Arch Psychiatr Nervenkr (1983) 233 : 271–278

**Archiv für Psychiatrie und Nervenkrankheiten**
Archives of Psychiatry and Neurological Sciences


# Computerized Tomographies of 34 Patients at the Chronic Stage of Acute Carbon Monoxide Poisoning

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**Summary.** The brains of 34 patients at the chronic stage of acute carbon monoxide poisoning (CO poisoning) were examined using computerized tomography (CT). Ventricular and sulcal dilatations were measured quantitatively, with picture analysis of CT for the measurement of ventricular dilatation. Significant ventricular and sulcal dilatations were found in all cases of the CO group compared with age-matched controls, and bilateral low density areas in the globus pallidus were seen in 9 of the patients. There were significant correlations between duration of initial unconsciousness and the ventricular dilatation or cortical atrophy. Such dilatations were considered to be due to the cerebral damage in the acute stage.

**Key words:** CO poisoning – CT study – Picture analysis – Partial correlation – Pallidal necrosis

## Introduction

Bilateral necroses in the globus pallidus and demyelination of the white matter are known to be the main changes in acute carbon monoxide (CO) poisoning (Fujii 1960). Using pneumoencephalography (PEG), Yasukochi and Yasuoka (1967) reported that the degree of ventricular dilatation showed a positive relation with neurological symptoms. However, PEG does not show pallidal necrosis.

With the development of computerized tomography (CT), it has become possible to observe low density areas in the globus pallidus and the degree of ventricular or sulcal dilatation simultaneously. Recently several studies have been reported using CT in CO poisoning (Ikeda et al. 1978; Kim et al. 1980; Sawada et al. 1980), but almost all were concerned with the acute stage. Moreover, no quantitative measurement of ventricular or sulcal dilatation was made.

In the present study, 34 patients who suffered from CO poisoning following a coal mining explosion on November 9 1963 were given a CT examination. The

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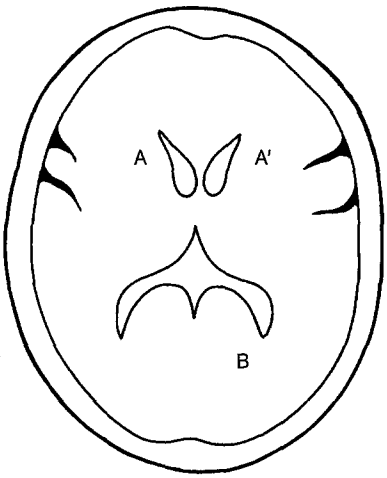
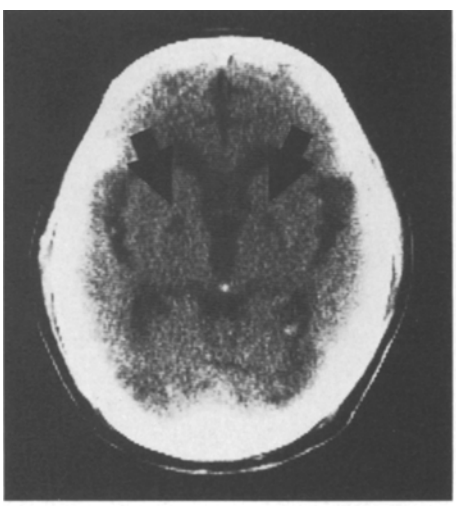



**Fig. 1.** Ventricular dilatation ratio (VD ratio); the ratio of the square measures of anterior horn areas ($A + A'$) to that of the intracranial area ($B$), i.e. A + A'/B. Sulcal widening; number of visible sulci based upon CT images 50 mm distant from OML



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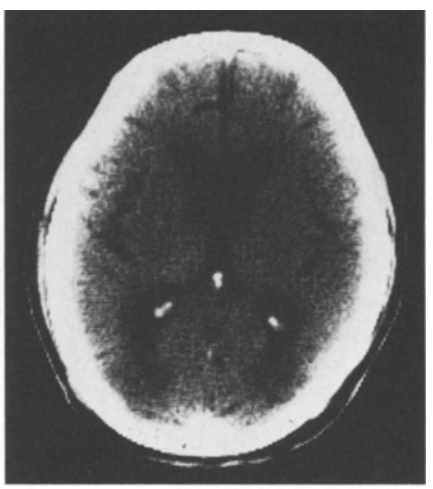

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**Fig. 2.** CT scan of a case in the CO Group I, showing low density areas (*arrows*) in the globus pallidus and ventricular dilatation and sulcal widening

**Fig. 3.** CT scan of a case in the CO Group II, showing ventricular dilatation and sulcal widening with no abnormality in the globus pallidus

degree of ventricular and sulcal dilatations were measured quantitatively. Correlations between four variables, i.e. age at examination, duration of unconsciousness, degree of ventricular dilatation and degree of cortical atrophy, were investigated.

## Materials and Methods

A total of 34 male patients from 40 to 70 years old (56.2 years ± 1.4, mean ± SE), have been admitted to Omuta Rosai Hospital since the accident about 19 years ago. They had no disturb-

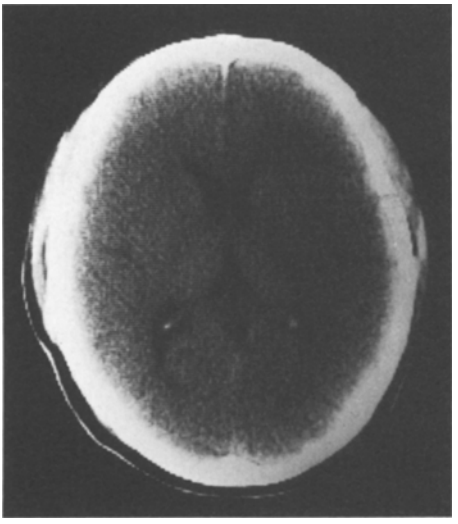

**Fig. 4.** CT scan of a control case showing no abnormality

ance of their normal daily routines, e.g. walking, feeding, dressing, bathing and excretion. They were subjected to daily physical exercise in hospital. The controls, 22 healthy males from 40 to 71 years old (57.0 years ± 1.8, mean ± SE), revealed no neurological sign of organic brain disease.

Computerized tomographies (HITACHI CT-HF, Japan) were obtained for all subjects. The position of the lowest tomographic cut was determined by the orbitomental line (OML). Based upon CT images 40 mm or 50 mm distant from OML, existence of a low density area in the globus pallidus was checked. The 34 patients were divided into two groups; Group I with a bilateral low density area in the globus pallidus and Group II showing no low density area.

Based upon CT images 50 mm distant from OML, which showed basal ganglia, the square measures of anterior horn areas and the intracranial area were obtained with an apparatus for picture analysis (OKUMA-OA-1, Japan), as shown in Fig. 1. The degree of ventricular dilatation (ventricular dilatation ratio; VD ratio) was considered as the ratio of the square measures of anterior horn areas to that of the intracranial area. Figure 1 also shows the number of visible sulci, which was considered to represent the degree of cortical atrophy, as reported by Konagaya et al. (1980).

From the patients histories, duration of unconsciousness at the time of the accident was determined. Four variables, i.e. age at examination, duration of unconsciousness, VD ratio and number of visible sulci were taken into consideration. Correlation coefficients between each of two variables were calculated, and partial correlation coefficients were obtained from the above variables.

## Results

Bilateral low density areas in the globus pallidus were found in 9 patients, as shown in Fig. 2, and they were regarded as pallidal necroses. As shown in Fig. 3 25 patients had no abnormality in the globus pallidus. Figure 4 represents a CT finding for one of the controls showing no abnormality.

As shown in Table 1, significant ventricular and sulcal dilatations were found in the CO group compared with age-matched controls. The 9 patients with pallidal necroses showed the same degree of ventricular dilatation and sulcal widening as the 25 patients with no pallidal necroses.

**Table 1.** Quantitative calculations of four variables

| | Number of cases | Age (years) | VD ratio | Duration (h) of unconsciousness | Number of visible sulci |
|---|---|---|---|---|---|
| Cases with pallidal necrosis (Group I) | 9 | 54.9±2.5 | 0.040±0.006* | 109.3±28.6 | 20.4±2.1* |
| Cases without pallidal necrosis (Group II) | 25 | 56.7±1.7 | 0.039±0.002* | 140.1±47.5 | 24.7±1.6* |
| Total CO Group (I+II) | 34 | 56.2±1.4 | 0.039±0.002* | 131.9±35.6 | 23.6±1.3* |
| Control Group | 22 | 57.0±1.8 | 0.023±0.001 | | 12.3±0.9 |

Mean±SE, *means $P<0.001$

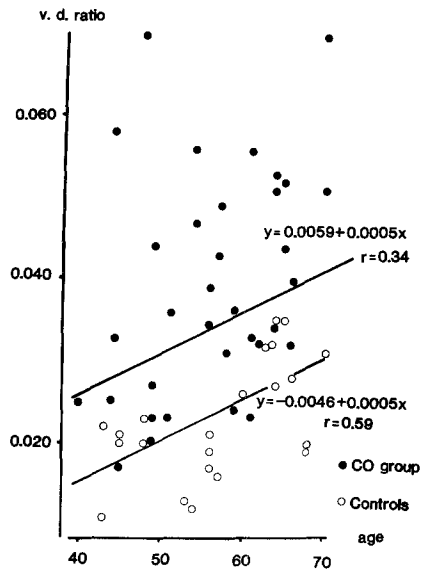


**Fig. 5.** Correlations between age (*abscissa*) and VD ratio (*ordinate*) in the two groups of patients (●) and controls (○)

**Table 2.** Correlation coefficients between each two variables of the following four: age, duration unconsciousness, VD ratio and number of visible sulci

| | Age | Duration of unconsciousness | VD ratio |
|---|---|---|---|
| Age | | −0.49** | 0.34* (0.59**) |
| Duration of unconsciousness | | | 0.24 |
| Number of visible sulci | 0.25 (0.21) | 0.32 | 0.51** (0.30 ) |

Control values are represented in parentheses
* means $P<0.05$,
** means $P<0.005$.

Figure 5 shows correlations between age and VD ratio in both CO and control groups. No significant difference was found between the regression coefficients of the two groups ($y=0.0059+0.0005\,x$, $\gamma=0.34$, $P<0.05$; $y=-0.0046+0.0005\,x$, $\gamma=0.59$, $P<0.001$).

Table 2 represents a significant negative correlation between age and duration of unconsciousness ($\gamma=-0.49$) and significant correlations between age and VD ratio, and between VD ratio and number of visible sulci ($\gamma=0.34$, $\gamma=0.51$, respectively). In the controls there was a significant correlation between age and VD ratio ($\gamma=0.59$). However, no significant correlation was obtained between age and number of visible sulci nor between VD ratio and number of visible sulci.

**Table 3.** Partial correlation coefficients among three variables (age, duration of unconsciousness and VD ratio or number of visible sulci) when each variable in parentheses is regarded to be constant

| | Duration of unconsciousness | VD ratio | Number of visible sulci |
|---|---|---|---|
| Duration of unconsciousness | | 0.50* (Age) | 0.53* (Age) |
| Age | −0.63** (VDR)<br>−0.62** (NVS) | 0.55** (DU) | 0.49* (DU) |

Abbreviations: DU; duration of unconsciousness, NVS; number of visible sulci, VDR; ventricular dilatation ratio.
* means $P<0.005$
** means $P<0.001$

Partial correlation coefficients among the three variables are shown in Table 3. When VD ratio or number of visible sulci was regarded as constant, there was a significant negative correlation between age and duration of unconsciousness ($\gamma=-0.63$, $\gamma=-0.62$, respectively). When duration of unconsciousness was regarded as constant, there were significant correlations between age and VD ratio, and between age and number of visible sulci ($\gamma=0.55$, $\gamma=0.49$, respectively). When age was regarded as constant, significant correlations were also found between duration of unconsciousness and VD ratio or number of visible sulci ($\gamma=0.50$, $\gamma=0.53$, respectively).

## Discussion

In acute CO poisoning Shida (1974) found that there was a significant correlation between duration of unconsciousness and neurological symptoms. Yasukochi and Yasuoka (1967) measured the degree of ventricular dilatation by PEG and found a correlation between it and clinical symptoms. The present study was an attempt to investigate correlations between duration of unconsciousness and ventricular or sulcal dilatation quantitatively.

As it has been reported that ventricular and sulcal dilatations are influenced by aging (Gyldensted 1977; Earnest et al. 1979), it would not be enough to simply investigate the correlation between duration of initial unconsciousness and ventricular or sulcal dilatation. In this study therefore, one of the three variables, i.e. age, duration of unconsciousness, VD ratio or visible sulci, was regarded to be constant, in order to calculate partial correlation coefficient between another two variables.

Considering the influence of aging, there were significant correlations between duration of unconsciousness and ventricular or sulcal dilatation in the CO group. In both patients and control groups significant correlations between age and VD ratio were obtained. No significant difference was found between the

regression coefficients of the two groups. Therefore, it is considered that CO poisoning had no influence on the ventricular dilatation of chronic stage patients. Such dilatation is considered to have been produced during the acute stage.

This finding is compatible with observations using CT at the acute stage (Ikeda et al. 1978; Kim et al. 1980). According to these studies, brain edema of the white matter, which had appeared in the early stage of CO poisoning, gradually decreased and ventricular dilatation was then seen. The high incidence of death at the time of the accident in this study was perhaps due to the severity of damage at the acute stage. As a result, a significant negative correlation between age and duration of unconsciousness may be expected.

Sawada et al. (1980) observed CT scans on 21 CO poisoning cases in the acute stage. They reported that 11 patients with pallidal necrosis showed abnormal ventricular dilatation after 1 year, while 10 patients with no pallidal necrosis showed normal ventricular dilatation. In the present study however, 9 patients with pallidal necrosis showed the same degree of ventricular dilatation and sulcal widening as with the 25 patients with no pallidal necrosis. Had a quantitative calculation been made in the previous study ventricular abnormalities may have been observed in the 10 patients with no pallidal necrosis.

In the present study 9 patients with pallidal necrosis had no disturbance in their daily life. The significance of pallidal necrosis as a CT finding has not yet been established. In neurological diseases of the basal ganglia, a low density area is not usually obtained on CT. At the present time it is technically impossible to measure the degree of pallidal necrosis by CT. Further studies in this field are required.

*Acknowledgment.* We wish to express our thanks to Prof. M. Takeichi and Prof. H. Nakao (Kyushu University) for helpful discussions.

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Received February 16, 1983