Original Contributions

Clinical Presentation as a Guide to Early Prognosis in Vertebrobasilar Stroke

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Background and Purpose: This study attempts to assess the feasibility and heuristic value of a classification scheme for vertebrobasilar stroke.

Method: Fifty-seven consecutive patients with vertebrobasilar stroke were classified on the basis of clinical features and computed tomographic abnormalities into single-sector (n=19), multisector (n=11), and top-of-the-basilar (n=27) groups; a sector was defined as that portion of the brain stem supplied by a single penetrating (median) or branch (paramedian or lateral) artery.

Results: Thirty-day and 3-year survival rates were 100% and 71%, respectively, in the single-sector group, and 96% and 73%, respectively, in the top-of-the-basilar group. Thirty-day and 3-year stroke recurrence free survival rates were 89% and 76%, respectively, in the single-sector group, and 96% and 88%, respectively, in the top-of-the-basilar group. Seven of the 11 patients in the multisector group died within 2 months of ictus, three having experienced recurrence.

Conclusions: These data, in part supported by prior studies, demonstrate the feasibility and heuristic value of the classification scheme and suggest that single-sector and top-of-the-basilar stroke patients have a relatively benign early prognosis and modest long-term stroke rates. (Stroke 1992;23:165-170)

It is becoming widely recognized that during the first few hours of a stroke there may be a window of opportunity during which the initiation of a variety of therapies may have a major impact on outcome. Although such promising approaches as thrombolytic therapy, the use of calcium and potassium channel blockers, and the prevention of free radical-induced neuronal damage are clearly at the investigative stage, there is a need for developing reliable methods for identifying candidates for these therapies. In particular, it will almost certainly be difficult to justify the use of such treatments in patients with a benign prognosis. For a variety of reasons, presently available imaging studies are of limited potential value in making therapeutic decisions early in the course of patients with posterior circulation strokes, and clinical diagnosis will remain an important guide to clinical decision making for the foreseeable future.

The early prognosis of several subpopulations of patients with posterior circulation infarcts has been reported, but there has never been an attempt to define stroke anatomy in a consecutive series of these patients. What is known about the prognosis of selected subpopulations may not be so useful clinically if there are large numbers of stroke patients who do not fall into one of the subpopulations or if it is difficult to classify anatomically many posterior circulation stroke patients. The present study attempts to address this issue in a consecutive series of vertebrobasilar stroke patients drawn from a stroke registry.

The principal guiding hypothesis in this study is that in nearly all cases, prognosis of vertebrobasilar stroke is related to the particular locus and nature of the pathologic vascular process, which in turn is reflected in the anatomy of the stroke. Basilar thrombosis has a poor prognosis because there is thrombus within the basilar artery that, with minimal extension (propagation), or fragmentation and embolism, will cause extensive further infarction. A pontine lacune has a relatively good prognosis because it reflects completed infarction in the distribution of a single basilar branch, due either to intrinsic disease (microatheroma or lipohyalinosis), or to encroachment on the vascular orifice by basilar plaque. Vascular and corresponding neuroanatomic lesions can be

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Building on early work by Foix and Hillemand, principles of hindbrain microvascular anatomy were "repeated as serial homologies at each succeeding level of the brainstem." We will refer to the sites of supply of vessel groups as sectors. Thus, lateral medullary infarction reflects occlusion of a vessel supplying the lateral sector in the Gillilan nomenclature, usually a branch of the posterior inferior cerebellar artery or the vertebral artery.

Most eponymous hindbrain vascular syndromes reflect ischemia within a single sector, but many patients defy syndromic classification. We have used a set of guiding vasculoanatomic principles in these cases to classify infarcts as single sector or multisector.

Because motor pathways are confined to near the midline throughout the brain stem up to the midbrain, motor symptoms and signs indicate involvement of a median sector except in cases of top-of-the-basilar infarctions, which have their own characteristic features (most consistently, visual loss). Involvement of cranial nerves III, IV, or VI or internuclear ophthalmoplegia also implicates a median sector. Except in the median medulla, which is rarely involved in infarction, sensory pathways travel laterally throughout the brain stem, and sensory symptoms and signs indicate involvement of a lateral or, occasionally, a paramedian sector. Prominent vertigo suggests lateral sector involvement, especially at the medullary level. Ataxia, particularly appendicular ataxia, suggests lateral sector involvement, except in the special case of ataxic hemiparesis, which may occur with median sector involvement or a lacune in the anterior circulation. Bilateral symptoms or signs indicate multisector involvement, but the presence of unilateral sensory and motor involvement is also likely to represent multisector ischemia, as is the combination of motor involvement with pronounced vertigo or appendicular cerebellar signs (except in ataxic hemiparesis). Diplopia resulting from skew deviation may be a complaint with lateral medullary infarction, in which sensory symptoms and signs are the rule, but otherwise the combination of diplopia or ophthalmoplegia and sensory symptoms suggests multisector involvement. Altered consciousness or visual or memory impairment always indicates multisector involvement, usually top-of-the-basilar but at times basilar thrombosis.

The principal corollary to our guiding hypothesis is that infarcts confined to a single sector have a benign prognosis, whereas those implicating two or more sectors have a more malignant prognosis. In part, this reflects the fact that many single-sector infarcts are lacunes, whereas multisector ischemia usually implicates the basilar artery and, hence, basilar thrombosis. The lateral medullary infarct is a special, frequent type of single-sector infarct that commonly reflects large-artery (vertebral) thromboembolic disease, but in prior studies has been shown to have the benign prognosis associated with other single-sector infarcts. We considered it as a single-sector event in this study on the basis of the anatomy of the infarct. An infarct involving the inferior cerebellum but sparing the brain stem (anterior inferior or posterior inferior cerebellar artery) would also be considered a single (lateral)-sector event. Top-of-the-basilar embolism reflects large-vessel thromboembolic disease in the more proximal vertebrobasilar system or cardiogenic embolism. Because it is clinically distinguishable from and may reflect a pathology different from that in basilar thrombosis, we considered it separately as a special class of multisector infarct. An infarct confined to the superior cerebellum (superior cerebellar artery) could be either a single (lateral)-sector event or a top-of-the-basilar embolism.

We defined prognosis in terms of mortality and stroke recurrence (or extension in the case of basilar thrombosis). Our actuarial analyses are based on time elapsed from the initial event, not the time of the patient's admission to the hospital. We did this to avoid loss of external validity related to variable time from ictus to presentation in various medical centers.

Subjects and Methods

Two hundred ninety consecutive patients with acute cerebrovascular events admitted to the Neurology Inpatient Service at the Veterans Affairs Medical Center (VAMC), Jackson, Miss., were entered into the stroke registry. The Jackson VAMC provides care to veterans (mainly male) in the central Mississippi catchment area who, largely by virtue of their low socioeconomic status, use the VAMC as their primary source of medical care. With very few exceptions, our stroke registry comprises patients who either came straight to the VAMC, or were immediately sent, without hospitalization, to the VAMC when their need for hospitalization and their eligibility for VAMC care became evident.

During the study period, all acute stroke and most transient ischemic attack (TIA) patients presenting to the Jackson VAMC were admitted to the Neurology Service. There were 246 patients with cerebral infarction and 30 with TIAs. Fifty-seven with posterior circulation infarcts and nine with posterior circulation TIAs provide the basis for this study. In the stroke patients, who were all men, the mean age was 63 years. There were 32 white and 25 black patients. Four patients had a prior history of stroke. Thirty patients were treated acutely with heparin; 49 received aspirin chronically, and, of these, 13 also received dipyridamole; four received coumadin chronically. All the TIA patients were men; eight were white and one black, with mean age of 57.6 years. One patient had a history of stroke.
All patients were evaluated and treated according to accepted standards as judged by the attending neurologist and staff. Treatment was not altered by participation in this study. All patients were notified of the study and agreed to take part.

Within 72 hours of admission, all patients were subjected to a detailed medical history interview and neurological examination by one of the investigators, a detailed higher cortical function examination by a behavioral neurologist, and a 16-channel electroencephalogram interpreted by a board-certified electroencephalographer. Every patient received one or more computed tomographic (CT) scans (Picker 1200SX Synerview, with 256x256 matrix), and lesions were clinically localized in 98.3%. Admission laboratory studies included a complete blood count, electrolytes, glucose, blood urea nitrogen, and creatinine. Erythrocyte sedimentation rate, syphilis serology, fasting cholesterol and triglyceride levels, and other studies deemed appropriate were obtained during the patient’s hospital course. All patients underwent electrocardiography; 24-hour Holter monitors, two-dimensional echocardiography, and cerebral angiography were performed on a selective basis as clinically indicated. The possibility of arterial dissection or temporal arteritis was routinely considered.

Most patients were followed up in the VAMC Neurology Outpatient Clinic. In those who failed to return to clinic, some follow-up data were obtained from records of their visits to other clinics and the admitting office, through death certificates, and through telephone calls to their homes. Follow-up until the end of the study was achieved in 94% of patients; patients not followed until death or the end of the study were treated as withdrawals in the actuarial analysis. Median follow-up was 1,063 (range 4-1,657) days.

Strokes and TIAs were mainly localized to the posterior circulation on clinical grounds. Among the stroke patients, CT scan was confirmatory in 21 and postmortem examination in two. Lacunar syndromes (pure motor stroke, ataxic hemiparesis, clumsy-hand–dysarthria) that were not associated with CT changes and have been reported with anterior circulation events were classified as anterior circulation events and are not included in this report. Stroke recurrence was defined as an acute deterioration of neurological function persisting >24 hours, following a period of stability, that could not be accounted for on some other basis, such as herniation.

Data were analyzed on a PDP 11/73 computer (Digital Equipment Corporation, Maynard, Mass.) equipped with spss (SPSS Inc., Chicago, Ill.). Survival and recurrence curves were calculated using the life-table method. In the recurrence studies, nonstroke deaths were treated in the same way as withdrawals.

Results

It was possible to classify all 57 stroke patients and eight of the nine TIA patients according to sectors involved. Of the stroke patients, there were 27 (47%) with top-of-the-basilar strokes, 19 (33%) with single-sector strokes, and 11 (19%) with multisector strokes. There were no infarcts confined to the cerebellum. Among events in the TIA patients, three were top of the basilar, two were single sector, three were multisector, and one was uncertain. Of the single-sector stroke patients, 15 were classifiable as lateral, none as paramedian, and four as median. Of the single-sector TIA patients, one was definitely lateral and the other was probably lateral.

In seven (26%) of the 27 top-of-the-basilar stroke patients, three (16%) of the 19 single-sector patients, and two (18%) of the 11 multisector patients, stroke was preceded by TIA. An adequate history was not obtainable for one multisector patient. In 11 cases, TIAs were suggestive of focal posterior circulation dysfunction; in only one patient, who had a poor history, were symptoms suggestive of impending syncope. In three patients, the TIAs consisted of vertigo, nausea, and impaired gait, with a tendency to fall, and a fourth patient episodically developed these same symptoms plus hiccups. Three of these developed lateral medullary infarcts and the fourth a top-of-the-basilar infarct.

All TIAs and single-sector strokes and 10 of 11 multisector, non–top-of-the-basilar strokes were ultimately determined to result from atheromatous macrovascular or microvascular disease. The one remaining multisector stroke patient had a 1-month history of left temporal headache and neck pain that strongly suggested the presence of vascular dissection, but angiography was not performed. Two of the 27 top-of-the-basilar patients were thought to have experienced cardiogenic embolism. We encountered no cases of unusual etiology, such as temporal arteritis or syphilis. One single-sector, one multisector, and two top-of-the-basilar patients had atrial fibrillation or a mechanical prosthetic heart valve, but angiographic abnormalities or the occurrence of multiple stereotyped events or a stuttering course suggested arterial thromboembolic disease.

Thirty-day survival among top-of-the-basilar patients was 96% (95% confidence interval [CI] 81–100%) (Figure 1); 96% of those free of nonstroke death at 30 days were free of recurrence (95% CI 81–100%) (Figure 2). Thirty-day survival among single-sector patients was 100% (Figure 1); of these, 89% were free of recurrence (95% CI 68–98%) (Figure 2). Seven of the 11 multisector stroke patients died of their stroke between 4 and 58 days after the ictus; of these, three had experienced clear-cut stroke progression, all within 3 weeks. Two of the nine TIA patients had a stroke, one 11 and one 29 months later, and three had additional TIAs.

Three-year survival among top-of-the-basilar patients was 73% (95% CI 48–90%), and 88% were free of recurrent stroke (95% CI 68–98%). Three-year survival among single-sector patients was 71% (95% CI 39–93%), and 76% (95% CI 42–95%) were free of recurrence. Of the four multisector stroke patients who survived their acute events, two experi-
enced recurrent strokes 2–3 years later, fatal in one. Of the 20 deaths, 13 were due to stroke (presenting or subsequent), three to cardiac disease, two to renal failure, one to cancer, and one to sepsis.

Discussion

The outstanding findings in this study are that all posterior-circulation stroke patients could be satisfactorily assigned to single-sector, multisector, or top-of-the-basilar classes, and that the early prognosis of both single-sector and top-of-the-basilar patients, who accounted for 80% of the study population, was quite good. Thus, we have at least demonstrated the heuristic value of our classification.

Prior studies have documented the relatively benign early course of lateral medullary infarcts. Currier et al reported 6-month, 2-year, and 5-year survival rates of 97%, 77%, and 54%, respectively. Peterman and Siekert reported one-month, three-year, and five-year survival rates of 97%, 80%, and 59%, respectively. Norrving and Cronqvist reported acute and 3-year survival rates of 88% and 74%, respectively, and acute and 3-year stroke-free rates of 95% and 90%, respectively.

The prognosis of top-of-the-basilar infarcts is less certain. Bogousslavsky et al reported that 13 (22.4%) of 58 patients with unilateral posterior cerebral artery infarction went on to develop cortical blindness in the course of a mean follow-up of 39.6 months. Among our 16 patients with unilateral posterior cerebral artery infarction, only one experienced recurrence in the course of a mean follow-up of 36 (median 40) months, and this consisted of an increase in hemiparesis. Because of the small numbers, we cannot exclude the possibility that the difference between the two studies is related to chance. Mehler described 61 patients with top-of-the-basilar syndrome, but the fact that his selection criteria are unclear, and that 77% (all those with a "benign" outcome) had an acute confusional state (versus four [15%] in our series) makes comparison with our study impossible.

Only our multisector group had a high early recurrence rate and mortality, in keeping with the results of previous studies. However, of the four multisector patients who survived the first 2 months, only one died (day 683), the result of an anterior circulation stroke after an earlier stroke of unknown locus at day 14; one experienced a minor stroke at day 416 and was alive at day 997, and two others were doing well at 880 and 971 days after stroke. This is in keeping with Caplan's observation that long-term prognosis may be fair even in patients with basilar occlusion, if they survive the early period.

In this study, we assigned lacunar infarcts of uncertain location to the anterior circulation. Lacunar infarcts in the posterior circulation would be classi-

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**FIGURE 1.** Graph of survival after single-sector stroke (top panel) and top-of-the-basilar stroke (bottom panel). Bars indicate 95% confidence intervals.

**FIGURE 2.** Graph of percentage of patients free of nonstroke death who were free of stroke recurrence, by single sector stroke (top panel) and top-of-the-basilar stroke (bottom panel). Bars indicate 95% confidence intervals.
fied as single-sector events. Our previous studies demonstrated 1-month and 12-month recurrence-free rates in lacunar infarct patients of 92% (95% CI 80–98%) and 83% (95% CI 65–94%), respectively, and 1-month and 12-month survival rates of 98% (95% CI 89–100%) and 94% (95% CI 80–98%), respectively; thus, it is unlikely that a totally successful localization of lacunes would have significantly altered our results.

This was not a treatment study, and there is no evidence that stroke recurrence was modified by treatment. Fifty percent of single-sector and top-of-the-basilar stroke patients were acutely anticoagulated, compared with 64% of the multisector group. Five of 13 recurrences occurred while patients were being anticoagulated.

We do not have data on stroke risk and mortality rates in a comparable population without cerebrovascular symptoms, but, despite small numbers, the data suggest that there is likely to be a less-favorable long-term prognosis for stroke recurrence of some type, or death, in patients with single-sector or top-of-the-basilar infarcts. Our results are comparable with those of earlier studies (see above) and consistent with the concept that, whereas single-sector and top-of-the-basilar infarcts are not predictive of impending massive stroke or death, they are markers for generalized vascular disease and its associated long-term morbidity and mortality.

Only 12 (21%) (95% CI 12–33%) of our patients had preceding TIAs. The 16% TIA frequency in the 19 single-sector stroke patients, 15 of whom had lateral medullary infarcts, compares with reported TIA rates in such patients of 25% to 50%. The 18% TIA rate in our 11 multisector patients is very low compared with prior series, which have reported rates of 50–80%. Our findings may relate to the prospective nature of our series, and the fact that data in most published series relate to patients with documented basilar occlusion. However, our experience is closer to that of Kubik and Adams, in which only two of 11 patients with autopsy-documented basilar thrombosis had truly transient episodes preceding stroke (confusion with amnesia, dizziness), whereas most experienced a course of saltatory progression that began with sustained, mild, but clearly multisector, symptoms.

Contrary to the commonly held opinion that vertigo rarely constitutes a posterior circulation TIA, TIAs in four of our 12 patients with preceding TIAs were characterized by vertigo and disequilibrium; three of the TIAs included nausea and vomiting, and one included all these symptoms plus hiccups. Three patients went on to have lateral medullary infarcts and one a top-of-the-basilar infarct. This observation is in keeping with the reports by Grad and Baloh and Norrving and Cronqvist. However, in no case was a TIA characterized by vertigo and disequilibrium alone a precursor of a multisector infarct. Furthermore, although isolated vertigo emerged as an unexpectedly common TIA symptom, given the great prevalence of vertigo in the general population, it is likely that only a minute fraction of vertiginous patients will go on to have hindbrain strokes, usually in the lateral sector.

Only three patients in this series (two with top-of-the-basilar and one with multisector stroke) presented with syncope, but, in each instance, recovery of consciousness was associated with persistent visual impairment, signaling that these were not typical syncopal episodes. Only one patient presented with symptoms of impending syncope, and the history in this case was very poor. The present study thus further confirms that syncope or symptoms of impending syncope is not likely to represent a posterior circulation TIA.

No patient in our series had a history of drop attacks. This is congruent with the series of Ferbert et al of patients with basilar (n=49) or bilateral distal vertebral occlusion (n=36), in which only four of 53 patients with a history of TIAs had experienced drop attacks, notwithstanding the locus and severity of the vascular pathology.

There was no statistically significant relationship between race and stroke type. Of the 25 blacks, 32% had single-sector, 36% top-of-the-basilar, and 32% multisector strokes; of the 32 whites, 34% had single-sector, 56% top-of-the-basilar, and 9% multisector strokes (χ²=4.97, p=0.42).

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