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1) 2)

## Abstract

### Cerebrovascular, and Other Health Effects, Due to the Exposure of Ex-Workers to Carbon Disulfide in the Maunufacture of Rayon

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**Objective:** The purpose of this study was to evaluate the cerebrovascular and other related health effects, due to the exposure of ex-workers to carbon disulfide in the manufacture of rayon.

**Methods:** The study subjects comprised of 453 workers from the rayon manufacturing industry (387 males, 66 females). They were examined with a brain MRI and for other risk factors related to their occupation, such as age, work department, work duration, duration of work cessation, and blood pressure. Laboratory tests were also performed such as blood sugar, hemoglobin, cholesterol, etc. The cumulative exposure levels were calculated as the mean exposure level, per work department, multiplied by the total work duration in months.

**Results:** 75.1% of the subjects were between the ages of 40 and 59 years. 76.0% of the subjects had worked in high exposure departments (e.g., department of spinning and refining etc). 52.5% of the subjects had worked for more than 10 years, and 63.3% of the subjects had given up the work (exposure) more than 10 years earlier. The brain MRI findings were normal, a single lacunar infarct, multiple lacunar infarcts (mostly, on subcortex and white matter), and a hemorrhage in 52.5, 8.6, 36.2 and 2.7% respectively. Multiple lacunar infarcts were not related to the cumulative exposure level but in the female workers only, were significantly related to the increasing level of work duration ( $p<0.05$ ), and in the male workers only, were related to the increased duration of work cessation and age ( $p<0.01$ ). Abnormal rates of laboratory tests were higher in the multiple lacunar infarcts subjects with hypertension compared to those with normal brain MRI findings ( $p<0.01$ ).

**Conclusions:** The multiple lacunar infarcts of the brain seemed not to be related to the cumulative exposure level but to the low exposure departments, duration of work, duration of work cessation, age and hypertension. This was conducted as a health evaluation on workers from the rayon manufacturing industry who had terminated their exposure to carbon disulfide many years earlier.

**Key Words:** Carbon disulfide, Ex-workers, Brain MRI, Lacunar infarct, Health effects

< : 2002 12 17 , : 2003 2 25 >  
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\* 2000

1998)

(CS2)

1900

(WHO, 1979; ILO, 1983).

1963 ( , 1996).

1.

가 1980

가

1994 ~ 2000

( , 1989; , 1991)

453

( , 1989; , 1992),

( MRI)

가 12 441

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1992; ( , 1989), ( , 1992)

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(1999)

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(Omae et al., 1998; Takebayashi,

4

312.7, 293.4±217.9 (p<0.01). 430.9± (3) 가 (HSBO)가

3) ( ) 가 (small vessel) (multiple lacunar infarct) ( , 1999) 가 2

4) MRI MRI 가 MRI (basal ganglion), <140 mmHg, <90 mmHg, (white matter), (thalamus), Hb 13 g/dL( ), Hb 12 g/dL( ), (subcortical area), (cerebellum) <140 mg/dL, 2 <200 (abnormal high signal mg/dL, HbA1C 4.8%, 1.7 bright object, HSBO) mg/dL, SGOT 40 IU/L, SGPT 35 (old hemor- IU/L, -GTP 63 IU/L( ), -GTP 35

**Table 1.** General characteristics of the subjects

Variables	Male N(%)	Female N(%)	Total N(%)
Age (yrs)			
~ 39	37 (9.6)	18 (27.3)	55 (12.1)
40 ~ 49	100 (25.8)	24 (36.4)	124 (27.4)
50 ~ 59	199 (51.4)	17 (25.8)	216 (47.7)
60 ~	51 (13.2)	7 (10.5)	58 (12.8)
Education			
Elementary	63 (16.3)	21 (31.8)	84 (18.5)
Middle school	94 (24.3)	31 (47.0)	125 (27.6)
High school	185 (47.8)	10 (15.2)	195 (43.1)
College and over	25 (6.4)	1 (1.5)	26 (5.7)
No response	20 (5.2)	3 (4.5)	23 (5.1)
Total	387 (100.0)	66 (100.0)	453 (100.0)

IU/L ( ), 240 mg/dL,  
 7.0 mg/dL, TSH<4.1 µU/ml, HBsAg ,  
 anti-HBsAg , , , ,

1.

3.

Table 1  
 package dBase SAS 6.12 453 387 (85.4%),  
 MRI 66 (14.6%)  
<sup>2</sup>-test 50 ~ 59 (199 , 51.4%), 40 ~ 49  
 (24 , 36.4%) 가  
 가 <sup>2</sup>-test 가 47.8%, 가  
 t-test 47.0% 가

**Table 2.** Occupational characteristics of the subject

Variables	Male (%)	Female (%)	Total (%)
<b>Work departments</b>			
Mixing	14 (3.6)	0 (0.0)	14 (3.1)
Ripening	29 (7.5)	0 (0.0)	29 (6.4)
Washing	23 (5.9)	0 (0.0)	23 (5.1)
Spinning	122 (31.5)	6 (9.1)	128 (28.3)
Refining	51 (13.2)	50 (75.8)	101 (22.3)
Mechanics	37 (9.6)	2 (3.0)	39 (8.6)
Electricity	10 (2.6)	0 (0.0)	10 (2.2)
Maintenance	13 (3.4)	0 (0.0)	13 (2.9)
Drainage	34 (8.8)	0 (0.0)	34 (7.5)
Chemistry	24 (6.2)	0 (0.0)	24 (5.3)
Management	23 (5.9)	5 (7.6)	28 (6.2)
Others	7 (1.8)	3 (4.5)	10 (2.1)
<b>Work (exposure) durations (yrs)</b>			
~ 4	38 (9.8)	20 (30.3)	58 (2.8)
5 ~ 9	132 (34.1)	25 (37.9)	157 (34.7)
10 ~ 14	128 (33.1)	13 (19.7)	141 (31.1)
15 ~ 19	74 (19.1)	6 (9.1)	80 (17.7)
20 ~	15 (3.9)	2 (3.0)	17 (3.7)
<b>Work (exposure) cessation (yrs)</b>			
~ 4	76 (19.6)	23 (34.9)	99 (21.9)
5 ~ 9	56 (14.5)	11 (16.7)	67 (14.8)
10 ~ 14	105 (27.1)	15 (22.7)	120 (26.5)
15 ~ 19	91 (23.5)	9 (13.6)	100 (22.1)
20 ~	59 (15.3)	8 (12.1)	67 (14.7)
<b>Total</b>	<b>387 (100.0)</b>	<b>66 (100.0)</b>	<b>453 (100.0)</b>

**Table 3.** Mean of variables by the work department and sex

		Work Department		
		High exposure	Low exposure	Total
Male	No. of subjects	278	98	376
	CEI	520.3 ± 307.1	155.4 ± 116.8**	425.2 ± 314.5
	Work duration (mo.)	127.2 ± 55.6	155.5 ± 64.1**	134.6 ± 59.2
	Work cessation (mo.)	150.5 ± 80.8	140.8 ± 84.7	148.0 ± 81.8
	Age on exam. (yr.)	50.4 ± 7.9	53.8 ± 7.7**	51.3 ± 8.0
Female	No. of subjects	57	8	65
	CEI	310.6 ± 219.0	61.0 ± 53.8**	279.9 ± 221.6
	Work duration (mo.)	95.7 ± 47.0	172.3 ± 74.2**	105.1 ± 56.4
	Work cessation (mo.)	120.9 ± 84.4	100.0 ± 80.0	118.3 ± 83.6
	Age on exam. (yr.)	45.1 ± 8.8	52.6 ± 11.1*	46.0 ± 9.4

\*No. of subjects indicates subjects that hemorrhagic findings were excluded.

†\* indicates  $p < 0.05$  and \*\* indicates  $p < 0.01$  by the t-test

‡CEI indicates cumulative exposure index.

**Table 4.** Distribution of brain MRI findings in total

MRI findings	Sex	Male (N=387)	Female (N=66)	Total (N=453)
		N (%)	N (%)	N (%)
Normal		200 (51.7)	38 (57.6)	238 (52.5)
Old hemorrhage		11 (2.8)	1 (1.5)	12 ( 2.7)
High signal bright object (HSBO)		176 (45.5)	27 (40.9)	203 (44.8)
	single	33 (8.5)	6 (9.1)	39 (8.6)
	multiple	143 (37.0)	21 (31.8)	164 (36.2)

\*N indicates total number of subjects.

†Multiple indicates multiple findings for high signal bright object on MRI film.

**Table 5.** Distribution of brain MRI findings (high signal bright object) by site.

Sex	HSBO	Male (N=376)		Female (N=65)		Total (N=441)	
		Normal	Multiple	Normal	Multiple	Normal	Multiple
Site		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Basal ganglion		344 (91.5)	15 (4.0)	64 (98.5)	0 (0.0)	408 (92.5)	15 (3.4)
White matter		304 (80.8)	52 (13.8)	55 (84.6)	8 (12.3)	359 (81.4)	60 (13.6)
Subcortex		271 (72.1)	94 (25.0)	46 (70.8)	15 (23.1)	317 (71.9)	109 (24.7)
Thalamus		372 (98.9)	1 (0.3)	65 (100.0)	0 (0.0)	437 (99.1)	1 (0.2)
Cerebellum		372 (98.9)	0 (0.0)	64 (91.5)	0 (0.0)	436 (98.9)	0 (0.0)

\*N indicates numbers that excluded old hemorrhage.

†Multiple indicates multiple findings for high signal bright object on MRI film.

‡Distribution of the single infarct aubjects was not demonstrated.

Table 2                      Table 3      MRI  
 가 31.5% 가

75.8%가  
 ,                      56.1%가 10                      가  
 ,                      31.8%가 10  
 65.9%가 10                      ,                      48.4%가 10

**Table 6.** Distribution of brain MRI findings (high signal bright object) according to the risk factors

Sex	Male		Female		Total	
	Normal N (%)	Multiple N (%)	Normal N (%)	Multiple N (%)	Normal N (%)	Multiple N (%)
No. of subject	200 (53.2)	143 (38.0)	38 (58.5)	21 (32.3)	238 (54.0)	164 (37.2)
<b>CEI</b>						
1st Quartile	41 (48.8)	34 (40.5)	15 (68.2)	5 (22.7)	56 (52.8)	39 (36.8)
2nd Quartile	46 (52.9)	33 (37.9)	15 (65.2)	5 (26.1)	61 (55.5)	39 (35.5)
3rd Quartile	47 (49.0)	38 (39.6)	3 (25.0)	8 (66.7)	50 (46.3)	46 (42.6)
4th Quartile	63 (60.6)	36 (34.6)	3 (60.0)	1 (20.0)	66 (60.6)	37 (33.9)
$\chi^2$ -test	ns		ns		ns	
<b>Work department</b>						
high exposure	158 (56.8)	98 (35.3)	35 (61.4)	17 (29.8)	193 (57.6)	115 (34.3)
low exposure	42 (42.9)	45 (45.9)	3 (37.5)	4 (50.0)	45 (42.5)	49 (46.2)
$\chi^2$ -test	p<0.05		ns		p<0.01	
<b>Work duration (yrs)</b>						
~ 4	23 (60.5)	11 (29.0)	15 (78.9)	3 (15.8)	38 (66.7)	14 (24.6)
5 ~ 9	76 (58.9)	44 (34.1)	16 (64.0)	7 (28.0)	92 (59.7)	51 (33.1)
10 ~ 14	52 (43.0)	55 (45.5)	6 (46.1)	6 (46.2)	64 (43.3)	61 (45.5)
15 ~	49 (55.7)	33 (37.5)	11 (12.5)	5 (62.5)	50 (52.1)	38 (39.6)
$\chi^2$ -test	ns		p<0.05		p<0.05	
<b>Work cessation (yrs)</b>						
~ 4	56 (75.7)	12 (16.1)	14 (78.9)	6(27.3)	70 (72.9)	18 (18.8)
5 ~ 9	30 (54.5)	17 (30.9)	5 (45.4)	3(27.3)	35 (53.0)	20 (30.3)
10 ~ 14	53 (52.5)	44 (43.6)	9 (60.0)	6(40.0)	62 (53.4)	50 (43.1)
15 ~	61 (41.8)	70 (48.0)	10 (58.8)	6(35.3)	71 (43.6)	76 (46.6)
$\chi^2$ -test	p<0.01		ns		p<0.01	
<b>Age(yr)</b>						
~ 39	31 (86.1)	3 (8.3)	12 (66.7)	6 (33.3)	43 (79.6)	9 (16.7)
40 ~ 49	60 (61.2)	23 (23.5)	15 (69.6)	6 (26.1)	76 (62.8)	29 (24.0)
50 ~ 59	95 (48.7)	86 (44.1)	8 (47.1)	5 (29.4)	103 (48.6)	91 (42.9)
60 ~	14 (29.8)	31 (66.0)	2 (28.6)	4 (57.1)	16 (29.6)	35 (64.8)
$\chi^2$ -test	p<0.01		ns		p<0.01	

\*Multiple indicates multiple findings for high signal bright object on MRI film.

2. MRI

1) MRI  
MRI Table 4  
52.5%, (HSBO) 44.8%, (1)  
2.7% , 4 (quartile)  
MRI 가 가

2) MRI (HSBO)

Table 5  
( 25.0%, (2) ( )  
23.1%) ( 13.8%, 12.3%) ( ) 4  
MRI 가  
가  
(p<0.05)

**Table 7.** Abnormal rates of the laboratory results according to the brain MRI findings.

Sex	Male		Female		Total	
	Normal N (%)	Multiple N (%)	Normal N (%)	Multiple N (%)	Normal N (%)	Multiple N (%)
HSBO						
Lab. tests						
Systolic hypertension	84 (42.0)	81 (57.0)**	11 (29.0)	10 (47.6)	95 (39.9)	91 (55.8)**
Diastolic hypertension	100 (50.3)	90 (63.4)*	6 (15.8)	9 (45.0)*	106 (44.7)	99 (61.1)**
Hemoglobin	3 (1.5)	3 (2.1)	6 (15.8)	0 (0.0)	9 (3.8)	3 (1.8)
Fasting blood sugar	15 (7.5)	12 (8.4)	2 (5.3)	1 (4.8)	17 (7.2)	13 (7.9)
Bloodsugar after meal	13 (6.6)	10 (7.1)	1 (2.7)	1 (4.8)	14 (6.0)	11 (6.8)
HbA1C	48 (24.1)	61 (43.0)**	10 (27.0)	10 (47.6)	58 (24.5)	71 (43.6)**
Urinary sugar	10 (5.0)	10 (7.0)	1 (2.6)	1 (4.8)	11 (4.6)	11 (6.7)
Urinary protein	11 (5.5)	5 (3.5)	1 (2.6)	1 (4.8)	12 (5.1)	6 (3.7)
Urinary occult blood	10 (5.0)	9 (6.3)	5 (13.2)	4 (19.1)	15 (6.3)	13 (9.9)
Serum creatinine	4 (2.0)	1 (0.7)	0 (0.0)	0 (0.0)	4 (1.7)	1 (0.6)
SGOT & SGPT	12 (6.0)	11 (7.7)	1 (2.6)	1 (4.8)	13 (5.5)	12 (7.3)
-GTP	39 (20.9)	37 (27.6)	5 (14.3)	4 (20.0)	44 (19.8)	41 (26.6)
HBsAg	10 (5.4)	7 (4.9)	5 (13.2)	0 (0.0)	15 (6.3)	7 (4.3)
Anti-HBs	108 (54.0)	75 (52.8)	24 (63.2)	15 (71.4)	132 (55.5)	90 (55.2)
T. cholesterol	24 (12.0)	20 (14.0)	4 (10.5)	2 (9.5)	28 (11.8)	22 (13.4)
Uric acid	6 (10.0)	7 (11.5)	0 (0.0)	0 (0.0)	6 (8.6)	7 (10.1)
TSH	5 (2.7)	2 (1.6)	2 (5.7)	3 (14.3)	7 (3.2)	5 (3.3)
Treadmill test	12 (6.4)	7 (5.2)	2 (5.4)	0 (0.0)	14 (6.3)	7 (4.5)

\* Multiple indicates multiple findings for high signal bright object on MRI film.

†\* indicates p<0.05 and \*\* indicates p<0.01 by chi-square test.

**Table 8.** Mean values of the related factors according to the brain MRI findings

Variables	Male		Female		Total	
	Normal Mean ± SD	Multiple Mean ± SD	Normal Mean ± SD	Multiple Mean ± SD	Normal Mean ± SD	Multiple Mean ± SD
CEI	435.0 ± 310.3	426.9 ± 334.6	244.4 ± 168.3	300.1 ± 168.0	404.6 ± 300.3	410.6 ± 320.6
Work duration	132.3 ± 61.4	138.1 ± 54.9	87.2 ± 45.5	128.0 ± 58.0**	125.1 ± 61.3	136.8 ± 55.2*
Work cessation	131.3 ± 89.4	171.6 ± 71.5**	113.7 ± 84.6	129.7 ± 86.4	128.5 ± 84.5	166.3 ± 74.6**
Age	49.2 ± 8.3	54.7 ± 6.6**	43.7 ± 8.5	48.2 ± 10.5	48.3 ± 8.5	53.9 ± 7.5**
Sys. hyperten.	133.7 ± 19.3	142.7 ± 24.3**	135.0 ± 18.8	143.2 ± 24.1**	126.8 ± 20.7	139.3 ± 25.6*
Dias. hyperten.	86.9 ± 13.8	92.4 ± 15.1**	88.5 ± 13.7	93.2 ± 15.1**	78.5 ± 11.3	86.7 ± 14.2*
FBS	109.5 ± 41.8	111.9 ± 30.0	110.8 ± 44.1	111.9 ± 28.0	102.5 ± 25.7	111.9 ± 41.7
HbA1C	4.6 ± 1.2	4.9 ± 1.1 *	4.4 ± 1.5	4.9 ± 1.4	4.6 ± 1.3	4.9 ± 1.1*
T.cholesterol	197.8 ± 40.6	203.1 ± 39.4	197.9 ± 40.8	202.8 ± 39.4	197.4 ± 39.9	205.1 ± 40.1
T.lipid	665.3 ± 196.2	665.9 ± 159.5	583.2 ± 163.3	656.1 ± 137.1	652.2 ± 193.4	664.7 ± 156.4

\*CEI indicates cumulative exposure index, FBS indicates fasting blood sugar.

†\*indicates p<0.05 and \*\* indicates p<0.01 by t-test

‡Units of variables are referred to the text.

§Multiple indicates multiple findings for high signal bright object on MRI film.

3.

(3)

Table 7

MRI

MRI

(p<0.05).

( p<0.01, p<0.05),  
(p<0.05) MRI

(4) ( )

( )

4

2

MRI

가

HBA1C

가

(p<0.01).

(p<0.01)

MRI

(5)

Table 8

MRI

4

MRI

가

가

(p<0.01)

(p<0.01), HbA1C  
(p<0.05),

74.9% 87.9%가

(p<0.01).

1

가

(, 1999)

( 83.0%, 17.0%),

(50 36.6%, 50 63.4%),

( 38.6%, 61.4%) Lewey (1941)

“ (vasculopathia sulfocarbonica)

MRI (Vigliani, 1954).

가 (Nesswetha & Nesswetha,1967; ,1998)

가 가

가

(, 1999)

가

가 (Omae, 1998)가

1987

가

MRI

가

2

(high signal bright object)

가 가 36.2% (

37.0%, 31.8%)

60-

가

83

MRI

41% 1

가 (Kawamoto, 1991)

Table 2

(Inoue,

1996).

가

(Nesswetha & Nesswetha, 1967; Lee & Kim, 1998)

(Takebayashi, 1998)

HDL-

MRI

(Fushimi, 1996)

Table 6

MRI

가

MRI

가

가

MRI

가

( )

가, ( )

가

가

가

, Table 3

8

가

가

MRI

MRI

가,

가

가,

가

가

HbA1C

가

가

MRI

Kawamoto (1991)

MRI

가

, Fushimi (1996)

MRI

가

(p<0.01)

MRI

가

1994 ~ 2000

1990;38(5):664-72.

453 ( 387 , 66 )

, 1999.

, MRI

8

1989;

50-59

1(2):186-96.

(51.4%),

40 ~ 49

(36.4%) 가

14

(31.5%),

(13.2%)

, 1992.5.

(75.8%),

(9.1%)

( )

1992;4(2):186-

5 ~ 9

34.1%, 37.9%

96.

, 1993.

가

10 ~ 14

(27.1%),

15 ~ 19

(23.5%)

, 1996.

5

(34.9%), 10 ~ 14

(22.1%)

. 가 1991;12(2):32-9.

(p<0.01),

1992;10(2):136-42.

MRI

CS2

52.5%,

(36.2%),

59-66.

. 1989;26(1):

2.7%

(

24.7%),

(

1992;4(1):20-

13.6%)

31.

MRI

1990;39(2):

가

245-51.

(p<0.05).

(CS2)

Korean J. Occup. Health 1989;28(2):33-6.

가

(p<0.05),

(p<0.01)

1993;5(2):216-22.

MRI

(Carbon disulfide)

1991;3(1):11-20.

( ) , HbA1C

Eunil Lee, Myung-Hyun Kim. Cerebral vasoreac-

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