

Electron Probe X-Ray Microanalysis of So-Called Calcifications of the Globus Pallidus Observed on CT Scan

Teruo SHIRABE, Takeshi YASUDA* and Kenji MORIMOTO*

*Department of Pathology (Neuropathology),
*Division of Neurology, Department of Medicine,
Kawasaki Medical School, Kurashiki 701-01, Japan
Accepted for Publication on July 29, 1982*

ABSTRACT. The elements of so-called calcifications of the globus pallidus observed on CT scan were analyzed by electron probe x-ray microanalysis in an autopsy case. These so-called calcifications contained iron, phosphorus, calcium and a small amount of zinc as inorganic materials. Together with morphological findings, these so-called calcifications were considered not to be true calcifications, but to be the same substance with so-called pseudocalcium usually observed in the globus pallidus of the aged person.

Intracranial calcifications can be observed in various pathological conditions such as vascular anomalies, hematomas, tumors, infections, phacomatoses, intoxications, irradiation, anoxia and hypoparathyroidism¹⁾. Other than these etiologically distinct calcifications, unexpected high density lesions may be found incidentally in the globus pallidus on routine computed tomography (CT) scan examinations^{2,3)}. These high density lesions, which are said to be seen mostly in elderly persons over 50 years, are also called customarily calcification and regarded physiological^{4,5)}. The incidence of these lesions has been estimated about 0.3 to 1.0% of all CT scan examination²⁻⁵⁾. This is a report of an analysis of the elements of these high density lesions of the globus pallidus in an autopsy case by electron probe x-ray microanalysis.

MATERIALS AND METHODS

The patient was a 83-year-old man (A. 13237) who had myocardial infarction eighteen years and cerebral infarction four years previously. The CT scan made one month before death disclosed high density lesions in bilateral globus pallidus, other than conspicuous cerebral atrophy (Fig. 1). The difference of Hounsfield units between these high density lesions and their surrounding cerebral parenchyma ranged from 21 to 25. There was no history of encephalitis, intoxications, irradiation, anoxia and hypoparathyroidism. At autopsy (A.81-150), the brain weighed 1,010 g. Arteries at the base of the brain showed marked atherosclerosis. Multiple small infarctions were observed in the left internal capsule, left putamen, left hippocampus and pons.

調 輝男, 安田 雄, 守本研二

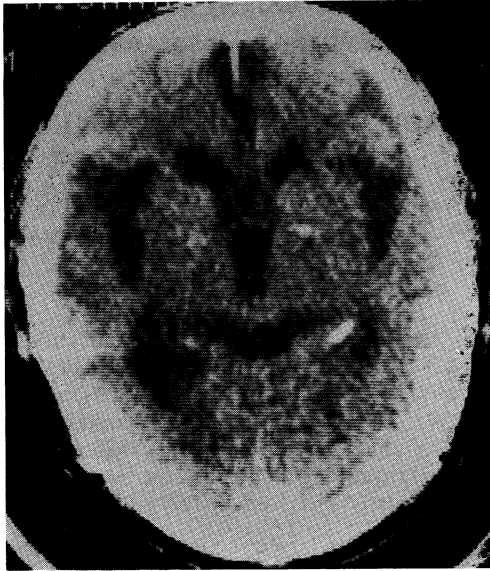


Fig. 1. CT scan made one month before death showing high density lesions in bilateral globus pallidus, other than conspicuous cerebral atrophy.

After routine histological examinations of the brain, the small specimens from the globus pallidus were embedded in epoxy resin. Unstained thin sections were observed electron microscopically. Elements of the same fields were analyzed using a computerized energy dispersive x-ray microanalysis system of EDAX 711 attached to a Hitachi HSE-2 scanning electron microscope^{6,7}. An accelerating voltage of 25 kV was used with a specimen current of 2.0×10^{-10} A. Spectra were recorded for 200 seconds. Energy peaks obtained were identified by comparison with a conventional peak identification chart.

RESULTS

Light microscopic examinations of the globus pallidus revealed numerous small granules of 4 to 16 microns in diameter, which were scattered in the stroma or deposited in the media of small arterial walls (Fig. 2). Some were gathered pericapillary. These granules were homogeneous or concentric, and deeply basophilic in color. Occasionally they had a tendency to fuse with each other and form roughly granular masses of 30 to 40 microns in diameter. Sometimes those deposited in the arterial walls were rod-shaped with pale purple color.

Electron microscopically, these granules were composed of homogeneous or concentric accumulations of electron dense amorphous substances (Fig. 3).

By electron probe x-ray microanalysis, the spectrum of these granules showed x-ray peaks of phosphorus, calcium, iron and zinc, in addition to



Fig. 2. Photomicrograph of globus pallidus showing numerous small granules scattered in the stroma or deposited in the arterial walls. HE, $\times 126$.

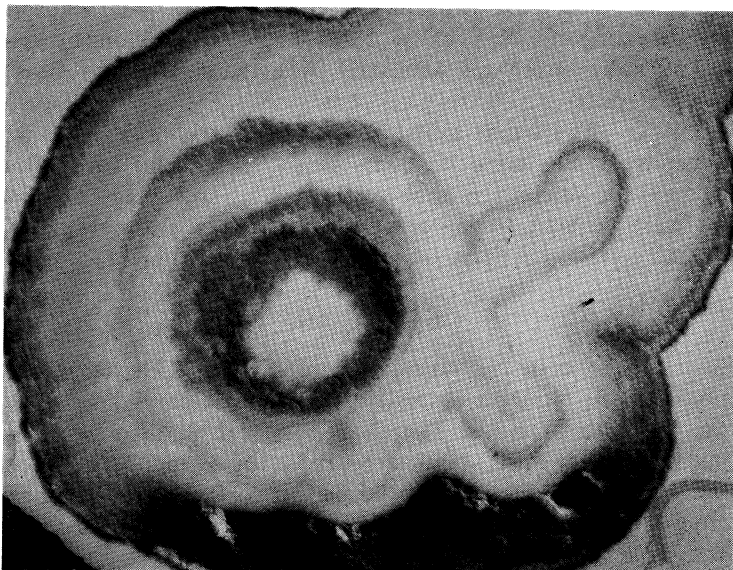


Fig. 3. Electron micrograph of a granule in the globus pallidus. It is composed of concentric accumulations of electron dense amorphous substances. $\times 4,700$.

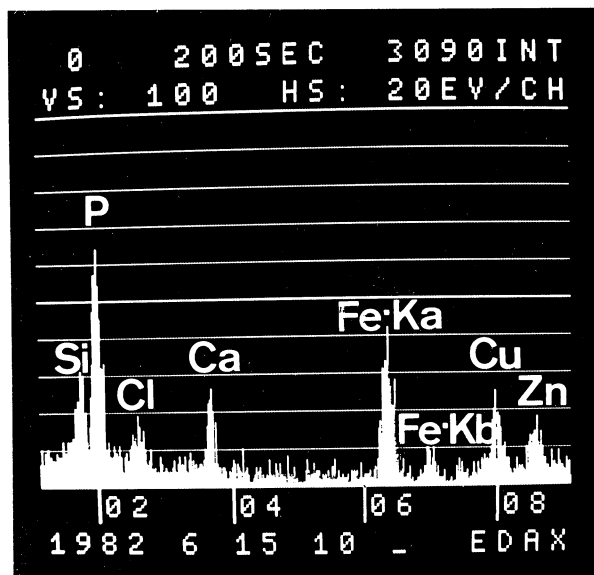


Fig. 4. The spectrum of the granules showing x-ray peaks of phosphorus, calcium, iron and zinc, in addition to concomitant peaks of silicon, chlorine and copper.

concomitant peaks of silicon, chlorine and copper (Fig. 4). Phosphorus was identified by detecting the K peak at 2.013 keV, and calcium by detecting the K peak at 3.69 keV. Iron was identified by detecting the $K\alpha$ peak at 6.398 keV and the $K\beta$ peak at 7.057 keV. Zinc was identified by detecting the K peak at 8.63 keV. The count rate of iron and phosphorus peaks were two to three times greater than that of calcium peak. The count rate of zinc peak was least. Peaks of silicon, chlorine and copper were detected equally in the controls and were thought to represent elements in the embedding materials, grids and metal-containing parts of the analyzing instrument.

DISCUSSION

Histologically, so-called calcifications observed on CT scan were recognized as accumulations of numerous small granules scattered in the stroma or deposited in the arterial walls. These histological findings of the so-called calcifications were practically identical to those of pseudocalcium occasionally found in the globus pallidus of the aged person⁸⁾. Pseudocalcium has been said to be composed of a kind of protein or acid mucopolysaccharides, quite different from true calcifications⁹⁾.

Recently electron probe x-ray microanalysis has become to be useful for identifying specific chemical elements in biological samples, correlating with electron microscopic findings. We used this technique to analyze the elements

of these granules. The spectrum of these granules showed x-ray peaks of phosphorus, calcium, iron and zinc. These results coincided with a previous report of x-ray microanalysis of pseudocalcium of the arterial walls in the globus pallidus¹⁰⁾. The count rate of iron and phosphorus peaks were two to three times greater than that of calcium peak. The count rate of zinc peak was least. The elements of granules scattered in the stroma were equal to those of granules deposited in the arterial walls. From these results and review of the literature, the granules were thought to be composed mainly of calcium phosphate and a kind of protein or acid mucopolysaccharides containing iron and zinc, which exist physiologically in the globus pallidus.

It is assumed that initially iron concentrates in a kind of protein or acid mucopolysaccharides in the globus pallidus of the elderly due to the specific metabolism process of this place, in other words, mineralization occurs, then calcium phosphate accumulates there. At the same time, trace elements of the brain such as zinc may also combine. Probably it depends on the amount of calcium phosphate or especially calcium itself whether the granules could be detected on CT scan or not, as Tomonaga et al.¹¹⁾ are stating. The amount of iron may not participate in hyperdensity so much, considering that hemosiderosis after hemorrhage is seldom recognized as a high density lesion.

REFERENCES

- 1) Löwenthal, A. and Bruyn, G.W. : Calcification of the striopallidodentate system. *In* Handbook of clinical neurology, vol. 6, diseases of the basal ganglia, ed. by Vinken, P.J. and Bruyn, G.W. Amsterdam, North-Holland Publishing Company, 1968, pp. 703-725
- 2) Murphy, M.J. : Clinical correlations of CT scan-detected calcifications of the basal ganglia. *Ann. Neurol.* 6 : 507-511, 1979
- 3) Aii, H., Kameyama, M., Nakano, Y. and Handa, J. : Calcification of basal ganglia on computed tomography. *Brain Nerve (Tokyo)* 32 : 971-979, 1980 (in Japanese)
- 4) Koller, W. C., Cochran, J.W. and Klawans, H.L. : Calcification of the basal ganglia. Computerized tomography and clinical correlation. *Neurology* 29 : 328-333, 1979
- 5) Cohen, C.R., Duchesneau, P.M. and Weinstein, M.A. : Calcification of the basal ganglia as visualized by computed tomography. *Radiology* 134 : 97-99, 1980
- 6) Shirabe, T. and Hirano, A. : X-ray microanalytical studies of lead-implanted rat brains. *Acta Neuropathol.* 40 : 186-192, 1977
- 7) Shirabe, T., Eto, K. and Takeuchi, T. : Identification of mercury in the brains of Minamata disease victims by electron microscopic x-ray microanalysis. *Neurotoxicology* 1 : 349-356, 1979
- 8) Takeya, S. : Histochemical researches of the brain. *Brain Nerve (Tokyo)* 2 : 84-91, 1950 (in Japanese)
- 9) Muentner, M.D. and Whisnant, J.P. : Basal ganglia calcification, hypoparathyroidism, and extrapyramidal motor manifestations. *Neurology* 18 : 1075-1083, 1968
- 10) Shirabe, T. and Okamoto, S. : X-ray microanalysis of the autopsied brains by energy dispersive x-ray microanalyzer. *Adv. Neurol. Sci. (Tokyo)* 21 : 578-579, 1977 (in Japanese)
- 11) Tomonaga, M., Honda, E., Yamauchi, Y., Tohgi, H., Yamanouchi, H. and Izumiyama, N. : Pathological studies of the basal ganglia calcification observed on CT scan. *Prog. Comput. Tomogr. (Tokyo)* 3 : 301-305, 1981 (in Japanese)