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CT infusion scanning for the detection of cerebral aneurysms

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✓ Computerized tomography (CT) infusion scanning can confirm the presence or absence of an aneurysm as a cause of spontaneous intracerebral hemorrhage. Eight patients who presented with spontaneous hemorrhage were examined using this technique. In five patients the CT scan showed an aneurysm which was later confirmed by angiography or surgery; angiography confirmed the absence of an aneurysm in the remaining three patients. This method is an easy effective way to detect whether an aneurysm is the cause of spontaneous intracerebral hemorrhage.

KEY WORDS • **aneurysm** • **intracerebral hemorrhage** • **cerebral angiography** • **subarachnoid hemorrhage** • **computerized tomography**

COMPUTERIZED tomography (CT) scanning has become the diagnostic procedure of choice in the detection of spontaneous intracerebral hemorrhage (ICH), replacing cerebral angiography in that role.[6,8,11] It is very accurate in assessing the size, location, and characteristics of various types of ICH, as well as in evaluating their effects on neighboring cerebral structures. While CT is superior to angiography in many respects, the unenhanced CT scan does not demonstrate aneurysms or arteriovenous malformations (AVM's) that sometimes cause intracerebral hemorrhage. Some investigators[4,6] have concluded that the etiology of ICH can be predicted with a high degree of accuracy, based on its location and characteristics on CT scan, but enough doubt exists in a number of cases to warrant further investigation.

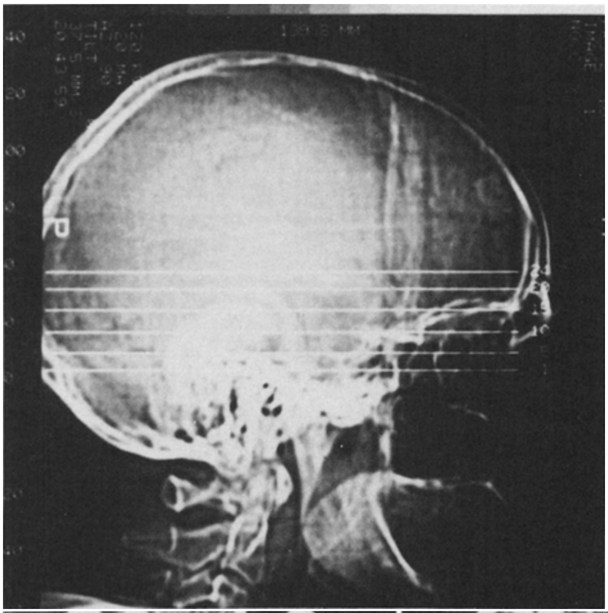
A prospective study was performed using CT scanning combined with the continuous infusion of contrast material in an attempt to rapidly identify cerebral aneurysm or AVM in cases of ICH. We term with technique "CT infusion scanning." High-resolution scanning in the detection of aneurysms has been described previously by others.[1] This technique, which takes only 10 to 15 minutes to perform, is especially useful in patients with spontaneous ICH who present with rapidly declining neurological function and require emergency surgical evacuation. If the etiology of the hemorrhage is not revealed by location and characteristics, CT infusion scanning can confirm the presence or absence of an aneurysm with a high degree of accuracy and in a short period of time, without the need to proceed to cerebral angiography. It has allowed us to proceed to surgery in cases of ICH with reasonable certainty that the hemorrhage was not caused by aneurysm. In several patients who were rapidly deteriorating from ICH caused by an aneurysm, CT infusion scanning has confirmed the presence and the location of the aneurysm and allowed evacuation of the hematoma and clipping of the aneurysm without waiting additional time for cerebral angiography.

Clinical Material and Methods

Computerized tomography infusion studies were prospectively performed in eight patients presenting with spontaneous ICH of uncertain etiology. In five patients these studies showed aneurysms which were later confirmed by angiography or at surgery. Three patients whose studies did not show aneurysms had ICH. Subsequent angiography confirmed the absence of an aneurysm.

The CT infusion scans were performed on a GE 9800 scanner, according to the following protocol. During scanning, the patients were given a constant intravenous infusion of 80 to 100 ml of sodium diatrizoate (Hypaque 60). Scans were obtained in the dynamic mode, to allow rapid scanning of a level from the floor of the sella turcica to a point just above the anterior communicating artery. This required 15 to 25 1.5-mm slices during the infusion (Fig. 1). Images were photographed at intermediate windows (Level 80 window, 400 Hounsfield units) to allow the distinction between blood and enhanced vessels. All the aneurysms detected were confirmed by angiography and/or direct vision at surgery. The patients who had ICH without aneurysms being detected by CT infusion scans all had subsequent angiograms that showed no aneurysm present.

The sensitivity of the method had previously been confirmed by examining a group of 39 patients with suspected aneurysm rupture using CT infusion scanning prior to angiography. Forty-five aneurysms were subsequently found on angiography. Twenty-nine were 5 mm in size or greater, of which 28 (97%) were detected by CT infusion scanning (Table 1). Nine (69%) of the 13 aneurysms greater than 2 mm but less than 5 mm were visualized by CT infusion scanning prior to angiography, and none of the three aneurysms of 2 mm



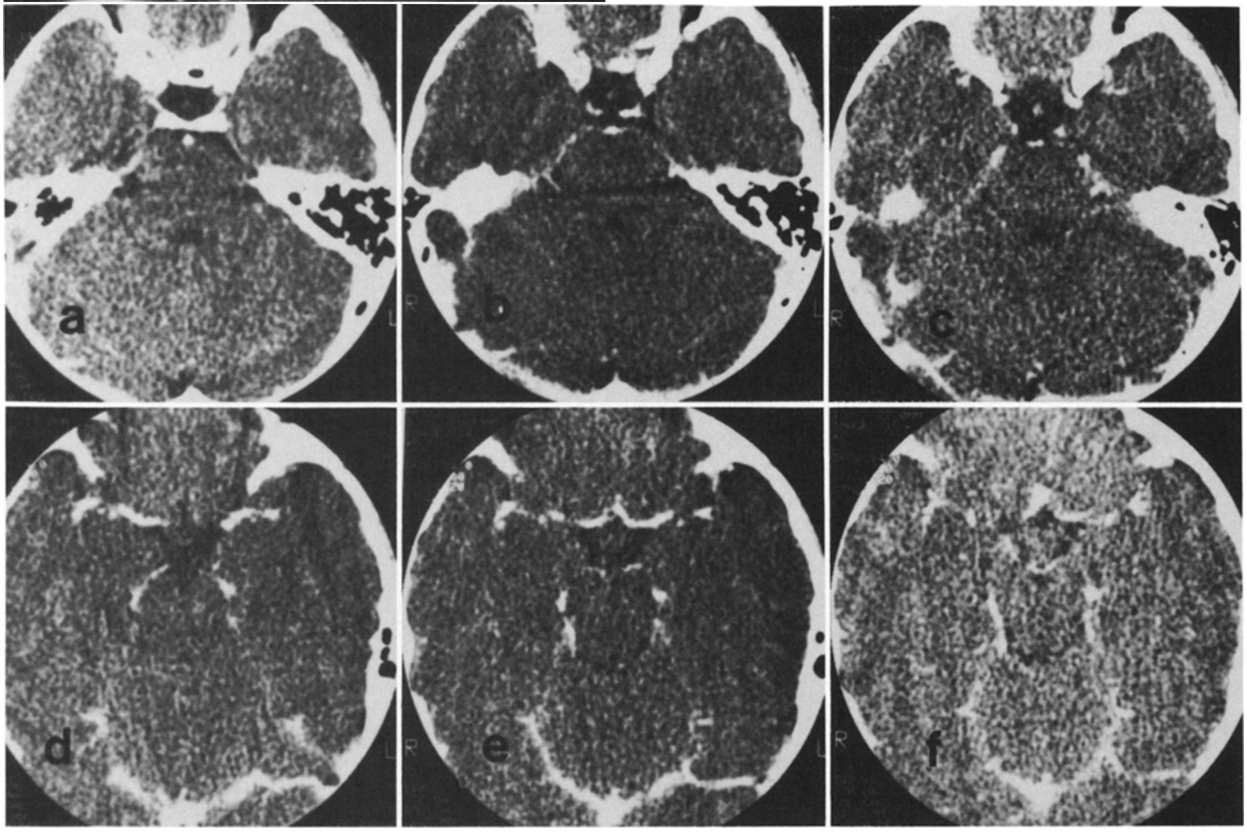


FIG. 1. Computerized tomography infusion scanning in a patient without an aneurysm. *Upper:* Scout film showing the region of scanning encompassing the circle of Willis. *Lower:* Scans progressing from the base of the skull upward. a: Scan showing the region just below the posterior clinoid process with the basilar artery in the prepontine cistern filled with contrast medium. b: The basilar bifurcation and the carotid arteries in the anterior part of the cistern are shown. c: The carotid arteries are followed further toward the carotid termination. d and e: The middle cerebral arteries are delineated on both sides. e and f: The anterior cerebral arteries and anterior communicating artery region are visualized.

or less were identified. Three areas considered suspicious for aneurysm were evaluated subsequently by angiography and shown to represent normal vessels, yielding a false-positive rate of 8.1%.

Selected Case Reports

Case 1

This 46-year-old woman collapsed at home without warning and was taken to a local hospital, where she was found to be awake but aphasic with mild hemiparesis. A CT scan showed a large left frontotemporal intracerebral hemorrhage without associated subarachnoid blood. She was transferred to Harborview Medical Center (HMC) where a CT infusion scan was performed. Two aneurysms were identified, one at the carotid artery termination and one in the carotid artery at the take-off of the posterior communicating artery. These were confirmed by angiography, and craniotomy was performed the following day. Both aneurysms were clipped and the ICH was removed.

The patient was discharged from the hospital 2 weeks after admission in good condition, with a resolving mild dysphasia. Figure 2 shows CT scans of the left ICH (Fig. 2 *upper*) and infusion scans showing a left carotid termination as well as a left posterior communicating artery aneurysm (Fig. 2 *center*). Preoperative angiography confirmed these aneurysms (Fig. 2 *lower*).

Case 2

This 34-year-old man was found at home by a friend, obtunded, barely arousable, and mute. On admission to HMC he had a blood pressure of 184/104 mm Hg, no verbal response, and a localizing response to painful stimulation; he also demonstrated left hemiparesis. His pupils were equal and reactive. A CT scan showed a large right frontal ICH with shift of the third ventricle, but no associated subarachnoid hemorrhage (Fig. 3a). A CT infusion scan (Fig. 3b and c) showed that the inferior aspect of the hemorrhage was separated from the main trunk of the middle cerebral artery bifurcation by approximately 6 to 9 mm. This was not apparent on the initial noncontrast CT scan. A craniotomy was performed for evacuation of the intracerebral hemorrhage, and the patient progressed to make an excellent recovery. A postoperative angiogram showed no evidence of cerebral aneurysm (Fig. 3d)

TABLE 1

Sizes of aneurysms detected by angiography and high-resolution computerized tomography (CT)

Size (mm)	No. Visualized By Angiogram	No. Visualized By CT
0–2	3	0 (0%)
3–5	13	9 (69.2%)
6–9	23	22 (95.6%)
≥ 10	6	6 (100%)

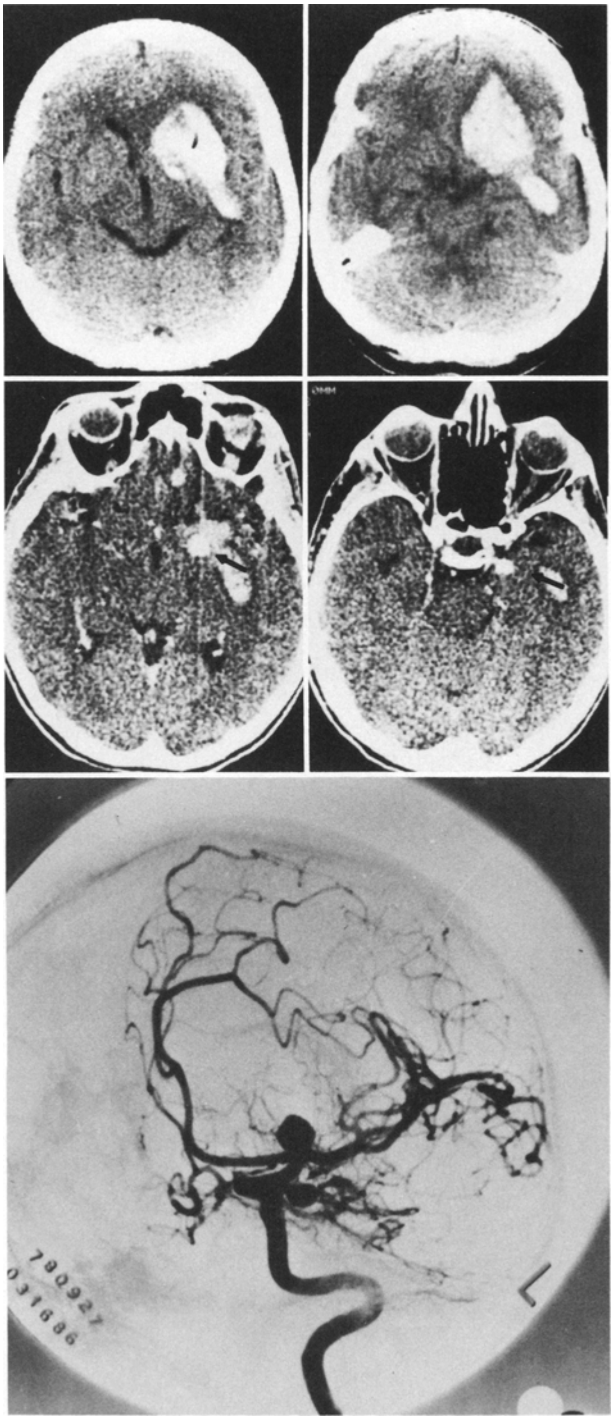
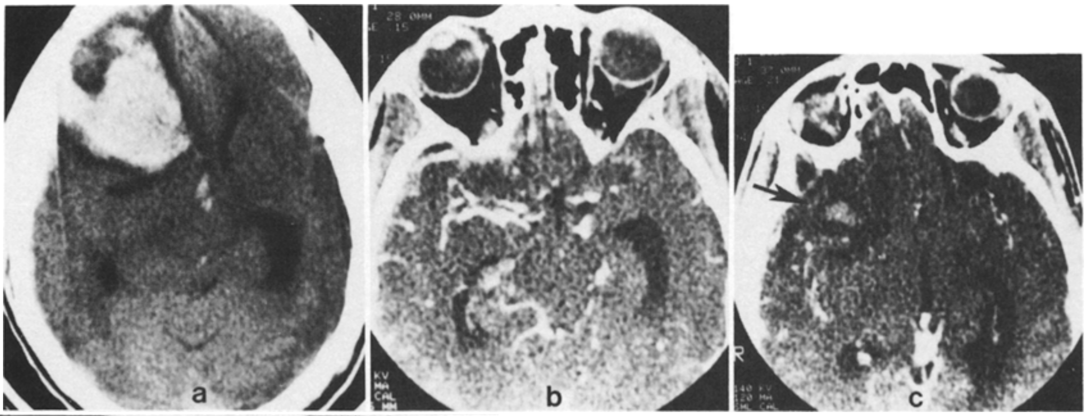


FIG. 2. Case 1. *Upper:* Computerized tomography scans showing intracerebral hemorrhage. *Center:* Computerized tomography infusion scans revealing a terminal carotid artery aneurysm responsible for the hemorrhage and a posterior communicating artery aneurysm *(arrows)*. *Lower:* Preoperative angiogram confirming the above findings.



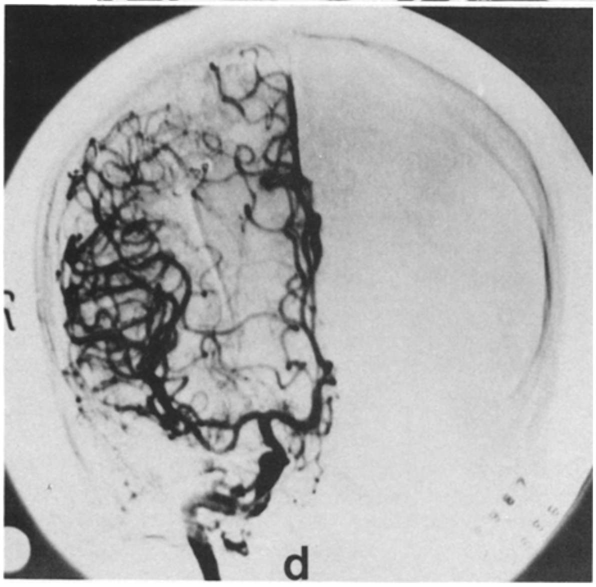


FIG. 3. Case 2. a: Computerized tomography scan showing a right frontal intracerebral hemorrhage. b and c: Computerized tomography infusion scan showing a normal middle cerebral artery with no aneurysm and the inferior aspect of the hemorrhage beginning above the vessel *(arrow)*. d: Postoperative angiogram confirming the absence of an aneurysm.

Results

Of the eight patients studied, five showed evidence of an aneurysm on CT infusion scanning. These aneurysms were confirmed either by angiography or by direct visualization at surgery. Three patients examined by this technique did not show an aneurysm as the cause of the ICH, and angiography subsequently confirmed the absence of any aneurysms.

Discussion

This study reports a method to rapidly determine whether or not an ICH has been caused by a ruptured aneurysm. The need to perform cerebral angiography to establish the etiology of spontaneous ICH has been an issue since CT came into use as the primary diagnostic study. Angiography is most useful if the spontaneous ICH is caused by an aneurysm or AVM. Other causes, such as tumor or hypertensive vasculopathy, may or may not be revealed by angiography. Primary ICH presumed to be due to hypertensive vasculopathy does not usually need to be further defined by angiography if it can be identified as such by CT. In a review of spontaneous intracerebral hematomas, Tsementzis[10] assembled eight clinical series (1670 cases) and six pathological series (2235 cases). In both series, the most common etiology of spontaneous ICH was hypertension, followed by aneurysm and AVM.

Several studies have tried to define the role of arteriography in patients with spontaneous ICH detected by CT.[4,5,9] Hayward and O'Reilly[4] stated that the diagnosis of either aneurysm or primary ICH could be made in 90% of cases based on the CT appearance alone. In 100 cases reviewed, external capsule hemorrhages were due to hypertensive ICH in 12 patients and to aneurysms in two patients. With temporal lobe hemorrhages, aneurysms were the primary cause in 19 patients and hypertensive ICH occurred in three patients. In contrast, postmortem studies performed at the same hospital on 103 patients by Crompton[3] led to slightly different conclusions. In fatal ICH caused by aneurysm, 13 were external capsular hemorrhages and 12 were temporal lobe hemorrhages. Toffol, *et al.*,[9] reviewed 102 patients with spontaneous ICH and found that the location as established by CT and the presence or absence of hypertension were helpful in determining etiology. Lobar hemorrhage in nonhypertensive patients was much more likely to be caused by an aneurysm or AVM than in hypertensive patients. A series of 309 consecutive patients with ICH due to aneurysm rupture reviewed by Pasqualin, *et al.*,[7] included 13 with hemorrhage in the basal ganglia. It can sometimes be difficult using CT alone to determine the origin of hemorrhages in the basal ganglia, temporal lobe, or frontal regions, especially large ones, and thereby to exclude the presence of a ruptured aneurysm.

With some spontaneous hemorrhages, if they are in a characteristic location and if a history of hypertension exists, it is not necessary to perform angiography to exclude an aneurysm or AVM; however, hemorrhages that appear to be hypertensive in origin may extend down toward the sylvian fissure, and sufficient question may exist about their etiology for cerebral angiography to be required. We have not found the presence or absence of subarachnoid hemorrhage to be reliable in determining etiology.

The CT infusion scan is a relatively easy study to perform, requires only 10 to 15 minutes, and costs less than cerebral angiography. Many patients with ICH present acutely and may suffer a rapid decline in neurological function. If surgery is indicated but the etiology is uncertain, angiography requiring additional time is often necessary. Removing an ICH and deferring the clipping of an aneurysm, if it is the cause of hemorrhage, can subject patients to a high risk of mortality.[12] We have favored rapid evacuation of large aneurysm-induced hemorrhages that cause increasing neurological deficit, and recommend clipping of the aneurysm at the same operation. A recent report by Brandt, *et al.*,[2] advocates a similar approach in younger patients with ruptured middle cerebral artery aneurysms who are moribund due to mass effect from an ICH. Computerized tomography infusion scanning has been able to detect aneurysms in this setting and allowed us to proceed directly to surgery knowing the location of the aneurysm without a delay for angiography.

These preliminary results suggest that CT infusion scanning can be useful in detecting cerebral aneurysm in cases of ICH of uncertain etiology, and can aid in future management decisions.

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