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Contrast-enhanced MR of cerebral arteritis: intravascular enhancement related to flow stasis within areas of focal arterial ectasia.

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Contrast-Enhanced MR of Cerebral Arteritis: Intravascular Enhancement Related to Flow Stasis within Areas of Focal Arterial Ectasia

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Summary: The authors present a case of probable amphetamine-induced cerebral arteritis in a 31-year-old man with AIDS, testicular carcinoma, and recurrent pneumocystis pneumonia. MR enhancement was demonstrated in areas of focal arterial ectasia, presumably due to slow flow. CT, MR, and angiographic findings were strikingly confirmed postmortem. Angiography remains essential in the diagnosis of cerebral arteritis.

Index terms: Arteritis, cerebral; Vasculitis; Magnetic resonance, contrast enhancement; Cerebral angiography, indications; Acquired immunodeficiency syndrome (AIDS)

Rapidly flowing blood in normally patent arteries produces little or no signal when imaged with contrast-enhanced magnetic resonance (MR) imaging. Time-of-flight and spin-dephasing effects create a "flow void," which overcomes potential visualization of Gd-DTPA-induced T1 shortening in blood. Elster and Moody (1) and others (2, 3) have demonstrated that arteries related to an infarction can be visualized with contrast-enhanced MR. This "intravascular enhancement sign" is largely the product of slow flow within partly occluded or collateral vessels near the infarct. Slow flow negates time of flight effects and allows factors that add to signal strength to predominate.

Arteritis with ectatic change is another pathophysiologic condition that may result in slow or even static blood flow within the cerebral vasculature. We have demonstrated intravascular contrast enhancement of slow flow within ectatic vasculitic intracerebral vessels, later confirmed angiographically and pathologically. Arterial enhancement may resemble other nonvascular processes. Angiography should be considered to resolve questionable cases.

Case Report

The patient was a 31-year-old, white, homosexual man with AIDS, first demonstrated to be HIV positive at the time of orchiectomy in July of 1988. He had a prior history of hepatitis B infection, testicular carcinoma, and *Pneumocystis carinii* pneumonia. In the interval from August 1989 to August 1990, he injected methamphetamine intravenously four times and used oral amphetamines intermittently.

The patient presented to our medical service in May of 1990 with acute onset of headaches, dizziness, and anomia. MR images of the brain obtained at that time revealed a tiny focal area of prolonged T2 within the left posterior temporal lobe white matter, lateral to the atrium of the lateral ventricle. A lumbar puncture was remarkable only for elevated protein (79 mg/dL). Chronic azidothymidine (AZT) therapy was discontinued, and his headaches improved. Follow-up MR, performed in September of 1990 demonstrated that the small high signal focus noted on the prior study was smaller and less hyperintense. Spinal fluid examination was unchanged.

Following resumption of AZT therapy in November of 1990, the patient had a transient (2-day) episode of right facial weakness, aphasia, and confusion with routine tasks. Bitemporal headache returned. Neurologic examination revealed slow response time, with occasional pauses to search for phrases or words, but the patient was otherwise unchanged from September. Electroencephalogram showed focal slowing over the left temporal region and decreased right occipital driving on photic stimulation. Contrast-enhanced computed tomography (CT) revealed multiple punctate foci of enhancement at the periphery of the cerebral hemispheres (Fig. 1). A repeat MR study was
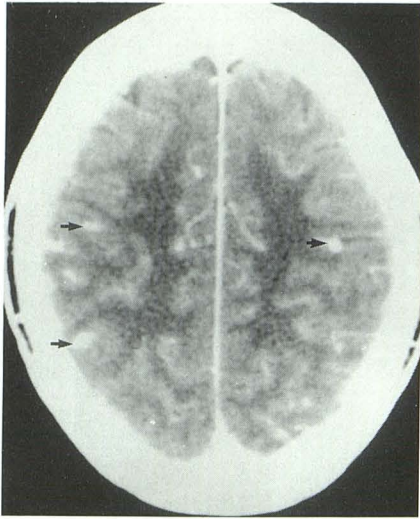
Fig. 1. Contrast-enhanced CT scan in a 31-year-old HIV positive patient with a history of amphetamine abuse. High cut through centrium semiovale white matter showing multifocal peripheral areas of nodular enhancement within convexity cortical sulci (*arrows*).

performed. T1-weighted post Gd-DTPA images (Fig. 2B) demonstrated multiple, small, scattered foci of enhancement distributed in a superficial pattern at the periphery of the brain. A few of these lesions were also visible on proton-density images (Fig. 2C), where the areas appeared hyperintense to brain and cerebrospinal fluid. Two new parenchymal lesions demonstrating prolonged T2 relaxation were identified in the left parietooccipital white matter (one visible in Fig. 2C). These parenchymal lesions were distinct from the surface abnormalities and most likely represented new areas of cortical infarction.

One month later, an MR-guided stereotaxic biopsy of the left parietooccipital lesion and overlying dura revealed focal necrosis with intense macrophage infiltration and microglial clusters suggestive of viral infection. However, no inclusion bodies were found. Axial T2-weighted MR images obtained at the time of biopsy demonstrated considerable improvement in the appearance of the left posterior parietooccipital lesion, but the remaining scattered peripheral foci of hyperintensity were unchanged. Neurologic examination revealed no new findings, but slowed cognition persisted.

The patient presented 1 month later with a 1-day history of left-sided (face/arm/leg) hemiparesis. Neurologic examination also revealed diminished sensation to pin prick involving only the left hand, left-sided hyperreflexia, and a left Babinski reflex. CT revealed a right basal ganglionic hemorrhage. MR also revealed the hemorrhage (Fig. 3), and showed that the previously described parenchymal lesions had decreased in both size and signal intensity. Repeat cerebrospinal fluid studies again showed only moderate elevation of protein and all cultures were again negative.

A cerebral angiogram was performed (Figs. 4 and 5). All major cerebral vessels (left carotid, right carotid, and left vertebral) were affected by extensive alternating regions of medium and small vessel aneurysmal dilatation and stenosis. Stagnant contrast was obvious in areas of arterial ectasia. These "aneurysms" corresponded to the nodular areas of enhancement seen at the brain surface on prior enhanced MR studies. A magnified anteroposterior sequence of the right basal ganglia demonstrated an irregularly beaded appearance of the lateral lenticulostriate vessels. Additionally, markedly decreased flow was noted within the posterior temporal branch of the left posterior cerebral artery. External carotid injections were normal. An 8-week trial of oral prednisone was initiated for the treatment of cerebral vasculitis.

The patient presented in February of 1991, 10 days after initiation of steroid therapy, with acute onset of ataxia followed by right hemiparesis and dysarthria. MR images revealed a new 1.5-cm diameter focus of T2 prolongation in the left posterior basal ganglia with extension into the posterior limb of the internal capsule. Residual (smaller) areas of surface enhancement, thought to reflect scattered areas of arterial ectasia, were again identified over the superficial regions of the brain. A CT scan revealed multiple cerebral infarctions.

By the end of February, the patient had clinically improved enough to permit transfer to a rehabilitation institute. While there, a new seizure disorder preceded a further decline in his overall medical condition. The patient suffered a recurrence of *P. carinii* pneumonia and died shortly thereafter.

At autopsy, multifocal, firm sausage-like distensions 1–2 cm in length were randomly distributed within leptomeningeal branches of the anterior, middle, and posterior cerebral arteries (Fig. 6).

Multifocal small recently organizing infarcts present in the cerebral hemispheres only partially correlated to the anatomic positions of arterial ectasias. The largest of these were slit-like cavities in both putamina and in the left posterior internal capsule. Small laminar infarcts were also seen in the left anterior insula and left mid-temporal gyrus. Brain stem and cerebellum were not involved. Microscopic examination revealed thick-walled hyalinized arteries. Intraluminal thrombi were adherent to the thickened and fibrotic intima in many areas of aneurysmal arterial dilatation. The histologic changes were compatible with a drug-induced arteritis, although a primary HIV vasculitis could not be ruled out.

Discussion

This report documents a case of cerebral vasculitis, documented by cerebral angiography and pathologic examination, in which contrast-enhanced MR images demonstrated intravascular enhancement in regions later confirmed by angiography to contain arterial ectasias and other vasculitic changes.

We were able to demonstrate areas of arteritic arterial dilatation with contrast-enhanced MR
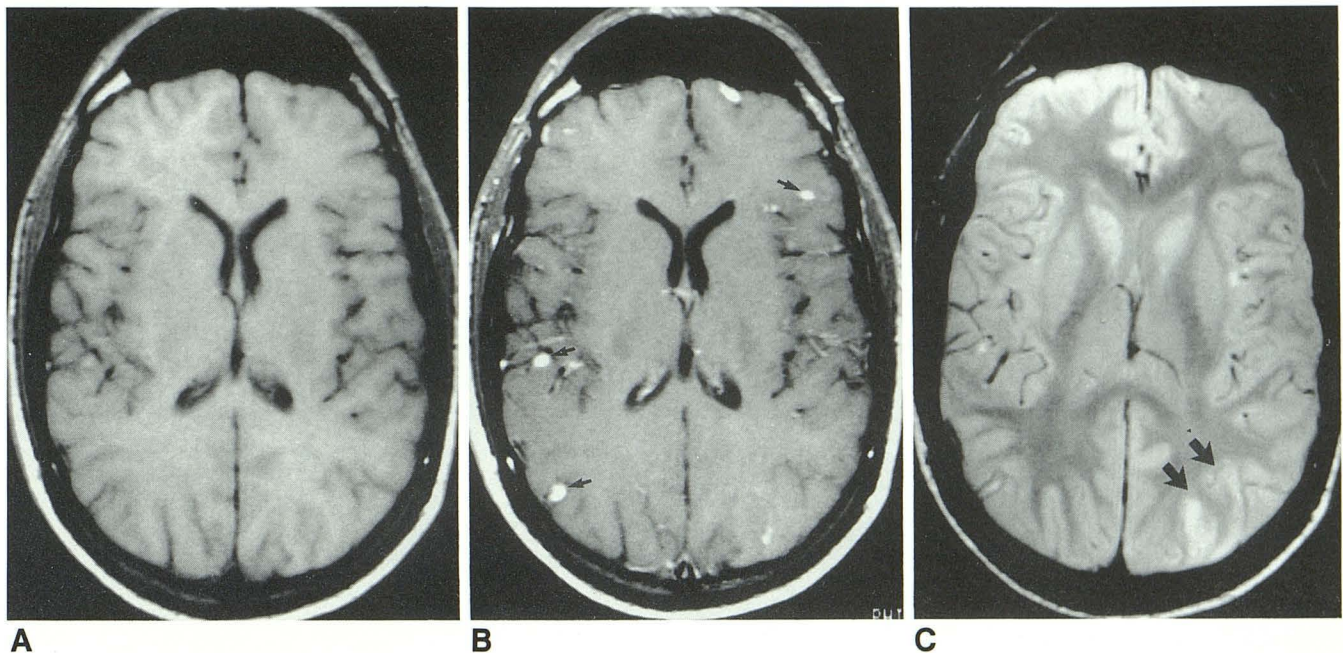
A   B   C

Fig. 2. Enhancement of slow flow in areas of arterial ectasia. MR images obtained shortly after CT presented as Figure 1 (transverse axial scans).

A and B, Pre- and post-Gd-DTPA infusion images (spinecho 600/20/2) demonstrate focal nodular enhancement in many sulcal sites (arrows) corresponding to areas of arterial ectasia later revealed by angiography.

C, Axial section at level identical to that shown as A and B above (spinecho 2200/20/1). Note hyperintense cortical infarct in left parietooccipital cortex (arrows) and several sulcal/cortical lesions.
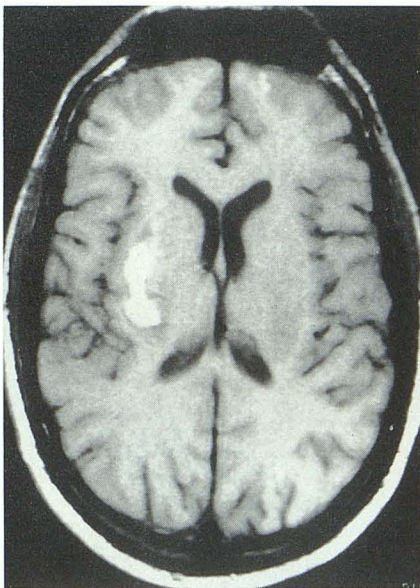

Fig. 3. Follow-up MR after acute development of left hemiparesis. Axial scan (spinecho 500/20/2) at the level of the basal ganglia shows focal intracerebral hematoma. Note subacute hemorrhage pattern of clot.

(Figs. 4 and 5). Visualization was made possible due to the stasis of blood within the areas of ectasia, pathologically confirmed by postmortem

gross examination (Fig. 6). Enhancement of blood was observed within these regions because, when flow is slower and less turbulent, factors that act positively on signal strength such as gadolinium and flow-related enhancement may predominate over the negative time-of-flight and odd echo-dephasing effects which otherwise would diminish signal strength (1). Rapidly flowing blood in normal arteries produces little or no MR signal (flow void). The signal strength of arterial blood is a reflection of multiple independent factors, including velocity of flow, turbulence (4), diastolic pseudogating, flow-related enhancement (5), spin-dephasing (6), and the effects of the extrinsically administered paramagnetic agents (7). Paramagnetic contrast agents add to intravascular signal strength by shortening the T1 of blood by proton-electron dipole-dipole proton relaxation enhancement (8). The "flow void" normally seen within patent, healthy arteries is observed because spin-dephasing and high velocity time-of-flight effects dominate, even when the T1 of blood is shortened by paramagnetic contrast administration (1). However, slowing of arterial flow allows visualization of the contrast-induced T1

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5 A
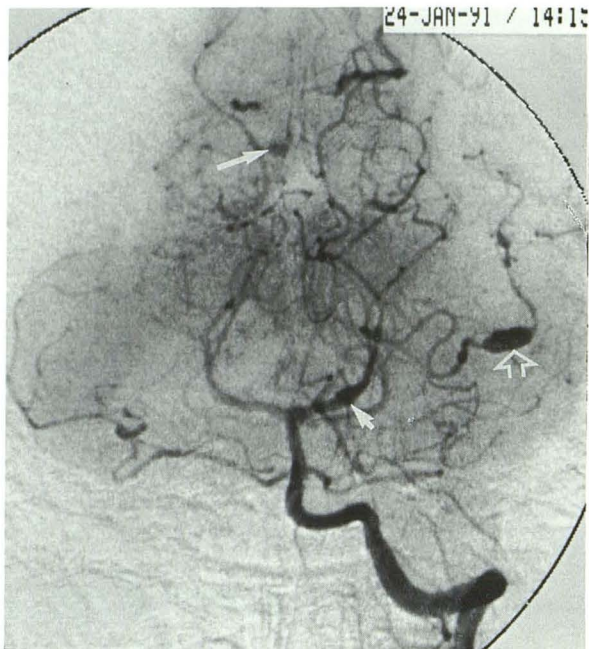
Fig. 4. Left vertebral intraarterial digital subtraction angiogram (anteroposterior Townes view). Note sausage-like dilatation of multiple large arteries, including the proximal left posterior cerebral artery (*short arrow*), the posterior temporal branch of the left posterior cerebral artery (*open arrow*), and the calcarine branch of the right posterior cerebral artery (*long arrow*).

Fig. 5. Right internal carotid artery injection (lateral view): midarterial (*A*) and late venous (*B*) images. Note stasis of contrast in several areas of arterial ectasia, including branches of the middle and anterior cerebral arteries (*white arrows*). Both images show prolonged stasis of contrast in multiple areas (*arrows*) conforming to foci of nodular sulcal enhancement seen on enhanced MR (Fig. 2B). Note exact correspondence between the most (middle cerebral artery) branch ectasia (*double curved arrows*) and the autopsy specimen (*double arrows* and Fig. 6).
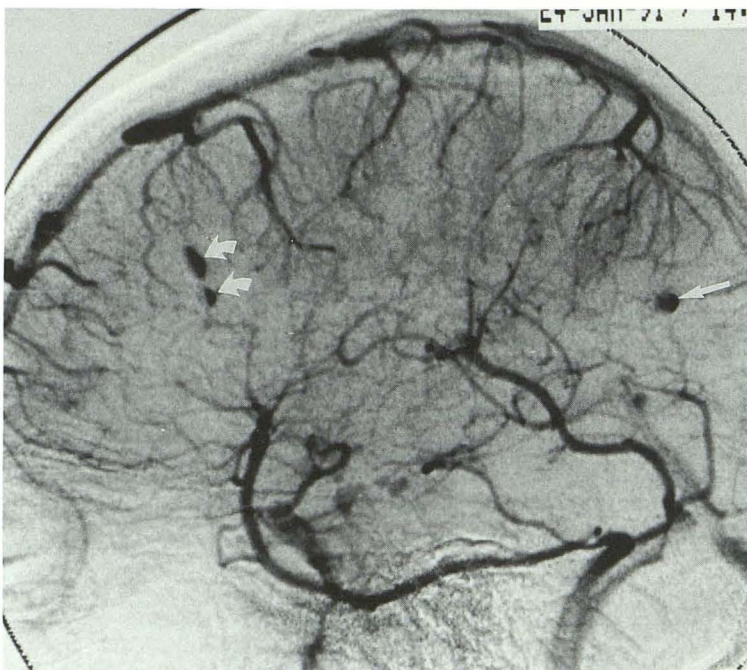
5 B

shortening of unclotted blood, by diminishing time-of-flight–induced hypointensity.

Arterial enhancement due to slow blood flow has been demonstrated with conventional MR in stroke patients without cerebral vasculitis. Elster and Moody and others (1–3) have demonstrated the "intravascular enhancement sign" in acute cerebral infarction. This phenomenon tends to occur early during the first week postinfarction

when diminished regional cerebral blood flow (9), arteriolar-capillary block, and maximal focal vasodilatation (10) produce sluggish flow in vessels near the infarct. We have observed similar arterial enhancement in cases of proximal arterial occlusion with slow retrograde collateral flow toward the more distal arterial territory. Slow flow in areas of arteritic ectasia can now be added as another cause of arterial enhancement.
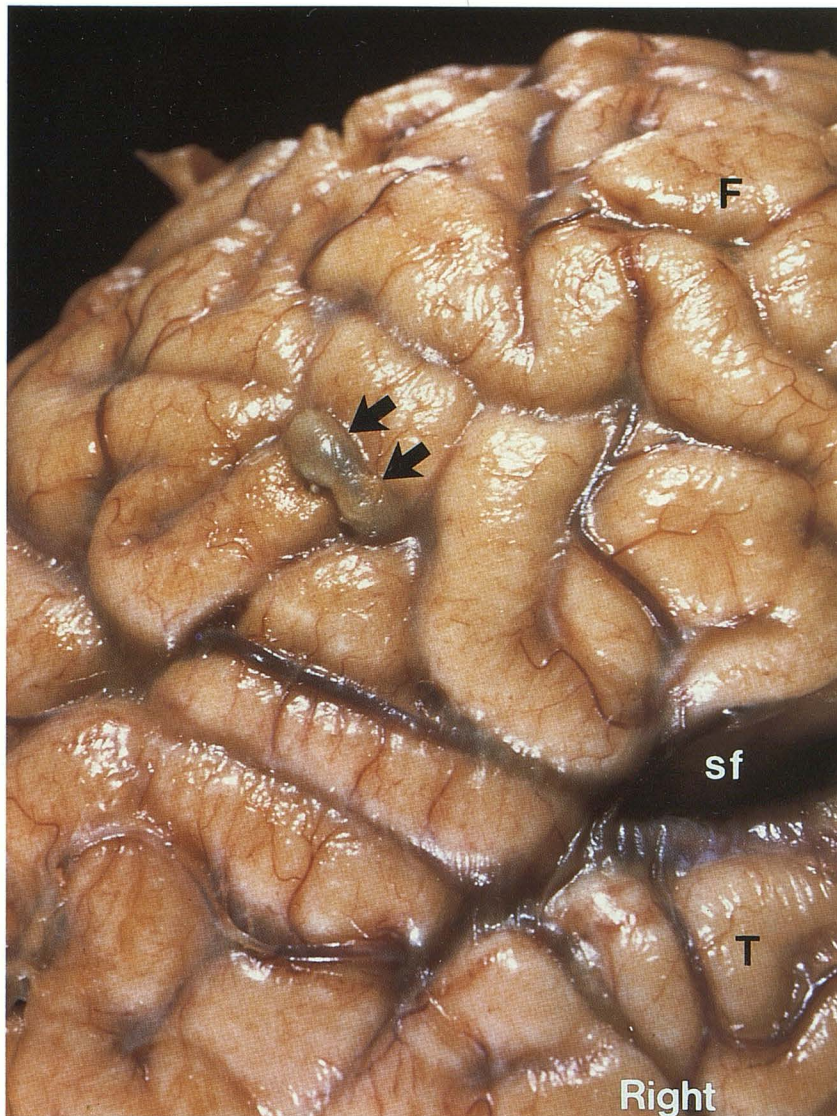
Fig. 6. Gross pathologic specimen of the right hemispheric brain surface from autopsy (F = frontal lobe, T = temporal lobe, SF = sylvian fissure). Note arterial ectasia corresponding to MR contrast enhancement of the same area of arterial ectasia shown by double curved arrows in Figure 5.

Arteritis of the cerebral vasculature has many etiologies. Angiographic features have been well described (11). A structured classification system (12) permits orderly consideration of possible causes. Concerning our patient, the specific etiology is uncertain.

Cerebral vasculitis not associated with overt leptomeningitis or identifiable infectious agents has been observed as a cause of stroke in patients with AIDS (13). Eosinophilic vasculitis, necrotizing vasculitis, and cerebral granulomatous angiitis are forms of cerebral vasculitis reported to occur in HIV-infected patients (14–16). A perivasculitis associated with AIDS encephalopathy has also been reported in children (17). Agents other than HIV may cause cerebral vasculitis and infarction in patients with AIDS. Herpes zoster ophthalmicus can produce cerebral infarction secondary to zos-

ter-associated arteritis (18). Syphilis may cause vasculitis of small vessels (Nissl-Alzheimer arteritis) and of larger vessels (Heubner arteritis) (19). Cytomegalovirus, Mycobacterium tuberculosis, and Toxoplasma gondii are known for their ability to produce central nervous system vasculitis and infarction (20–22).

Cerebral vasculitis associated with both oral and intravenous amphetamine abuse has been documented angiographically (23–26) and may cause intracerebral hemorrhage (27). Cerebral vasculitis may result from a direct toxic effect of amphetamine on the endothelium or may reflect hypersensitivity to an impurity in the diluent (28, 29). Damage to the intima may initiate platelet aggregation and subsequent vasculitis (30). Resulting necrotizing angiitis, histologically similar to periarteritis nodosa, has been demonstrated in

patients who frequently used methamphetamine (31). In these patients, Citron (31) found a variety of vascular changes, including arterial aneurysms and sacculations, findings similar to the changes seen in our patient.

We have shown that the recognition of intravascular enhancement of slow flow within vasculitic intracerebral vessels may serve as a clue to the diagnosis of cerebral arteritis. Unfortunately, such MR findings may closely resemble other processes, such as nodular leptomeningeal or peripheral cortical metastatic disease. Therefore, patients with arteritis may be subjected to potentially dangerous stereotaxic biopsy procedures, unless the diagnosis of vasculitis is considered beforehand, and angiography performed. Close attention to the location of the enhancement (sulcal, not parenchymal) may suggest a vascular etiology, even without suggestive clinical signs. In the future MR angiography with sequences sensitive to slow flow may permit reliable noninvasive angiographic confirmation of the vascular nature of such enhancement. Until that time, angiography remains an essential diagnostic step.

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