A cross-sectional study on the brainstem auditory evoked potential among workers exposed to carbon disulfide

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Received February 18 / Accepted August 19, 1992

Summary. In order to clarify the chronic effect of carbon disulfide (CS2) on the central nervous system (CNS), the brainstem auditory evoked potential (BAEP) was measured in spinning workers exposed to CS2 in a viscose rayon manufacturing factory and unexposed workers in Japan. Workers exposed to CS2 were divided into three groups according to length of exposure: current spinning workers with an exposure duration of more than 240 months (L group, n = 34), current spinning workers with an exposure duration of 24-84 months (S group, n = 25), and former spinning workers with an exposure duration of more than 120 months (R group, n = 16). Unexposed controls were selected from workers in a nylon filament factory using the same criteria (N group; n = 40). BAEP records were analyzed based on the latencies of three main components (I, III, V) and interpeak latencies (I-III IPL, III-V IPL, I-V IPL). Latencies of component V, III-V IPL, and I-V IPL in the L group were significantly greater (P < 0.01, P < 0.05, P < 0.05, respectively). The significantly higher III-V IPL in the L group suggested that in humans, chronic exposure to CS2 involves the auditory ascending tract in the brainstem. Recovery from this neurotoxic effect is apparently possible, as the BAEP parameters in the R group were not significantly higher than those of the N group despite the long previous CS2 exposure of the R group.

Key words: Carbon disulfide – Exposed workers – Brainstem auditory evoked potential – Central nervous system pathy. In the CNS disorders, headache, general fatigue, and sleep disturbance have been described by many investigators on the basis of clinical observations [9, 14]. Neuropsychological methods have been used to detect early changes in the CNS function due to CS2 exposure in workers [1, 4, 5, 7, 10]. However, among the neurophysiological methods only electroencephalography (EEG) has been used in field surveys on the functional changes in the CNS of CS2-exposed workers [3, 12, 15, 17].

Recent development of computer technology has led to rapid advances in the measurement of evoked potentials of the CNS in neurophysiology. One of these potentials is the brainstem auditory evoked potential (BAEP). Although some controversial problems exist, the precise origins of the later components of BAEP have been identified by neurosurgical operation or experiment. Furthermore, interindividual and intertrial differences in BAEP latencies are small [2, 16]. Since the differences between the latencies of the main components of BAEP (interpeak latencies, IPL) make it possible to evaluate the conduction function of the CNS brainstem, CNS lesions can be analyzed using BAEP method.

We performed a cross-sectional medical survey of Japanese workers exposed to CS2 in a viscose rayon manufacturing factory. BAEP measurements were done for CS2-exposed and unexposed workers in order to clarify the effect of CS2 exposure on CNS function.

Subjects and methods

Subjects. Workers with diabetes mellitus, renal dysfunction, or neurological disease were excluded from this study. Workers consuming more than 100 g alcohol or smoking more than 40 cigarettes per day were also excluded. Current and former male spinning workers (n = 74) aged from 40 to 55 years were selected from a viscose rayon filament manufacturing factory in Japan. The spinning workers were divided into three groups according to exposure duration: current workers with an exposure duration of more than 240 months (L group, n = 34, age 47.2 ± 3.1 years), current work-
ers with an exposure duration of 24–84 months (S group, \( n = 25 \), age \( 44.1 \pm 2.7 \) years), and former workers with an exposure duration of more than 120 months and not subjected to exposure for more than 84 months (R group, \( n = 16 \), age \( 49.1 \pm 3.6 \) years). Unexposed workers were selected from workers in a nylon filament factory using the same exclusion criteria (N group, \( n = 40 \), age \( 46.3 \pm 3.4 \) years) as for the workers under current exposure.

**Exposure to CS\(_2\).** One year after the present survey, Okayama, one of the authors, measured CS\(_2\) exposure level in the plant by personal sampling using charcoal passive samplers. During this period, no improvement of the exhaust ventilation apparatus had been done. The time-weighted average of exposure to CS\(_2\) among 44 spinning workers in the factory ranged from 3.3 to 8.2 ppm, the mathematical average being 4.76 ppm. Evaluation of this data also took into consideration the fact that the exhaust ventilation apparatus had undergone major improvement 14 years ago. Thus, workers with long exposure duration and those with past exposure had been exposed to higher levels of CS\(_2\) than when this study was conducted.

**Figure 1.** Typical wave pattern of BAEP in subjects. The two upper sweeps were recorded at the ipsilateral earlobe of the stimulated ear, and the two lower sweeps at the contralateral earlobe. Calibration: 0.5 uV, 2 ms

**Table 1.** Worker age and duration of CS\(_2\) exposure in study subject groups (mean ± standard deviation; range)

<table>
<thead>
<tr>
<th></th>
<th>L group ((n = 34))</th>
<th>S group ((n = 24))</th>
<th>R group ((n = 16))</th>
<th>N group ((n = 40))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>47.2 ± 3.13</td>
<td>44.1 ± 2.69</td>
<td>49.1 ± 3.57</td>
<td>46.3 ± 3.38</td>
</tr>
<tr>
<td>(42–52)</td>
<td>(40–49)</td>
<td>(40–55)</td>
<td>(41–51)</td>
<td></td>
</tr>
<tr>
<td>Exposure (years)</td>
<td>27.2 ± 3.01</td>
<td>4.39 ± 2.35</td>
<td>22.8 ± 7.04</td>
<td>–</td>
</tr>
<tr>
<td>(19.4–32.7)</td>
<td>(2.0–8.5)</td>
<td>(7.6–27.0)</td>
<td></td>
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</tbody>
</table>

**BAEP measurement.** The examined workers were introduced into a quiet, air-conditioned room (temperature: 24–26°C) and asked to sit in a chair for 15 min before examination. BAEP measurement was performed in an electrically shielded cage with copper wire netting. Click sound stimulations of 126 dBSPL sound pressure level (126dBSPL; duration 0.1 ms) were given to the right ear of the subjects through a headphone by an ST 5 type Click Pattern Stimulator (Medelec Co., UK). A needle electrode inserted into the scalp subcutaneously 3 cm anterior to the vertex served as the active electrode. A disk electrode attached to the right ear served as the reference electrode, and one attached to the left ear as the ground electrode. Electrical responses were amplified by a 1279 Bioelectric Amplified (Nippon Denki San-ei Co., Japan) with a bandpass of 50 Hz to 10 kHz. A total of 800–1024 responses were averaged using a 7507 Type Two Channel Averager (Nippon Denki San-ei Co., Japan) over 10.24 ms. Two averaged responses for each subject were recorded with a positive potential in the upward direction by XY recorder (Type 3036, Yokogawa Electrics Co., Japan). The main components and interpeak latency between components were measured for each record.

**Figure 1** shows a typical wave pattern of BAEP with a 126-dBSPL click sound for a control worker. The five main components of BAEP were named in the order of appearance, the first, second, third, fourth and fifth component, in the usual manner [11]. Since the first, third, and fifth components showed stable patterns on the BAEP chart, these were analyzed in detail.

**Statistical analysis.** The statistical significance between BAEP parameters in the current CS\(_2\)-exposed groups (L and S group) and the unexposed group (N group) was tested by analysis of variance (ANOVA) including multiple comparison by Scheffe’s method. Statistical significance between BAEP parameters in the R group and the N group was tested by Student’s t-test.

**Results**

One case in the S group and one case in the N group were excluded from the analysis because of failure of the BAEP measurements, bringing the numbers in the L, S, R, and N groups to 34, 24, 16, and 39, respectively. The mean age in the R group was higher than that in the S and N groups, and the mean exposure duration in the S group was shorter than that in the L and R groups (Table 1). Table 2 shows the latencies of the three main components of BAEP (I, III, and V). The ANOVA among the L, S, and N groups showed significant differences in the latency of component V (\( F = 6.80, df = 2, 92, P = 0.002 \)) with a significant difference between the L and N groups by multiple comparison using Scheffe’s method (\( P < 0.01 \)). In all exposed groups, the latencies of component V tended to be delayed compared with those in the N group. Although not significant, the latencies of component I and III in the L, S, and R group tended to be delayed compared with those in the N group.

Table 3 shows the IPLs of BAEP in the four groups. ANOVA of III-V IPL in the L, S, and N groups showed