Cerebral Blood Flow Imaging with Technetium-99m-HMPAO SPECT in a Patient with Chronic Subdural Hematoma: Relationship with Neuropsychological Test

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We report the relationship between cerebral blood flow (CBF) and neuropsychologic tests in a patient with a chronic subdural hematoma suffering from severe dementia and left hemiparesis. Regional CBF was quantified using ^{99m}Tc-HMPAO SPECT and ^{133}Xe-CBF. CBF-SPECT could detect the hematoma which was isodense by CT scan and the neuropsychological test improved remarkably with the increase in CBF after surgery. We conclude that if there is a strong clinical suspicion of subdural hematoma and CT scan is not diagnostic then CBF-SPECT may be valuable in localizing the hematoma and monitoring the effect of operation.

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A slowly progressive intracranial mass in chronic subdural hematoma (CSH) can cause a reversible neurologic dysfunction due to mechanical compression and displacement of structures within the brain (*1*). CBF studies with ^{133}Xe-enhanced CT (*2*) and ^{133}Xe-inhalation methods (*3*) show a more pronounced CBF reduction in patients with CSH afflicted by hemiparesis and/or mental disturbance than in those suffering from headaches only. However, brain SPECT imaging with ^{99m}Tc-hexamethylpropylene amine oxime (HMPAO) in CSH has not been reported before. We report the relation of quantitative CBF-SPECT, using ^{99m}Tc-HMPAO and ^{133}Xe-CBF, with neuropsychologic tests in a patient with chronic subdural hematoma suffering from severe dementia and left hemiparesis.

CASE REPORT

A 78-yr-old male patient complained of morning headaches 1 mo prior to admission. He experienced an unsteady gait and left arm weakness. His past medical history was uneventful, except for some occasional excessive alcohol intake. One week later, his family noticed changes in his personality and recent memory loss. Examination on admission revealed severe demented states with left hemiparesis. According to Hasegawa's dementia scale (*4*), his score was 5.5/32.5 (Table 1); information, orientation, concentration, calculation, reasoning, judgment and memory were all impaired. His right grip power was 30 kg and his left was 7 kg. Babinski's sign was negative, and no sensory deficits were noted. Deep tendon reflexes in both limbs were normoactive. There was no dysarthria. His blood pressure was 140/52 mm Hg. An electroencephalogram (EEG) revealed severe generalized slowing in both hemispheres.

A CT scan performed on the day of admission revealed an isodense right frontoparietal subdural hematoma that was compressing the right lateral ventricle (Fig. 1). The cerebellum was intact.

To calculate absolute rCBF values in ^{99m}Tc-HMPAO SPECT, we measured average flow with a ^{133}Xe technique prior to SPECT imaging. The clearance curve of ^{133}Xe was recorded over a period of 10 min from 32 detectors and from a separate detector that monitor the radioactivity of expired air. rCBF was calculated based on the initial slope index (ISI) (*5*). Image acquisition for

TABLE 1
Neurologic Score Based on Hasegawa's Dementia Scale Before and After Surgery

Questions (full score)	Before	After
1. What is the date today? (3)	0	3
2. Where are you? (2.5)	0	2.5
3. What is your age? (2)	0	2
4. How long have you been here? (2.5)	0	2.5
5. Where were you born? (2)	2	2
6. When did World War II end? (3.5)	3.5	3.5
7. How many days are there in a year? (2.5)	0	2.5
8. Who is the Prime Minister? (3)	0	3
9. Subtract 7 from 100, then 7 from 93 (4)	0	2
10. Name these numbers in reverse order: 6-8-2, 3-5-2-9 (4)	0	0
11. (A) Do you remember or (B) Name all five objects that were presented to you earlier (3.5)	0	0.5
Total score (32.5)	5.5	23.5

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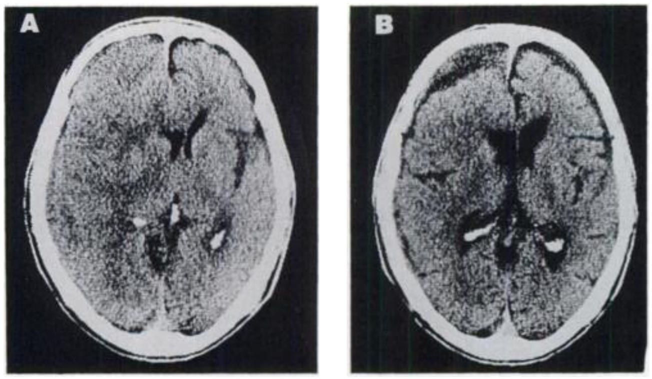

FIGURE 1. (A) CT scan performed on the day of admission. Shift of the midline from right to left and distortion of the lateral ventricles were observed. Without contrast enhancement, the location of the hematoma could not have been identified. (B) CT scan performed 6 days after surgery. There was no midline shift, but some subdural effusion was detected in the right frontoparietal region.

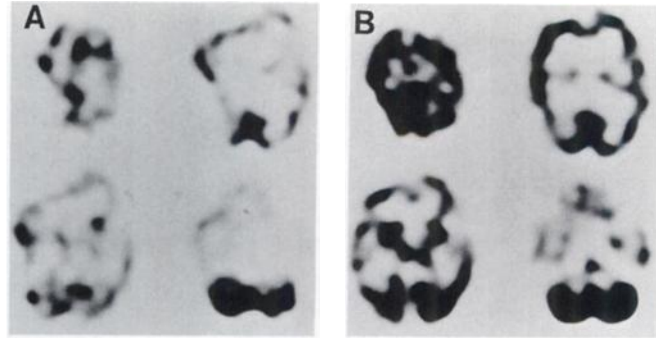

FIGURE 2. (A) CBF-SPECT images before the operation. The crescentic avascular areas in the right frontoparietal and temporoparietal regions can be observed. CBF reduction was most prominent in the area adjacent to the hematoma, but generalized CBF reduction was observed in both hemispheres and in the subcortical regions. All images are displayed in a gray scale from 0 ml/min/100 g to 40 ml/min/100 g. (B) CBF-SPECT images after the operation. CBF values in both hemispheres had returned to an almost normal level, but a partial flow defect was observed in the right parietal region.

^{99m}Tc-HMPAO was started 10 min after tracer injection of 740 MBq with a single-head rotating gamma camera with a low-energy, high-resolution parallel-hole collimator (Toshiba GCA 90A). Sixty-four views, 30-sec frames collected over 360°, were recorded into a 128 × 128 matrix format. Transaxial sections at 27-mm intervals were used for reconstructing 1.08-cm thick computed images in planes parallel to the orbitomeatal line (OML). For CBF quantification of SPECT, radioactivities relative to a reference region were calculated by dividing SPECT images by the average counts/pixel in the right cerebellar hemisphere (OML ±2 cm), and were converted to rCBF (ml/min/100 g) by multiplying the ISI value (ml/min/100 g) of the cerebellum measured with ^{133}Xe (*6*). Regions of interest of 6 × 6 pixels (19.8 × 19.8 mm) were used to obtain rCBF. The volume of each sample was 4.23 cm^3. Several frontal, temporal, parietal, and occipital cortices and thalamo-basal ganglia samples were obtained from three or four continuous slices for each of these brain regions. These were averaged to calculate the mean CBF per voxel corresponding to each brain region studied.

CBF-SPECT demonstrated crescentic areas with hematomas in the right frontoparietal and temporoparietal regions. CBF decreased in the cortical and subcortical regions of both hemispheres (Fig. 2). The hemispheric CBF values were 22.8 ml/min/100 g for the right side and 27.2 ml/min/100 g for the left side (Fig. 3).

On the next day, the patient underwent a right parietal craniectomy to remove the hematoma. One week after the operation, his headache and left hemiparesis had completely disappeared; his mental status had improved, except for calculation, reasoning, judgment and recent memory; his score according to Hasegawa's scale was 23.5/32.5 (Table 1). A follow-up CT scan performed 6 days after the operation showed that the middle structures had returned to the sagittal plane, but some subdural effusion was detected in the frontoparietal region (Fig. 1). Low perfusion on ^{99m}Tc-HMPAO SPECT was also normalized in both hemispheres, except for the right parietal region (Fig. 2). Regional CBF also increased to an almost normal level in all regions except for the right parietal region (Fig. 3). Hemispheric CBF for the right side was 37.8 ml/min/100 g and 38.4 ml/min/100 g for the left side.

DISCUSSION

CSH contains an encapsulated admixture of blood and fluid from the adjacent tissues and cavities. Regarding the density of the hematoma in relation to the adjacent brain tissue, the degree of extravasated blood is important because the x-ray absorption of CSH varies depending on the protein moiety of the hemoglobin (*7*). The density of the hematoma spontaneously decreases with time and typically passes through an isodense stage 2–4 wk after a head injury (*8*). CT scan showed that our patient had an isodense hematoma, and the diagnosis was made based on the midline shift and the distortion of ventricles (*9*). Technetium-99m-HMPAO SPECT may be superior to CT in detecting a hematoma when it is in an isodense stage because SPECT permits a clear localization of crescent isodense hematoma which is visualized as areas of flow deficit.

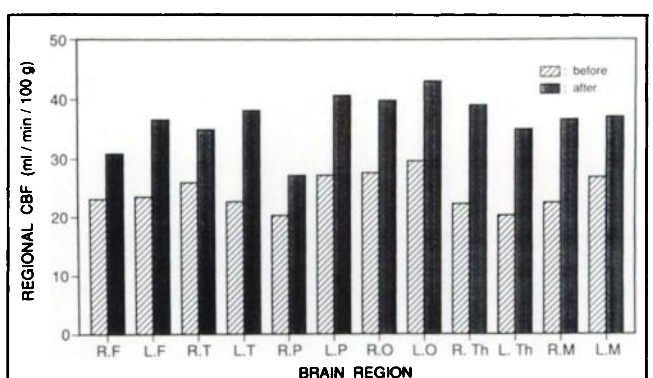

FIGURE 3. Regional CBF values before and after surgery. R = right, L = left, F = frontal, T = temporal, P = parietal, O = occipital, Th = thalamo-basal ganglia, and M = mean hemisphere.

Clinically, our patient showed signs of dementia and left hemiparesis. Generalized CBF reduction was observed in the cerebral cortex and the subcortical regions. We believe that in this case, rCBF reduction in the parietal region on the right side was the main cause of contralateral hemiparesis because rCBF reduction was most profound in this region and no asymmetry in rCBF was found in other pyramidal systems. A possible explanation for mental disturbance is the rCBF reduction in the frontal and temporal regions, because the rCBF in these regions decreased to values a little higher than the rCBF value in the parietal region, and neurologic signs improved dramatically with the rCBF rise after the operation. These data suggest that in CSH the mechanisms for neurologic deficit seem to include cerebral ischemia, although it is not clear whether the CBF reduction is due to the pressure of the hematoma or the gross distortion of the vessels (*10*). Based on the ^{133}Xe inhalation ISI, Ikeda et al. (*3*) found that preoperative rCBF ranged from 32.3 ml/min/100 g to 40.1 ml/min/100 g in the hemisphere with hematoma and that in the rolandic region of patients with hemiparesis, rCBF had the lowest subnormal value, 32.3 ml/min/100 g in ISI. They considered that the critical value of ISI at which neurologic deficit starts to appear is 30 ml/min/100 g. In our patient, the preoperative rCBF values in the parietal region, thalamus and right hemisphere were 20.2 ml/min/100 g, 22.3 ml/min/100 g, and 22.8 ml/min/100 g, respectively. These values are very close to the ischemic threshold at which spontaneous EEG activity is affected; neurologic deficit begins to appear in conscious monkeys when the rCBF drops below 23 ml/min/100 g and hemiplegia is complete below 10 ml/min/100 g (*11*). Regarding the CBF value, our results are in accordance with those of Tanaka et al. (*2*) who reported that CBF measured by xenon-enhanced computed tomography in the affected hemisphere ranged from 10.5 ml/min/100 g to 21.2 ml/min/100 g in patients with hemiparesis and/or mental disorders.

Xenon-133 CBF and ^{99m}Tc-HMPAO SPECT have advantages and disadvantages. Poor resolution is the disadvantageous feature of the ^{133}Xe-CBF method, but it can quantify CBF in absolute units and is easily reproducible. Technetium-99m-HMPAO SPECT, in contrast, can produce high-resolution images, but measurement of absolute CBF value is difficult. By using these methods in conjunction, a simple and quantitative measurement of CBF can obtained.

We conclude that generalized CBF reduction appears to be a characteristic of severe CSH and that CBF-SPECT may be helpful in localizing hematoma when the CT scan is not diagnostic.

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EDITORIAL

The Current Role of SPECT in Imaging Subdural Hematoma

The article by Isaka et al. (*1*) in this month's issue of the *Journal* is a good demonstration of our newly-acquired capability to correlate anatomy and physiology in the evaluation of central nervous system diseases. Using CBF-SPECT, the authors demonstrated generalized, bihemispheric, diminished cerebral blood flow in a patient with a right-sided subdural hematoma (SDH), left hemiparesis and cognitive impairment. The CBF decrease was most profound in the hemisphere ipsilateral to the subdural hematoma. After surgical evacuation of the hematoma, the hemiparesis resolved and cognition improved, with significant CBF improvement in all regions except the right parietal region. From these findings, the authors conclude that part of the neurologic deficit in patients who have sustained subdural hematomas is due to generalized cerebral ischemia, and not simply due to the mass effect of the extra-axial fluid collection.

Hopefully studies such as this will lead to a better understanding of the

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