01 Jan 1992

Early Clinical Differentiation of Cerebral Infarction from Severe Atherosclerotic Stenosis and Cardioembolism

S. G. Timsit

R. L. Sacco

J. P. Mohr

M. A. Foulkes

et. al. For a complete list of authors, see https://scholarsmine.mst.edu/chem_facwork/3298

Recommended Citation

S. G. Timsit et al., "Early Clinical Differentiation of Cerebral Infarction from Severe Atherosclerotic Stenosis and Cardioembolism," *Stroke*, vol. 23, no. 4, pp. 486 - 491, Lippincott, Williams & Wilkins; American Heart Association, Jan 1992.
The definitive version is available at https://doi.org/10.1161/01.STR.23.4.486

Early Clinical Differentiation of Cerebral Infarction From Severe Atherosclerotic Stenosis and Cardioembolism

S.G. Timsit, MD; R.L. Sacco, MS, MD; J.P. Mohr, MD; M.A. Foulkes, PhD; T.K. Tatemichi, MD; P.A. Wolf, MD; T.R. Price, MD; and D.B. Hier, MD

Background and Purpose: **Hyperacute cerebral infarction trials require early differentiation of infarction subtype. Our aim was to determine clinical factors predictive of infarction subtype from data collected in the early hours of admission.**

Methods: **Using the 1,273 patients enrolled in the Stroke Data Bank, stroke risk factors and demographic, clinical, and radiological features were compared between the 246 cardioembolic and 113 large-vessel atherosclerotic cerebral infarcts.**

Results: **Stroke Data Bank definitions ensured more transient ischemic attacks in atherosclerotic infarcts and more cardiac disease in cardioembolic infarcts, but the diagnosis was distinguished further using a logistic regression model. Fractional arm weakness (shoulder different from hand) (odds ratio 3.1, 95% confidence interval [CI] 1.6–5.8), hypertension (odds ratio 2.8, CI 1.4–5.3), diabetes (odds ratio 2.5, CI 1.2–5.1) and male gender (odds ratio=2.2, CI 1.2–4.1) occurred more frequently in patients with atherosclerotic than cardioembolic infarcts. Reduced consciousness (odds ratio=3.2, CI 1.4–7.3) was more frequent in cardioembolism. For a male patient with hypertension, diabetes, and fractional arm weakness, the estimated odds of an atherosclerotic infarction were 47-fold that of a cardioembolic infarction. Patients with atherosclerotic infarcts were more likely to have a fractional arm weakness regardless of infarct size, whereas, for those with cardioembolic infarctions, fractional weakness was more frequent in infarcts less than 20 cc in volume.**

Conclusions: **Clinical features that are observed at stroke onset can help distinguish cerebral infarction subtypes and may allow for early stratification in therapeutic trials. (*Stroke* 1992;23:486–491)**

KEY WORDS • **cerebral infarction** • **cardioembolic stroke** • **epidemiology** • **risk factors**

It is often difficult to classify patients into different mechanisms of cerebral infarction based solely on clinical criteria. A thorough diagnostic work-up is required because the presenting clinical syndromes are not often distinctive enough to permit an inference of the cause of infarction. Few studies[1] have collected detailed information on the clinical and radiological characteristics of large, homogeneous subsets of patients with acute cerebral infarction. The Stroke Data Bank[2] provided a large collection of prospectively collected information on patients with different subtypes of infarction. To determine the clinical features important in distinguishing different mechanisms of stroke, we compared cerebral infarction from large-artery thrombosis to that from cardiac embolism. The aim of our study was to determine the relative importance of data collected in the early hours of admission and to develop a model predictive of infarct subtype.

From the Neurological Institute (S.G.T., R.L.S., J.P.M., T.K.T.), Columbia–Presbyterian Medical Center, New York; Biometry and Field Studies Branch of the National Institute of Neurological Disorders and Stroke (M.A.F.), Bethesda, Md.; Boston University Medical Center (P.A.W.), Boston, Mass.; University of Maryland (T.R.P.), Baltimore, Md; and Michael Reese Hospital and Medical Center (D.B.H.), Chicago, Ill.

Presented in part at the first European Stroke Conference, May 10–12, 1990, Düsseldorf, FRG.

Supported in part by Horace W. Goldsmith Foundation research grant NS-27517 and by the Stroke Data Bank under contracts N01-NS-2-2302, N01-NS-2-2384, N01-NS-2-2398, N01-NS-2-2399, and N01-NS-6-2305 from the National Institute of Neurological Disorders and Stroke, Bethesda, Md.

Address for correspondence: Ralph L. Sacco, MD, Neurological Institute, Stroke Service, 710 West 168th Street, New York, N.Y. 10032.

Received May 27, 1991; accepted December 13, 1991.

Subjects and Methods

The Stroke Data Bank was a prospective observational study in which acute care and follow-up clinical and laboratory data on patients with stroke were collected. The collaborative study involved the Biometry and Field Studies Branch of the National Institute of Neurological Disorders and Stroke (NINDS) as the coordinating center, with four academic hospital centers: University Hospital of Boston University Medical Center, Michael Reese Hospital and Medical Center, University of Maryland Hospital, and the Neurological Institute of Columbia University. A full description of the Stroke Data Bank can be found elsewhere.[2]

Each patient with acute stroke was examined by one of the Stroke Data Bank investigators within a week of onset (median 46 hours), and most underwent initial and subsequent computerized tomographic (CT) scan-

ning. A classification for diagnosis was designed to characterize each stroke by causal mechanism. This classification used in each clinical center took into account the neurological and medical history, neurological symptoms and signs, findings on head CT scans, and, when available, angiography, electrocardiography, transthoracic echocardiography, Holter monitoring, and carotid Doppler ultrasonography. Among patients with infarction, angiography was performed in 29% and echocardiography in 56%.

Strokes were classified into the following categories and defined elsewhere[3,4]: infarction due to large-artery thrombosis (ATH), lacune, embolism from a commonly accepted cardiac source (EMB), embolic infarction with tandem arterial pathology, infarction of undetermined cause or with normal angiogram, parenchymatous hemorrhage, subarachnoid hemorrhage, and stroke from other unusual causes. Strokes in patients with inadequate evaluations, conflicting data, or adequate evaluations that failed to confirm the initial impression of the stroke subtype were diagnosed as being of undetermined cause. This permitted a more specific classification of the other diagnostic categories. For the purposes of this study we will describe further the two infarct subtypes studied.

To classify a patient as having ATH required the presence of a severe stenosis (>80%) or occlusion of the internal carotid artery origin or syphon when angiography was performed. Dissection was not included in this category. The requirement of severe stenosis was used to help differentiate hemodynamic mechanisms from the less severe stenosis needed for the diagnosis of tandem arterial pathology. Major cerebral artery stem occlusion was accepted as angiographic proof of ATH only when a patient had acceptable CT evidence or a transient ischemic attack (TIA) within the previous 30 days in the same territory. Carotid noninvasive testing, if available, could provide the necessary information on arterial atherosclerosis. Supportive CT evidence were findings suggestive of a distal field or borderzone infarction such as suprasylvian frontal and central lucencies which faded toward normal in the parietooccipital region and spared the penetrating territories of the lenticulostriates. Infarcts limited to the proximal territories could not be distinguished as due to atherothrombosis or embolism based on CT scan alone. In the absence of confirmatory laboratory results, a prior TIA or an ipsilateral bruit and either a normal CT scan before 10 days or CT scan evidence of a large area of low density including the proximal field may have led to a diagnosis of ATH. However, an ipsilateral bruit alone was not sufficient evidence to make a diagnosis of ATH.

Cardiac embolism was diagnosed when a recognized cardiac source of embolism was determined and there were additional findings suggestive of an embolic cerebral infarction. Recognized sources were defined as atrial fibrillation or flutter, bacterial or marantic endocarditis, myocardial infarction within the preceding 6 weeks, atrial myxoma, mitral annulus calcification, mitral valve prolapse, right-to-left cardiac shunts, and pulmonary vein thrombosis. The finding of any of these abnormalities alone was insufficient to diagnose EMB, which required other supportive clinical and CT evidence. The CT was confirmatory when a low-density zone was found that corresponded to the territory of a single cerebral surface branch of a major cerebral artery in a setting of a stroke with no prior TIA. Multiple infarcts of different branches of the same major cerebral artery were also accepted. Hemorrhagic infarction inferred by scattered areas of high density was supportive, but not diagnostic, of EMB. When angiography was performed, occlusion or retrograde collateral into a single cerebral surface branch was supportive of a diagnosis of embolism. Multiple sites of occlusion along the course of a major cerebral artery were also supportive of embolism only if they were confined to a single major arterial territory and there was no cerebrospinal fluid or clinical features suggestive of arteritis. In the absence of confirmatory laboratory results, a sudden onset of focal stroke with a nonlacunar syndrome and a recognized source for embolism, despite a normal CT scan, could lead to a diagnosis of EMB.

Demographic variables, historical stroke risk factors, clinical features and syndromes at presentation, and findings on neurological examination and CT scan were compared in patients with ATH and EMB cerebral infarction. Clinical syndromes were categorized as large hemispheric, small hemispheric, lacunar, and basilar. Syndromes are more completely defined in the Stroke Data Bank operations manual.

We compared for the two groups weakness severity on initial neurological examination as measured by the Stroke Data Bank weakness score[2]; the frequency of arm, leg, and face involvement; and hemiparesis profiles. Further stratification was done by syndrome and by CT infarction volume in ATH and EMB patients. Hemiparesis profiles were defined as fractional or nonfractional. A nonfractional profile for the arm was defined by equal weakness in the shoulder and hand and, for the leg, by equal weakness in the hip and foot. Fractional profiles consisted of proximal or distal predominant weakness. For the upper limb, proximal predominant weakness was defined as weakness in the shoulder exceeding that in the hand and, for the lower limb, weakness in the hip exceeding that in the foot. Distal predominant weakness was defined as the converse.

Volume and location of the clinically relevant cerebral infarction, measured by first CT, were compared in ATH and EMB. The CT results were classified as normal or abnormal and as showing superficial or nonsuperficial infarction, mass effect, or edema.

For proportions, a univariate analysis was done using χ^2 tests of association. For continuous variables, the t test was used for significance of means and the nonparametric median test for judging the significance of differences in median values. Given the many tests made in this large data set, some were likely to achieve nominal levels of significance by chance alone. We chose not to adjust significance levels using multiple comparison techniques but rather to consider values with $p<0.01$ simply as indicators for further consideration of the variable in our multivariate model.

Stepwise multiple logistic regression was used to identify factors jointly predictive of large-artery disease and embolism from a cardiac source. For the model, the set of potential factors was reduced by backward elimination until only those significant at the 0.05 level remained. Parameters were estimated from the data by maximum likelihood estimation. Odds ratios and 95% confidence intervals (CIs) were calculated based on the

TABLE 1. Angiographic Findings in Atherosclerotic Infarction and Echocardiographic Findings in Cardioembolic Infarction

	n	%
Atherosclerotic infarction group		
Patients	113	
Angiography performed*	79	
ICA occlusion/severe stenosis	49	62.0
MCA occlusion/severe stenosis	8	10.1
ACA stenosis	1	1.3
PCA occlusion	1	1.3
VB (occlusion/severe stenosis)	12	15.2
Other findings	8	10.1
Cardioembolic infarction group		
Patients	246	
Echocardiography performed†	128	
Left atrial enlargement	75	58
Left ventricular dilatation	54	42
Akinetic region	34	26
Mitral annulus calcification	20	16
Mitral stenosis (moderate/severe)	13	10
Aortic stenosis (moderate/severe)	11	9
Mural thrombus	8	6

ICA, internal carotid artery; MCA, middle cerebral artery; ACA, anterior cerebral artery; PCA, posterior cerebral artery; VB, vertebrobasilar arteries.

*Angiography was performed within a median of 5.0 days.

†Sum of various findings on echocardiogram exceeds 100% because many patients had more than one abnormality.

estimated coefficients and their standard errors. An expected probability was also calculated and compared with the actual diagnosis subtype to assess whether the variables that were good discriminators were also good predictors. A similar approach in a separate model was used to determine the factors jointly predictive of fractional weakness and nonfractional weakness.

Results

Data available for analysis on 1,805 patients with stroke were limited to the 1,273 (71%) cases with cerebral infarction; of these, ATH was diagnosed in 113 (9%) and EMB in 246 (19%). The diagnosis of ATH was supported by angiography in 70% (79 of 113) as described in Table 1. In 71 the angiogram disclosed an occlusion or stenosis greater than 80%; in the remaining eight the stenosis may have been considered nonhemodynamic on angiographic grounds alone, but in conjunction with CT findings, patients were classified as having ATH.

Among the 34 ATH patients who did not undergo angiography, the diagnosis was supported by at least one CT scan in all, noninvasive carotid imaging in 59% (20 of 34), and the absence of a cardioembolic source. The CT findings included "watershed infarction"[5] in 16 and large middle cerebral artery infarction in 6.[6] In only three patients was TIA the basis of the diagnosis. The final diagnosis of ATH was made by the principal investigator based on a best-guess clinical decision without confirmatory laboratory evidence in only nine patients.

For EMB, all patients had a CT scan, which helped support the diagnosis, and 74% had a prior history of cardiac disease. A history of atrial fibrillation was found in 40%. The first electrocardiogram was abnormal in 91% of the patients, and Holter monitoring, when performed, was abnormal in 46% (37 of 81). More than half had echocardiograms, which demonstrated a variety of overlapping abnormalities (Table 1). Of those who underwent angiography ($n=27$) or noninvasive carotid testing ($n=53$), 85% had only minimal carotid stenosis.

The prevalence of male patients and a history of hypertension, diabetes, claudication, and stroke were significantly greater in the patients with ATH than in those with EMB (Table 2). In contrast, cardiac disease, decreased consciousness upon presentation, and mean age were all greater in patients with EMB than in those with ATH. The frequencies of black and other patients were also different among the two groups. Mean hematocrit, but not other laboratory values such as blood glucose, was also greater in the ATH group. Hemispheric clinical syndromes were more prevalent in EMB than in ATH patients, whereas the converse was true for basilar syndromes (Table 2). Of the patients who were hemispheric, the distribution of large and small syndromes was not different.

The severity and distribution of the motor deficit were not significantly different between the two groups. The hemiparesis profile for the arm, however, was significantly different between the two groups (Table 3). A nonfractional weakness was more frequent in patients with EMB, whereas fractional weakness was more prevalent in those with ATH. Among the patients with fractional arm weakness, the proportion of distal or proximal predominant weakness was not significantly different in the two infarct subtypes. The significant difference between ATH and EMB patients for fractional arm weakness was limited to those patients with hemispheral syndromes (ATH 59.2% with fractional weakness versus EMB 29.7%; $p<0.001$). No difference was found for those cases with nonhemispheral syndromes where the percentage of fractional arm weakness in the ATH group decreased (ATH 29.0% versus EMB 29%; NS). Fractional weakness in the leg was not significantly different in ATH compared with EMB patients (ATH 31.0% versus EMB 21.5%; NS).

Disturbances of language were more prevalent in patients with EMB than in those with ATH (Table 3). Among those with language disturbance, Broca's aphasia was more frequent in ATH than in EMB patients (29.6% versus 12.2%; $p=0.03$), but no significant difference was found between the two groups for global aphasia (ATH 29.6% versus EMB 46.9%; NS). No differences were found between the two groups for other deficits using conservative statistical criteria.

There was a similar frequency of identifying a clinically relevant CT abnormality in the two groups (ATH 55.7% versus EMB 54.6%; NS). The total volume of cerebral infarction on the initial clinically related CT was not statistically different for EMB compared with ATH (Table 4). Infarction confined to the cortical surface was more common on the first clinically related CT in ATH compared with EMB patients.

The motor profile was compared for three different infarct volumes: 0–19 cc, 20–49 cc, and ≥50 cc. There was more fractional arm weakness for the infarctions of moderate (20–49 cc) and large size in ATH compared to EMB. No statistically significant difference between the two groups was found for the small infarcts (Figure 1). The overall proportion of cases with fractional arm

TABLE 2. Demographic Features, Stroke Risk Factors, and Clinical Syndromes for Atherosclerotic and Cardioembolic Infarction Groups

Characteristic	Infarction group: Atherosclerotic (n=113)	Infarction group: Cardioembolic (n=246)	p
Demographic features			
Male gender	64.6%	46.3%	<0.001
Race			
White	44.2%	44.3%	
Black	46.9%	52.8%	
Other	8.8%	2.8%	<0.001
Mean age	64.5±1.1	68.8±0.9	<0.001
Stroke risk factors			
Hypertension	74.5%	59.7%	0.01
Cardiac disease	30.1%	74.0%	<0.001
Diabetes	29.2%	17.1%	0.01
Previous transient ischemic attack	39.8%	13.1%	<0.001
Previous stroke	39.4%	28.8%	<0.001
Claudication	10.9%	5.0%	NS
Alcoholic beverage consumption*	7.9%	3.1%	NS
Mean parameters			
Hematocrit	42.3±0.5	39.9±0.4	<0.001
Systolic blood pressure (mm Hg)	156.2±2.8	150.5±1.9	NS
Diastolic blood pressure (mm Hg)	91.3±1.5	87.9±1.3	NS
Blood sugar*	154.6±8.0	154.2±5.0	NS
Clinical features at onset			
Decreased consciousness	14.6%	29.3%	<0.001
Deficit on awakening*	25.2%	27.2%	NS
Severe headache*	11.5%	11.6%	NS
Vomiting	8.4%	5.2%	NS
Coma	0.9%	3.8%	NS
Seizure	2.9%	3.1%	NS
Clinical syndromes			
Large hemispheral†	46.9%	57.7%	
Small hemispheral†	15.9%	21.5%	
Lacunar	8.9%	6.1%	
Basilar‡	18.6%	6.5%	
Other	9.7%	8.1%	<0.001

Probability values determined by χ^2 with $(k-1)$ df for frequencies and t test for means; *>10% of patients had missing values; percentages are based on available data.

†p<0.001 for large hemispheral and small hemispheral versus lacunar, basilar, and other syndromes.

‡p<0.001 for basilar versus nonbasilar.

weakness was greater in the ATH than in the EMB group even when the volume of infarction was controlled in this stratified analysis. To assess whether volume and subtype of cerebral infarction were both predictors of fractional arm weakness, a restricted regression model was developed. Volume of infarction (p<0.05) as well as stroke subtype (odds ratio 4.4, 95% CI 2.3–8.5) were discriminators of fractional arm weakness by logistic regression.

As expected because of Stroke Data Bank definitions, multiple logistic regression confirmed the importance of cardiac disease for the diagnosis of EMB and of TIA for ATH, but also documented the significance of other findings (Figure 2). The probability of having the diagnosis of ATH was increased by fractional arm weakness (odds ratio 3.1, CI 1.6–5.8), hypertension (odds ratio=2.8, CI 1.4–5.3), diabetes (odds ratio 2.5, CI 1.2–5.1), and male gender (odds ratio 2.2, CI 1.2–4.1). On the other hand, the probability of EMB was increased in patients with decreased consciousness at the time of onset (odds ratio 3.2, CI 1.4–7.3). In order to address whether decreased consciousness was a surrogate for infarct volume, a model limited to CT volume and decreased consciousness was done. Volume of infarction was not a significant discriminator of the diagnosis subtype.

The predicted probability of ATH over EMB was calculated from two different models. The first model, which contained TIA and cardiac disease alone, showed that only 28.2% of the actual ATH cases were in the predicted probability of ATH range of 0.5–1. When hypertension, sex, diabetes, fractional weakness, and decreased consciousness were added to the model, the frequency of correctly diagnosing ATH increased to 62.6%, whereas the correct prediction of EMB minimally changed from 96.0% in the restricted model to 90.1% in the second model. To maximize sensitivity (the probability of a diagnosis of ATH when ATH is present) in model 2, the cut point was lowered to 0.3 instead of the originally chosen 0.5. This resulted in an enhanced sensitivity of 81% with a modest reduction in specificity (probability of a diagnosis of EMB when EMB is present) to 72%.

Discussion

In the Stroke Data Bank, every effort was made to separate cerebral infarction due to large-vessel atherosclerotic disease from that due to embolism based on clinical, CT, and angiographic findings. This effort resulted in some changes in the large categories of stroke resulting from infarction. In particular, the group often labeled as atherothrombosis was divided into two subgroups: large-artery thrombosis with no evidence of embolic infarction and a form of artery-to-artery embolism arising from an atherosclerotic source. A separate category, infarct of undetermined cause, was created to help ensure the homogeneity of the Stroke Data Bank diagnostic groups.[3] A prior study showed that the interobserver agreement for the Stroke Data Bank definitions was low on initial impression but increased after the work-up was known.[7]

For the ATH patients, angiography demonstrated evidence of severe atherosclerosis without showing distal intracranial branch occlusions in 70%. Although these findings supported a nonembolic mechanism, it is possible that embolism had occurred in some, as recanalization or thrombolysis and fragmentation of an embolism can occur as early as 24 hours after occlusion.[8–10] For the patients who did not have an angiogram, 47% had a pattern of "watershed" infarction documented by CT scan. It is generally accepted that the majority of watershed infarctions are related to distal field insufficiency, particularly in the setting of internal carotid artery occlusion,[11] although a few cases have been caused

TABLE 3. Motor and Other Clinical Deficits on Initial Neurological Examination in Atherosclerotic and Cardioembolic Infarction Groups

Characteristic	Infarction group: Atherosclerotic (n=113)	Infarction group: Cardioembolic (n=246)	p
Motor deficits			
Median total weakness score	12	14	NS
Arm weakness			
None	18.6%	22.0%	
Nonfractional	31.9%	49.2%	
Fractional	49.6%	28.9%	<0.001
Other clinical deficits			
Language*	28.7%	51.8%	<0.001
Ataxia*	15.9%	7.0%	0.02
Visual field	33.6%	46.1%	0.03
Dysarthria*	58.2%	46.7%	NS
Extraocular movement	34.5%	40.7%	NS
Hemineglect*	34.5%	43.3%	NS
Sensory*	61.2%	62.6%	NS

Probability values determined by χ^2 with $(k-1)$ df for frequencies and median test for median. Fractional weakness, proximal or distal weakness (shoulder >/< hand); nonfractional weakness, equal weakness (shoulder=hand).

*>10% of patients had missing values; percentages are based on available data.

by microemboli.[12,13] Clinically, a history of TIA helped to support the diagnosis of ATH in our group. In the setting of occlusive extracranial carotid artery disease, TIAs were more prevalent in patients with hemodynamic insufficiency inferred by angiogram than in those with distal embolism.[14] The ATH subset was reasonably homogeneous given the extent of the work-up with clinically available diagnostic tools. The diagnosis was more straightforward for cardioembolic infarction.

Our analyses showed that besides stroke risk factors and the conventional diagnostic criteria outlined in the Stroke Data Bank definitions, other important clinical signs differentiated the two subtypes. The strongest discriminator for ATH was a fractional weakness of the arm. Apart from a history of cardiac disease, a decreased consciousness was more predictive of EMB. A history of hypertension, diabetes, and male gender were also discriminators of ATH and EMB. If we restricted our model to TIA and cardiac disease, the separation into the diagnostic categories was less accurate. The addition of categories of fractional weakness, decreased consciousness, hypertension, diabetes, and male gender to our model improved the discrimination between ATH and EMB.

Patients with ATH more often had fractional arm weakness than did those with EMB. Our findings were contrary to the current view that infarction in the distal field leads to proximal more than distal weakness of the upper limb. This hemiparesis profile for the arm probably reflects the location of the infarct along the upper portions of the frontoparietal convexity and the organization of the corticospinal tract. The volume of infarction by first CT was not statistically different, although differences in the size of infarction have been reported by other authors.[5,15] Of our two groups, the ATH group had more superficial infarctions than did the EMB.

Fractional arm weakness was essentially a hemispheral sign. Infarct size, as well as infarct subtype, were independent discriminators of arm weakness profile. However, the relation between volume and occurrence of fractional weakness differed in the two groups. Fractional weakness was more frequently associated with small EMB infarctions, whereas ATH patients were more likely to have a fractional arm weakness regardless of infarct size. We infer that the location and size of infarction play a role in the type of weakness. Further study of infarct location in patients with a fractional or nonfractional weakness may help explain the reasons for the differences between the two stroke subtypes.

TABLE 4. Computed Tomographic Scan Characteristics in Atherosclerotic and Cardioembolic Infarction Groups

Characteristic	Infarction group: Atherosclerotic	Infarction group: Cardioembolic
No. with clinically relevant infarct*	63 (55.7%)	129 (54.6%)
Median volume† (cc)	14	23
Infarct topography		
Superficial infarct‡	38.1%	24.8%
Superficial, deep infarct	41.3%	52.7%
Deep, small infarct	7.9%	13.2%
Deep, large infarct	12.7%	9.3%

*For patients with more than one computed tomographic scan, the first abnormal scan was used.

†p=0.09 by median test.

‡Superficial infarct with no deep component; for superficial versus nonsuperficial infarct, p=0.04 by χ^2.

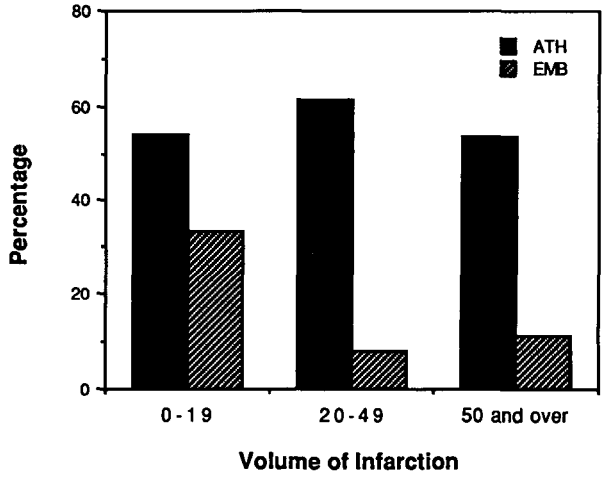

FIGURE 1. *Percentage of fractional arm weakness by volume of infarction on first computed tomographic scan for atherosclerotic and cardioembolic infarction. Fractional weakness was more frequent in patients with small infarcts in the cardioembolic infarction (EMB) group, whereas the atherosclerotic infarct (ATH) group was more likely to have fractional arm weakness regardless of infarct size. For infarct volumes, 0–19 cc,* p=*0.06; 20–49 cc,* p<*0.001; ≥50 cc,* p<*0.001 by* χ^2 *test. Overall Cochran-Mantel-Haenszel* χ^2 *for association of subtype and fractional arm weakness controlling for volume was* p<*0.001.*

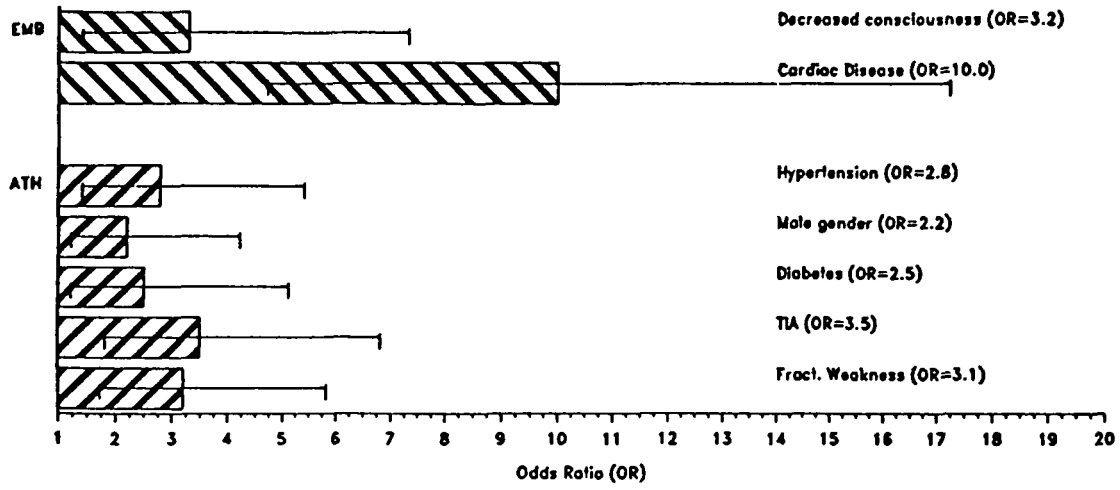

FIGURE 2. *Odds ratios and 95% confidence intervals for diagnosis of atherosclerotic or cardioembolic infarction estimated from logistic regression model.*

Decreased consciousness was also predictive of EMB. This remained true even after controlling for lesion volume and despite the lower frequency of basilar syndromes in the EMB group. Loss of consciousness has been reported to be more frequently associated with a cardioembolic stroke than with other types of infarctions.[16,17] Recent studies of patients with decreased consciousness by CT scan[18] and MRI[19] have suggested that horizontal displacement of the brain above the tentorium is closely related to impairment of alertness. Because infarcts are slightly larger and probably more inferiorly located in EMB than in ATH, the lateral shift may be greater and could account for the increased frequency of decreased consciousness.

Our results demonstrate that these two infarct subtypes can be differentiated by clinical features. The diagnosis in a hypertensive, diabetic man who presented with fractional arm weakness had an estimated 47 times the odds of being large-artery disease as embolic infarction. Of course, this model is restricted to two mechanisms of infarction and does not include the lacunar infarct subtype, which may share more risk factors and clinical features with ATH than with EMB. These results need to be expanded and corroborated using an independent data set. We need to develop a better algorithm for the early clinical differentiation of cerebral infarction subtype that will encourage randomization of homogeneous groups in hyperacute cerebral infarction trials. The improved discrimination of stroke subtype is the initial step toward the development and testing of subtype specific therapies.

Acknowledgment

The Stroke Data Bank Manual of operations, which includes the Stroke Data Bank forms, is available from the National Technical Information Service (NTIS), US Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161 (NTIS Accession No. PB88 101852/as).

References

1. Mohr JP, Caplan LR, Melski JW, Goldstein RJ, Duncan GW, Kistler JP, Pessin MS, Bleich HL: The Harvard Cooperative Stroke Registry: A prospective registry. *Neurology* 1978;28: 754–762
2. Foulkes MA, Wolf PA, Price TR, Mohr JP, Hier DB: The Stroke Data Bank: Design, methods, and baseline characteristics. *Stroke* 1988;19:547–554
3. Sacco RL, Ellenberg JA, Mohr JP, Tatemichi TK, Wolf PA, Hier DB, Price TR: Infarction of undetermined cause: The NINCDS Stroke Data Bank. *Ann Neurol* 1989;25:382–390
4. Mohr JP, Barnett HJM: Classification of ischemic stroke, in Barnett HJM, Mohr JP, Stein BM, Yatsu FM (eds): *Stroke: Pathophysiology, Diagnosis, and Management.* New York, Churchill Livingstone, 1986, pp 281–291
5. Ringelstein ER, Zeumer H, Angelou D: The pathogenesis of strokes from internal carotid artery occlusion: Diagnostic and therapeutical implications. *Stroke* 1983;14:867–875
6. Damasio H: A computed tomographic guide to the identification of cerebral vascular territories. *Arch Neurol* 1983;40:138–142
7. Gross CR, Shinar D, Mohr JP, Hier DB, Caplan LR, Price TR, Wolf PA, Kase CS, Fishman IG, Calingo S, Kunitz SC: Interobserver agreement in the diagnosis of stroke type. *Arch Neurol* 1986;43:893–898
8. Dalal PM, Shah PM, Aiyar RR: Arteriographic study of cerebral embolism. *Lancet* 1965;2:358–361
9. Irino T, Taneda M, Minami T: Angiographic manifestations in post recanalized cerebral infarction. *Neurology* 1977;17:471–475
10. Fieschi C, Argentino C, Lenzi GL, Sacchetti ML, Toni D, Bozzao L: Clinical and instrumental evaluation of patients with ischemic stroke within the first six hours. *J Neurol Sci* 1989;91:311–321
11. Bogousslavsky J, Regli F: Borderzone infarctions distal to internal carotid artery occlusion: Prognostic implications. *Ann Neurol* 1986; 20:346–350
12. Torvick A: The pathogenesis of watershed infarcts in the brain. *Stroke* 1984;15:221–223
13. Jorgensen L, Torvik A: Ischaemic cerebrovascular diseases in autopsy series: Part 2. Prevalence, location, pathogenesis and clinical course of cerebral infarcts. *J Neurol Sci* 1969;9:285–320
14. Pessin MS, Hinton RC, Davis KR, Duncan GW, Mohr JP: Mechanisms of acute carotid stroke. *Ann Neurol* 1979;6:245–252
15. Yamaguchi T, Minematsu K, Choki J, Ikeda M: Clinical and neuroradiological analysis of thrombotic and embolic cerebral infarction. *Jpn Circ J* 1984;48:50–58
16. Ramirez-Lassepas M, Cipolle RJ, Bjork RJ, Kowitz J, Snyder BD, Weber JC, Stein SD: Can embolic stroke be diagnosed on the basis of neurologic clinical criteria? *Arch Neurol* 1987;44:87–89
17. Kittner SJ, Sharkness CM, Price TR, Plotnick GD, Dambrosia JM, Wolf PA, Mohr JP, Hier DB, Kase CS, Tuhrim S: Infarcts with a cardiac source of embolism in the NINCDS Stroke Data Bank: Historical features. *Neurology* 1990;40:281–284
18. Ropper AH: Lateral displacement of the brain and level of consciousness in patients with an acute hemispheral mass. *N Engl J Med* 1986;314:953–958
19. Ropper AH: A preliminary MRI study of the geometry of brain displacement and level of consciousness with acute intracranial masses. *Neurology* 1989;39:622–627