IV. 3 Regional Cerebral Blood Volume in Normal Subjects and Patients with Dementia using 11-C Carbon Monoxide Inhalation Methods and Positron Emission Tomography

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The measurement of cerebral blood volume was performed using positron emission tomography (ECAT II) and 11-C carbon monoxide ($^{11}$CO) in normal young adults and aged subjects and in patients with Alzheimer's disease and with vascular dementias. Cerebral blood volume is one of the fundamental factors to control cerebral circulation which might change during aging process and in pathological conditions. This preliminary study showed decreased volume of cerebral vasculature in aged subjects. Moreover, Alzheimer's disease could be differentiated from normal aged and vascular demented patients by decreased cerebral blood volume.

Subjects and Methods

8 mCi per minute of $^{11}$CO gas supplied from cyclotron to patients. Inhaled $^{11}$CO binds to hemoglobin of red blood cells. Radioactivity of $^{11}$CO-RBC was monitored and inhalation of $^{11}$CO was discontinued when it reached enough counts per scanned planes for imaging. Approximately 3 to 4 minutes were allowed for equilibration in the body blood pool.

ECAT II machine was used for measurement of tissue distribution of $^{11}$CO. After the equilibration, scanning were performed at 30 mm, 50 mm and 70 mm above orbito-meatal line in each subject. All images were obtained using medium resolution Shadow shield and medium resolution for head mood. Data acquisition time was 300 seconds to 900 seconds to collect 0.3 to 0.6 million coincident events per plane.

3 ml of venous blood was taken during scanning for the quantitation of rCBV. Radioactivity of whole blood was measured using cross calibrated well counter.

Regional CBV can be calculated according to the following equation,

$$rCBV = C_i(T)/C_b(T)0.85 \text{ d}$$
where \( C_t(T) \) is the regional tissue concentration of \(^{11}\text{C-O-RBC} \) measured at time \( T \) with ECAT II, and \( C_b(T) \) is the venous blood concentration of \(^{11}\text{C-O-RBC} \) measured at time \( T \). The term 0.85 corrects for different hematocrit between in cerebral tissue and in peripheral veins. The \( d \) relates tissue density of brain matter. These procedures were developed and described by Phelps et al.\(^1\)

Five young adults, age ranged from 23 to 36 (mean=31), were all healthy volunteers. Conventional X-ray computed tomography of these subjects showed normal and unatrophied brain. Four aged subjects with no neurological abnormality and no mental deterioration, ages ranged from 70 to 74 (mean=72), had atrophied brain on X-ray CT. Four demented subjects, two patients with Alzheimer's disease and others are with multi-infarct dementias. All these subjects had routine ECAT examination for measurement of rCBV.

Results and Discussion

Figure 1 showed tomographic images of cerebral vasculature obtained from ECAT examination in normal subjects. Images at the OM + 0 and +30 mm illustrated jugular bulb, sigmoid sinuses and transverse sinuses most prominently. Images at the OM + 40, 50 and 60 mm demonstrated large cerebral vessels, veins of Galen, inferior sagittal sinus and straight sinus. Large vessels in the Sylvian fissures were also appeared. Images at the OM + 70 mm showed superior sagital sinus and cortical blood beds.

Figure 2 showed CBV images for young adult, aged and demented (multi-infarct dementia) subject at the OM + 50 mm.

Table 1 showed mean values of cerebral blood volume for critical gray matter. Mean cerebral blood volume of aged subjects was 30 % lower than that of young adults. However, it is difficult to determine which parts of blood vessels, artery, capillary or venous, reduced prominently. Obtained values of CBV using this methods might include whole blood beds.

In patients with Alzheimer's disease, CBV was lower than that of normal aged subjects. This indicated that not only degenerative changes of brain matter but circulatory disturbance might occur in Alzheimer's disease.

In patients with vascular dementia, CBV was equal to or slightly increased than that of normal aged subjects. This results indicated that increased blood volume compensated low blood flow (observed in oxygen-15 inhalation study).

Regional cerebral blood volume is one of the important factors to maintain cerebral circulation. This factor had interesting characteristics in demented subjects, higher in vascular dementias and lower in Alzheimer's disease than normal aged subjects. In the combined study with 15-oxygen inhalation methods for cerebral blood flow and oxygen metabolism, and \(^{18}\text{FDG} \) methods for glucose metabolism, pahtophysiology of demented brain should be studied.
References


Table 1. Cerebral blood volume of normal and demented patients

<table>
<thead>
<tr>
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<th>young normal</th>
<th>aged normal</th>
<th>Alzheimer's disease</th>
<th>vascular dementia</th>
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<tr>
<td>mean CBV (%)</td>
<td>4.6±0.4 n=5</td>
<td>3.7±0.6 n=4</td>
<td>2.8±0.1 n=2</td>
<td>3.8±0.2 n=2</td>
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Fig. 1. ECAT images of cerebral blood volume