If severe brain edema was present, the bone flap was not replaced; if the hematoma ruptured into the ventricle, ventricular drainage was used postoperatively. Needle aspiration of the hematoma was performed during the acute phase in only 6 patients in the early 1960s, all with failure. Three hundred and six patients were operated on within 7 days of the hemorrhage, 24 patients more than 7 days after hemorrhage, and in 5 the timing of surgery was unclear from the records. The operative mortality in the 315 patients was 40% (126 cases).

In the Beijing Hsuan Wu Hospital series, clinical grade was closely related to mortality (table 2). If the
patients had no mortality among 23 patients.

Ischemic Stroke

According to the statistics of the Neurological Department of the Beijing Hsuan Wu Hospital from 1958 to 1976, 642 patients were admitted and diagnosed as having ischemic stroke. Of these, 502 patients had obstructions of the carotid artery and its branches (mortality, 13.7%), and 140 patients had obstruction of vertebral-basilar arteries and their branches (mortality, 14.2%).

Before the 1960s, some carotid endarterectomies were done in Beijing, Xian, and other cities. In the early 1960s thoracic surgeons and neurosurgeons in Xian collaboratively performed extracranial bypass operations that involved inserting an artificial vessel, that is, a graft from the carotid to the subclavian artery.

The first superficial temporal artery-middle cerebral artery (STA-MCA) anastomosis was done in 1976 in the Hospital of Zinjiang Medical College. When the surgical microscope and microinstruments became available, bypass surgery became widely utilized within a short time. In a period of 2 years, from June 1977 to June 1979, 108 bypass operations were performed at the Beijing Hsuan Wu Hospital. At this writing, only two earlier reports can be cited, as many hospitals have not yet conducted studies and compiled conclusive data.

Sixty-six cases of bypass operation have been described in detail: 28 were at the Hospital of the Zinjiang Medical College between March 1976 and December 1977, and 38 were at Beijing Hsuan Wu Hospital between July 1977 and December 1977. Sixty of the patients were male, 6 were female, 49 (76%) were over 40 years old. In 34 patients, the lesion was on the left side, whereas in 31, it was on the right. In one patient, the lesion was in the posterior fossa.

The angiographic site(s) of occlusion in these 66 cases were the ICA in 22 cases, the MCA in 33 cases, the ACA in 3 cases, the vertebral artery in 1 case, Moyamoya syndrome in 1 case, and occlusion and diffuse arteriosclerosis in 2 cases. Ten patients had normal angiograms. The main clinical features of these 66 cases were: transient ischemic attacks (TIAs) or reversible ischemic neurologic deficits (RINDs) in 8 cases, TIAs or RINDs plus stroke in 2 cases, repeated stroke in 15 cases, and completed stroke in 41 cases.

Sixty-five patients underwent STA-MCA bypass procedures, and 1 patient received an occipital artery posterior inferior cerebellar artery anastomosis. There was no operative mortality, and the only surgical complication was prolonged wound healing in 2 cases. Angiography was performed 10 to 14 days after operation for the 30 patients in the Beijing Hsuan Wu Hospital series, and the overall patency rate was 77% (23 cases).

Moyamoya Syndrome

Although the angiographic features of Moyamoya syndrome have been recognized in the PRC for a long time, only after the Japanese authors published their observations was particular attention paid to them. Many cities have reported such patients, and the suggestion is that this syndrome is not uncommon in the PRC.

At Beijing Hsuan Wu Hospital, 40 such patients were identified between 1958 and 1976. Shanghai Hwa Shan Hospital reported 27 cases seen between 1961 and 1978. The Second Hospital of Wuhan Medical College recorded 75 instances of typical Moyamoya features in 108 patients who underwent cerebral angiography for leptospiral arteritis; all their cases were confirmed by epidemiology, clinical diagnosis and serologic studies. The following information was collected from these 3 series totaling 142 patients:

The patients ranged in age from 2.5 to 65 years. In the Second Hospital of Wuhan Medical College series, in which all patients had leptospiral arteritis, 72% (54 patients) were under 12 years old, and 84% (63 patients) were under 20. In the Beijing Hsuan Wu Hospital and Shanghai Hwa Shan Hospital series, only 37.4% (25 patients) were under 20 years, 46.2% (31 patients) were between 21 and 40 years, and 16.4% (11 patients) were between 41 and 65 years. There were 85 males and 57 females, a ratio of 1.5:1. The etiological findings in our 142 patients are described in table 3, and autopsy findings in 9 cases are presented in table 4.

There were two main types of cerebral symptoms in Moyamoya syndrome: ischemic and hemorrhagic. In general, in the juvenile group, ischemia predominated, whereas in the adult group, hemorrhage was more common. The symptoms of these two groups, however, revealed many differences. The ischemic group experienced hemiparesis and repetitive TIAs or RINDs, whereas the hemorrhagic group exhibited signs of SAH with or without symptoms of hematoma. In the Second Hospital of Wuhan Medical College series, because all cases were judged to be due to leptospiral arteritis, patients had symptoms of acute or subacute infection, and their main symptom in the brain was due to ischemia. In 53 instances in which the cerebrospinal fluid was examined, only 10 samples showed a red blood cell count over
Table 3. Etiology of Moyamoya Syndrome*

<table>
<thead>
<tr>
<th>Etiology</th>
<th>No. of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leptospiral arteritis</td>
<td>75</td>
</tr>
<tr>
<td>Tuberculous arteritis</td>
<td>1</td>
</tr>
<tr>
<td>Tuberculous meningitis</td>
<td>1</td>
</tr>
<tr>
<td>Possible Etiology</td>
<td></td>
</tr>
<tr>
<td>Severe atherosclerosis</td>
<td>1</td>
</tr>
<tr>
<td>History of chronic syphilis</td>
<td>1</td>
</tr>
<tr>
<td>History of head trauma</td>
<td>2</td>
</tr>
<tr>
<td>History of infection in the face</td>
<td>2</td>
</tr>
<tr>
<td>History of fever and coma</td>
<td>2</td>
</tr>
<tr>
<td>Intracerebral hematoma</td>
<td>2</td>
</tr>
<tr>
<td>Etiology unknown</td>
<td>52</td>
</tr>
<tr>
<td>Total</td>
<td>142</td>
</tr>
</tbody>
</table>

*Data are from references 23, 24, 25.

Angiography is the only definitive method of establishing this diagnosis. All 142 patients underwent carotid angiography. Bilateral studies were performed in 32 patients, for a total of 174 carotid arteries. 98.8% of the C1 portions of the ICA were severely narrowed or occluded, almost 50% of the narrowing or occlusion extended to involve C2, and in a few patients, to C3; the C4 portion was always normal. In 77% to 90%, the M1 and A1 segments of the MCA and ACA were narrowed or occluded, whereas the distal portions of these arteries were almost normal if the vessel was opacified in the angiogram. Only a few patients had a single M1 or single A1 narrowed or occluded.

Abnormal net-like vessels (Moyamoya) were seen in all but one patient. This patient's carotid artery, MCA, and ACA were totally occluded, and the net-like vessels were proved at autopsy. The net-like vessels were mainly at the base of the brain or in the area of the basal ganglia. In some cases, they were

Table 4. Nine Autopsied Cases of Moyamoya Syndrome*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Hemorrhagic group (5 cases)</th>
<th>Ischemic group (4 cases)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>14–55</td>
<td>4–9</td>
</tr>
<tr>
<td>Main symptom</td>
<td>hemorrage</td>
<td>hemiplegia</td>
</tr>
<tr>
<td>Onset to death (days)</td>
<td>1–7</td>
<td>9–30+</td>
</tr>
<tr>
<td>Cause of death</td>
<td>acute herniation</td>
<td>brain malacia or pneumonia</td>
</tr>
<tr>
<td>Cerebrovascular pathology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congenital anomaly of carotid artery</td>
<td>3†</td>
<td>0</td>
</tr>
<tr>
<td>Narrowed or occluded C1-2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Narrowed or occluded MCA1 and ACA1</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Intimal thickening of C1, MCA1, and ACA1</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Lymphocystic infiltration</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Slightly involved PCA and basilar artery</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Thrombosis in MCA and ACA</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Changes in the vein</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Changes in small cerebral vessels</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rate merabile in basal of brain</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Collateral circulation</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Pathology of brain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herniation</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Intracerebral hematoma</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Malacia</td>
<td>1 (old focus)</td>
<td>3</td>
</tr>
<tr>
<td>Encephalitis</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Etiology of Moyamoya Syndrome‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congenital arterial anomaly† and other inflammatory factors in carotid artery, MCA, ACA</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Leptospiral arteritis</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Tuberculous arteritis</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

*Three cases were from Changchun, 3 cases from Wuhan, 2 from Shanghai, and 1 from Beijing.
†Two cases of congenital narrowing, 1 case of congenital muscular anomaly.
‡The etiology was identified in 7 cases; of these 3 exhibited congenital arterial anomaly, and all had some inflammatory factor. Three cases were confirmed leptospiral arteritis, and 1 case was from tuberculous arteritis. The cerebrovascular pathology of these 9 autopsy cases explained all the typical changes seen on angiography. No encephalitis was seen.
very extensive, reaching from the anterior fossa to the occipital lobe. Three pseudo-aneurysms were revealed in the net-like vessels.

Wide collateral circulation was demonstrated in the angiogram. The blood supply of the net-like vessels derived from some normal but relatively enlarged arteries. Transdural external-internal carotid anastomoses were present in all the patients seen at the Beijing Hsuan Wu and Shanghai Hwa Shan Hospitals, but only in about 60% of patients seen at the Second Hospital of Wuhan Medical College. In the latter series, some patients had acute-stage leptomeningeal arteritis, which resulted in a less extensive collateral circulation than in the other series. In addition, the shortest time from onset to angiography was almost 2 weeks. In some patients the enlarged PCA could be visualized anastomosing directly with the branches of the MCA, ACA, or anterior choroidal artery. The circulation time of the brain was always slowed due to the occlusion of the arteries. However, early filling veins could be seen in the arterial phase suggesting that the circulation time in the net-like vessels was more rapid.

Because Moyamoya is perhaps only a syndrome and not a specific disease, the main approach should be treatment of the underlying disorder. The only exceptions are when an intracerebral hematoma forms and compresses the brain, in which instance its removal should be considered. When ischemic symptoms persist or hemiparesis progresses, a bypass procedure may be considered, although more detailed study of this problem is required. The prognosis in this syndrome seems good. In the Beijing Hsuan Wu Hospital and Shanghai Hwa Shan Hospital series totaling 67 patients, 6 patients died in the hospital, mainly due to progression of the original disease and complications such as recurrent bleeding or intracerebral hematoma. The prognosis of the patients with leptomeningeal cerebral arteritis depended on their individual courses.

Discussion

The incidence ratio of aneurysms to AVMs appears to be much lower in the PRC (0.84–2:1) than in the West (6.5:1). Since AVM is a dysembryoplastic disease, it might be helpful to consider this disorder in the context of other, similar manifestations in Chinese patients. The author has collected statistical data on 12,785 cases of brain tumor in the PRC. All patients were Chinese and the dysembryoplastic tumors comprised 9.5%. In a statistical study of 1,639 cases of spinal tumor in the PRC, the dysembryoplastic tumors comprised 11%. Together, these two studies record one of the highest incidence rates in the world literature. Further investigation of this phenomenon is warranted.

The results of aneurysm surgery are improving but cannot be described as good. One reason is that the statistics include data from the early days of neurosurgery in the PRC. Before the 1970s, the understanding of the operative indications and the timing of surgery were uncertain. Furthermore the data reflect the results obtained before microsurgery was used. An attempt is being made now to ensure that four-vessel angiography is routine so that multiple aneurysms will not be missed. Grade IV or V patients are no longer submitted to surgery. In addition, microsurgical technique and hypotensive anesthesia are being utilized nowadays during dissection of the aneurysm. In the few years since these measures were instituted, the Beijing Hsuan Wu Hospital has had no mortality due to aneurysm surgery in 40 patients with Botterell Grade I, II, or III.

Although intracerebral hemorrhage due to cryptic-AVM is not discussed in this paper, it should be considered when Chinese patients, especially children and young adults, experience hemorrhage in a location that makes HIH unlikely. If there are doubts, the small part of the clot that adheres tightly to the brain tissue should be routinely examined with care by the surgeon and the pathologist; sometimes this careful examination will reveal a cryptic AVM. One of the few papers on this subject in Chinese was written at the Third Hospital of the Beijing Medical College. Of 10 cases of cerebellar hemorrhage confirmed at autopsy 6 were due to AVMs and 5 to cryptic-AVMs. A similar experience has been reported from Japan.

Of 6,566 cases of CBVD collected from 4 large hospitals in Beijing, 2,279 cases (34.7%) were HIH. The mortality was 43%, and almost 50% of the survivors had severe permanent neurological deficits. From the standpoint of prevention, controlling arterial hypertension is very important. Community control programs to prevent hypertension, stroke, and coronary heart disease have been organized in some cities and provinces in the PRC.

In the PRC, TIAs and RINDs are still considered tenuous indications for bypass operation. Physicians understand that completed stroke can develop from TIAs or RINDs, but it is not known if bypass surgery can abolish these symptoms and prevent a future stroke. Therefore a large series of Chinese patients with TIAs and long-term follow-up, similar to the registry reported by Heyden et al., is very important to us. Bypass surgery is being used as a preliminary procedure in operations to clip MCA aneurysms and to treat carotid artery-cavernous sinus fistulae. A pedicled omentum transposition to brain has been attempted in the treatment of ischemic stroke.

The net-like vessels of Moyamoya syndrome may represent a special form of compensatory circulation. When another collateral circulatory route is well established, the Moyamoya phenomenon will disappear. The pathology of the Moyamoya syndrome almost always involves the carotid artery system bilaterally, although there may be some degree of difference between the two sides. In clinical practice, however, the symptoms are always manifested only on one side. In our series, the complications, including bleeding or ischemic lesions in the brain, were not consistent or parallel with the more severely pathological side as
revealed by angiography. Perhaps some other pathological change, such as rupture of a pseudo-aneurysm or occlusion of a main artery, was more significant in some patients.

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References

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