Brain MRI Findings of Carbon Disulfide Poisoning

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Objective: To evaluate the findings of brain MRI in patients with carbon disulfide poisoning.

Materials and Methods: Ninety-one patients who had suffered carbon disulfide poisoning [male:female=87:4; age, 32−74 (mean 53.3) years] were included in this study. To determine the extent of white matter hyperintensity (Grade 0−V) and lacunar infarction, T2-weighted MR imaging of the brain was performed.

Results: T2-weighted images depicted white matter hyperintensity in 70 patients (76.9%) and lacunar infarcts in 27 (29.7%).

Conclusion: In these patients, the prevalent findings at T2-weighted MR imaging of the brain were white matter hyperintensity and lacunar infarcts. Disturbance of the cardiovascular system by carbon disulfide might account for these results.

Index terms:
Brain, poisoning
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Carbon disulfide is a volatile, colorless liquid which at room temperature has an aromatic odor, and in viscose rayon plants has been used as a solvent in the spinning process. It is known to have central and peripheral neurotoxic effects, and among the conditions it causes are atherosclerotic change, diabetes mellitus, and coronary heart disease (1−4).

In previous studies, the radiologic findings of carbon disulfide poisoning were diffuse or focal brain atrophy, infarcts in the basal ganglia, subcortial white matter and gray matter, and central demyelination (5−9). A few case reports have described the computed tomographic (CT) (5−8) or magnetic resonance imaging (MRI) findings (8, 9), though no study has involved a large number of patients.

The purpose of this study is to evaluate the findings of MRI of the brain in 91 patients with carbon disulfide poisoning.

MATERIALS AND METHODS

The clinical and imaging findings of 91 patients [M:F=87:4; age, 32−74 (mean, 53.3) years] previously employed at a viscose rayon factory, and in whom carbon disulfide poisoning had been diagnosed on the basis of the criteria of the Korean Ministry of Labor (4), were retrospectively reviewed. The duration of exposure ranged from 3 to 27 (mean, 12.9) years, and its level was estimated as follows: cumulative exposure index = $\sum$ duration $\times$ exposure data, this latter being assessed by an industrial hygienist as the past job-exposure matrix (4).

The patients underwent MRI between December 1991 and March 2001; if performed several times, the initial findings were analyzed. In 64 patients, a 1.5-T MRX-II unit (Toshiba, Nasu, Japan) and a Signa Advantage (General Electric Medical Systems,

Milwaukee, Wis., U.S.A.) were employed. The axial pulse sequences used were spin-echo T1-weighted (TR/TE=500–600/10–15 msec), T2-weighted (TR/TE=2200–3500/80–105msec), and proton-density (TR/TE=2200/20 msec) or FLAIR (TR/TE=10000/120–130 msec). In the remaining 27 patients, scanning was performed at these same sequences but other units were used.

The MRI findings were interpreted by a radiologist with no knowledge of the exposure level, being assessed for the presence of white matter hyperintensity and lacunar infarcts. T1- and T2-weighted images indicated that white matter lesions were isointense and hyperintense, respectively, and their location and grade were described. For grading, a modified six-point scale established by Horikoshi et al. (10) was used: grade 0: no lesions; grade I: less than 10 scattered focal lesions; grade II: 10 or more, but less than 20, scattered focal lesions; grade III: 20 or more scattered but non-confluent focal lesions; grade IV: partially confluent lesions; grade V: bilaterally diffuse confluent lesions (Figs. 1, 2). Lacunar infarcts were also counted, and their locations described. The grades of white matter hyperintensity and lacunar infarcts were compared between different age groups and between low and high exposure groups. Correlation analysis and the t test were used for statistical analysis.

RESULTS

In 70 (76.9%) of the 91 patients, T2-weighted imaging revealed white matter hyperintensity (Figs. 1, 2). Lesions were found in eight of nine patients (88.9%) aged 30-39, 11 of 15 (73.3%) aged 40–49, 36 of 47 (76.6%) aged 50-59, 12 of 17 (70.6%) aged 60–69, and all three (100%) aged 70–79. On the basis of the cumulative exposure index, 51 patients were included in the low exposure group and 40 in the high exposure group. The prevalence of white matter lesions in these two groups was 76.5% and 75%, respectively, with no significant difference between them. In all 70 patients with white matter lesions, some of these were located near the frontal horn of the lateral ventricle; other frequent locations were the corona radiata and centrum semiovale. The grading of white matter hyperintensity according to age and exposure is summarized in Tables 1 and 2.

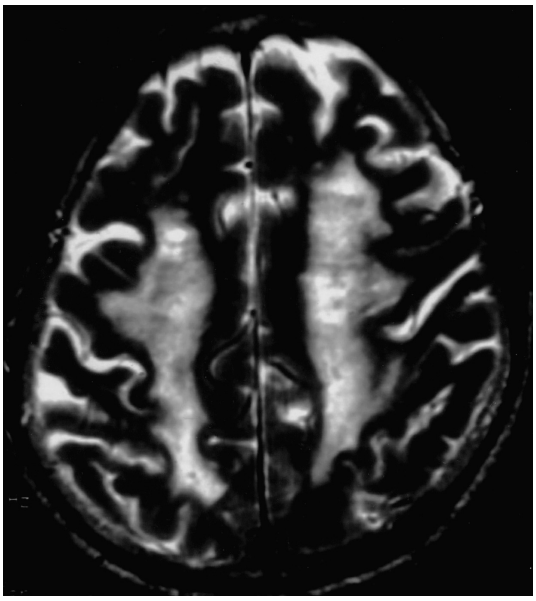
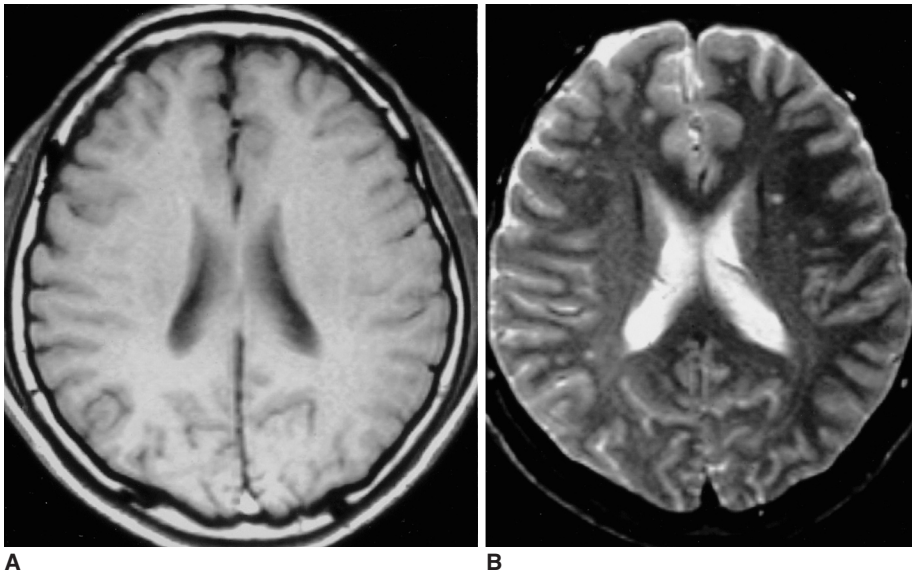


Fig. 2. A 64-year-old man with hypertension after exposure to carbon disulfide for 13 years. T2-weighted axial image shows a grade-V, diffuse, confluent white matter lesion in the centrum semiovale.



A **B**

Fig. 1. A 34-year-old man exposed to carbon disulfide for nine years, but with no accompanying disease. T1- (**A**) and T2-weighted (**B**) axial images depict between 10 and 20 grade-II focal white matter lesions in the fontal lobe.

In 27 (29.7%) of 91 patients, the presence of lacunar infarcts was demonstrated (Fig. 3). They were found in none of nine patients (0%) aged 30–39, two of 15 (13.3%) aged 40-49, 15 of 47 (31.9%) aged 50-59, eight of 17 (47.1%) aged 60-69, and two of three (66.7%) aged 70–79. Among the total of 101 lacunar infarcts, 40 (39.6%) were in the basal ganglia, 26 (25.7%) in frontal white matter, ten (9.9%) in the thalamus, nine (8.9%) in the corpus callosum, seven (6.9%) in the pons, five (5.0%) in parietal white matter and four (4.0%) in the external capsule. In the low and high exposure groups, the prevalence of lacunar infarcts was 33.3% and 25.0%, respectively, with no significant difference between the two groups.

Accompanying diseases were hypertension (n=59), hyperlipidemia (n=22), diabetes mellitus (n=13), angina (n=4), and alcoholism (n=4).

DISCUSSION

Carbon disulfide poisoning was first reported in 1856 by August Delpech, who described it as 'carbon disulfide neurosis'. Its presence in viscose rayon factories was first noted during the early years of the last century, and in the 1930s it became a social problem. In an improving industrial environment, however, the risk of such poisoning markedly decreased, but with the recent spread of viscose rayon factories to developing countries the problem has reappeared (1–4, 11). In Korea, carbon disulfide poisoning was one of the most important occupational diseases of the 1980s, and new cases are still being diagnosed, up to and including this year. Victims frequently suffer hypertension, sensorineural hearing loss, multiple cerebral infarcts, retinal microaneurysm, polyneuropathy, and retinal change (4).

In our study, the most prominent finding of carbon disulfide poisoning was the high prevalence of white matter hyperintensity and lacunar infarction. It is well known that the most important factor affecting the former is age (10, 12–15), and in their study of 240 consecutive patients, excluding those with trauma and demyelinating disease, Awad et al. (12) reported incidental white matter hyperintensity in 22% of patients aged 0–20 years, 22% aged 21-40, 51% aged 41-60, and 92% aged over 60. Fazekas (13)

Table 1. Severity of White Matter Hyperintensity at MRI According to Age

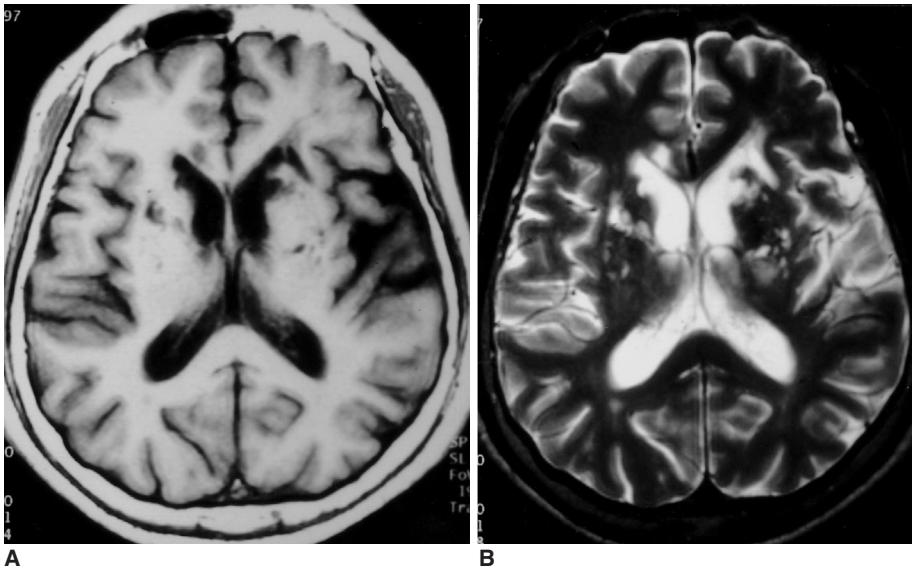
Age	Number of Patients	Grade					
		0	I	II	III	IV	V
30–39	9	1	7	1	0	0	0
40–49	15	4	9	2	0	0	0
50–59	47	11	20	5	6	4	1
60–69	17	5	7	1	0	2	2
70–79	3	0	2	0	0	1	0

Note.—Grade I = less than 10 focal lesions, II = 10 or more, but less than 20, focal lesions, III = 20 or more non-confluent focal lesions, IV = partially confluent lesions, V = bilaterally diffuse confluent lesions

Table 2. Severity of White Matter Hyperintensity at MRI According to Exposure

	Number of Patients	Grade					
		0	I	II	III	IV	V
Low Exposure Group	51	12	25	4	3	5	2
High Exposure Group	40	10	19	5	3	2	1

Note.—Grade I = less than 10 focal lesions, II = 10 or more, but less than 20, focal lesions, III = 20 or more non-confluent focal lesions, IV = partially confluent lesions, V = bilaterally diffuse confluent lesions



A B

Fig. 3. A 58-year-old man exposed to carbon disulfide for 15 years, but with no accompanying disease. T1- (**A**) and T2-weighted (**B**) images indicate that multifocal lacunar infarcts are present in the basal ganglia and genu of the corpus callosum.

found white matter lesions in 45% of 87 normal volunteers: 11% of those were aged 0−39 years, 31% were 40−49, 47% were 50-59, 60% were 60−69, and 83% were 70 or over. In our study, white matter hyperintensity also increased with age, and when compared with previous studies of normal subjects, its prevalence was higher among all age groups, especially the young one.

Gerad et al. (16) reported that in the generic population, white matter hyperintensity occurred in 7.8% of asymptomatic patients with no cardiovascular risk factors, in 31% of asymptomatic patients with hypertension, diabetes mellitus or heart disease, and in 78.5% of patients with cardiovascular risk factors and a history of completed stroke, reversible ischemic neurologic deficit, or transient ischemic attack. These findings can be explained by the fact that with increasing age, cerebral blood flow decreases gradually and progressively, and atherosclerotic vascular disease occurs. The presence of hypertension, diabetes, or other cardiovascular risk factors causes acceleration of these processes. Braffman et al. (17) stated that at T2-weighted imaging, pathologic findings of white matter hyperintensity do, in fact, represent subtle changes in gliosis and demyelination, presumably due to chronic vascular insufficiency and/or frank infarction. Brant-Zawadzki and kucharczk (18) claimed that most white matter hyperintensity is likely to take the form of small, clinically silent infarcts, or there may be diffuse ischemic change. It is well known that the prevalences of hypertension, coronary vascular disease, and diabetes mellitus are high in patients with carbon disulfide poisoning, and this was true of our study group. Wojtczak-Jaroszowa and kubow (11) suggested that the possible mechanisms through which carbon disulfide plays a role in vascular disease are (1) an increase in blood pressure; (2) increased blood cholesterol levels and/or the induction of lipid accumulation in vessel walls; (3) the induction of a lipid peroxidation process, leading to the increased likelihood of blood clotting; and (4) the promotion of cell mutation in arterial walls. Lee aand kim (19) reported that a decrease in CO_2 reactivity and the pulsatile index of cerebral vessels was related to carbon disulfide exposure, suggesting that decreased cerebral vascularity through atherosclerotic change in cerebral vessels was a possible outcome. The high prevalence of white matter hyperintensity seen at MRI in patients with carbon disulfide poisoning can, therefore, be explained by an increase in risk factors such as hypertension, atherosclerosis and diabetic change, rather than by brain injuries directly due to carbon disulfide.

Small perforating branches of the cerebral arteries may become occluded, and the resulting infarcts may be small; as the softened tissue is removed, a small cavity, or lacune, is left (20). There has always been strong correlation between lacunar infarction and a combination of hypertension, atherosclerosis and, to a lesser degree, diabetes (20−23), and in our study, the prevalence of lacunar infarcts was high. It is well known that carbon disulfide induces hypertension, and its oresence was noted in 20 (74.1%) of our 27 patients with lacunar infarcts. The high prevalence of lacunes revealed by MRI in patients with carbon disulfide poisoning can, therefore, also be explained by the fact that carbon disulfide induces hypertension and atherosclerosis.

In our study, there were no significant differences in white matter hyperintensity or lacunar infarction between the low and high exposure groups, a finding probably due to the fact that in carbon disulfide poisoning, correlation between the induction of cardiovascular diseases such as hypertension and atherosclerosis, and amount of exposure, is not linear. It should also be remembered that due to a lack of data which accurately reflects workers' exposure to carbon disulfide in the 1970s and 1980s, the true extent of such exposure cannot be determined. Further evaluation of the effects of carbon disulfide exposure is therefore required.

In conclusion, white matter hyperintensity and lacunar infaction were the prevalent findings of T2-weighted brain MR imaging in patients with carbon disulfide poisoning. Disturbance of the cardiovascular system by carbon disulfide might account for these results.

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