

MRI pallidal index

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5)

Abstract

Relationship of Biological Indices of Manganese with Pallidal Index on MRI in Liver Cirrhotics

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Objectives: The objectives of this study were to clarify which biological manganese exposure indices reflect the pallidal signal intensities in magnetic resonance imaging (MRI) in liver cirrhotics.

Methods: We examined whole blood, plasma, RBC and urinary manganese concentrations, as well as, brain MRI in 22 cirrhotic patients and 10 healthy controls. From MRI scans we calculated the signal intensity of the globus pallidus using the pallidal index (PI), the ratio of the globus pallidus to subcortical frontal white-matter signal intensity in axial T1-weighted MRI planes multiplied by 100. In addition, we studied the relationships between PI and other measurements.

Results: The high signal intensity in the globus pallidus on T1-weighted MRI was observed in 18 (81.8%) patients. There was a significant correlation between whole blood and RBC manganese concentration, and PI on MRI. According to multiple linear regression, whole blood and RBC manganese concentration reflected PI on MRI better the other indices did.

Conclusions: Whole blood and RBC manganese concentrations could be useful as biological manganese exposure indices that reflect PI on MRI.

Key Words: Liver cirrhotics, Manganese, T1-weighted image, Pallidal index

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Mn

가

Mn

가

(manganese, Mn)

superoxide dismutase glutamine syn-

thetase

(Welder & Danman, 1984)

(MRI) Mn

Mn

(, 1998). Mn

MRI

(Nelson

Mn

et al., 1993)

Mn

MRI가

Mn

MRI

가

(Kim et al., 1999). MRI

Mn (Hauser

et al., 1994; Butterworth et al., 1995; Saito,

Ejima, 1995; Spahr et al., 1996; Park et al.,

2003), MRI (

가 , 1998; , 1999; , 1999)

Mn 가 MRI

가

Mn 가 MRI가

(Krieger et al., 1995; Melvin et al.,

1999).

Mn MRI

Mn

가 가

Mn

가 가

Mn

Mn

가

(Chandra et al.,

1981; Nelson et al., 1993). Mn

1836 (Couper, 1837)

Mn

가

Mn

Mn

Mn

(Horiuchi et al., 1970).

가 10~40

가

Mn

Mn

Mn

MRI

(, 1998; Hauser et al., 1994).

Mn T1

(pallidal index,

가

(, 1998).

PI

가

1. 2003 1 1 6 30
 가 31
 22 B
 () 가
 10 Mn
 Mn
 2. MRI, () Mn
 가
 Aspartate aminotransferase ('AST'), Alanine aminotransferase ('ALT') gamma-glutamyl transferase ('-GTP'), albumin,
 3cc
 3000 rpm 15
 Mn
 (AAS;
 Spectra AA880-GTA 100, Varian, Australia)
 (Francois et al., 1988; Baldwin et al., 1994). 0.1 ml 0.1% (v/v)
 Triton X-100 20 , 15 μ
 Mn

MRI 1.5 Tesla system (Signa Horizon LX, GE Medical Systems, Milwaukee, WI, U.S.A.) MRI

2 T1 (T_R/T_E=600/20) T2 (T_R/T_E=4000/100) 가 T1 가
 PI T1 (globus pallidus) 100 (Krieger et al., 1995; Fig 1).

Child-Pugh scoring system(Pugh et al., 1973) 가

3.

Mann-Whitney U-test



Fig. 1. Axial T1-weighted image shows increased bilateral signal intensities at the globus pallidus (white arrow). Determination of pallidal index (PI) is as follows.

$$PI = \frac{\text{signal intensity of the globus pallidus (white arrow)}}{\text{signal intensity of the subcortical white matter (black arrow)}} \times 100$$

Spearman correlation
 coefficient(ρ ,)
 Kruskal-Wallis 1.
 PI, Mn
 . Kruskal-Wallis
 Mann-Whitney U-test (Table 1).
 22 48.4
 Mn 가 PI . B
 0.05 . 22 가 4 (18.2
 SPSS release for Windows version 10.0 %) . 18 (81.8 %)
 MRI 가 . 10
 48.3 . MRI

Table 1. Characteristics of the subjects

	Case (n=22)	Control (n=10)
Age (years)	48.4 ± 6.43	48.3 ± 6.0
Alcohol drinking (premorbid)	16 (72.7%)	6 (60.0%)
Hepatic encephalopathy	4 (18.2%)	0 (0.0%)
High signal intensity on MRI	18 (81.8%)	0 (0.0%)
Pallidal index	122.62 ± 14.96** (92.55-141.85)	106.23 ± 7.94 (93.30-116.00)
Mn _{wb} (µg/dℓ)	2.34 ± 1.11* (0.76-5.10)	1.44 ± 0.49 (0.88-2.22)
Mn _p (µg/dℓ)	0.19 ± 0.05 (0.10-0.30)	0.21 ± 0.06 (0.16-0.32)
Mn _{RBC} (µg/dℓ)	3.74 ± 1.88 (1.75-8.67)	
Mn _u (µg/L)	0.60 ± 0.41 (0.08-1.95)	0.78 ± 0.28 (0.45-1.16)
Hemoglobin (g/dℓ)	11.8 ± 2.0** (7.4-16.0)	15.8 ± 1.2 (14.6-18.8)
Total bilirubin (mg/dℓ)	2.67 ± 2.28 (0.7-8.7)	1.30 ± 0.37 (0.8-2.0)
Direct bilirubin (mg/dℓ)	1.40 ± 1.39* (0.2-4.6)	0.24 ± 0.07 (0.2-0.4)
Indirect bilirubin (mg/dℓ)	1.27 ± 1.16 (0.3-5.7)	1.06 ± 0.32 (0.6-1.6)
AST (IU/L)	78.0 ± 52.9** (27-264)	31.4 ± 10.6 (19-54)
ALT (IU/L)	96.2 ± 134.9 (26-587)	46.6 ± 29.0 (17-103)
-GTP (IU/L)	130.1 ± 215.2 (13-879)	45.6 ± 25.2 (19-84)
Child-Pugh score	8.5 ± 2.9 (6-14)	

Statistical significance test was done by Mann-Whitney U-test.

Data are Mean ± standard deviation (range).

* : p < 0.05, ** : p < 0.01 vs control

Mn_{wb}: whole blood Mn concentration

Mn_p: plasma Mn concentration

Mn_{RBC}: RBC Mn concentration

Mn_u: urinary Mn concentration

MRI pallidal index
 (=0.509, P<0.01, n=32) Child-Pugh score(=0.571, P<0.01, n=22), (=-0.615, P<0.01, n=32) PI (Table 2).

106.23 Mn 2.34 $\mu\text{g/dl}$ Child-Pugh PI Mn
 1.44 $\mu\text{g/dl}$ (p<0.05). Mn Child-Pugh PI Mn
 , , AST가 PI 106.23 , Child-Pugh class A(score 5 to 6 points) PI 110.60, class B(7 to 9 points) 128.48, class C(10 to 15 points) 127.87 PI (p<0.01). Class B C
 2. PI Mn class A PI class B Mn class B (Table 3).

Mn PI(=0.489, P=0.007, n=29). 가 가
 Mn PI (=0.573, P=0.005, n=22). 가 가 (Table 3).
 Mn PI(=0.043, P>0.05, n=29),
 Mn PI(=-0.234, P>0.05, n=27)

Table 2. Correlation coefficients() of manganese(Mn) concentrations, age, and liver function test with pallidal index(PI) (n = 32)

	Pallidal index	Mn _{wb}	Mn _p	Mn _{RBC}	Mn _u	Age	Total bilirubin	Child-Pugh score	Hemo-globin	-GTP
Pallidal index	1	.489**	.043	.573**	-.234	-.194	.509**	.571**	-.615**	-.173
Mn _{wb}		1	.195	.868**	-.163	.044	.263	.221	-.268	-.289
Mn _p			1	.212	-.060	-.066	-.194	-.179	.270	-.207
Mn _{RBC}				1	.181	.116	.300	.285	-.050	-.300
Mn _u					1	.209	-.143	-.020	.091	-.026
Age						1	-.184	-.212	-.065	-.009
Total bilirubin							1	.851**	-.382*	-.026
Child-Pugh score								1	-.681**	-.446
Hemo-globin									1	-.045
-GTP										1

* : p < 0.05, ** : p < 0.01

Mn_{wb}: whole blood Mn concentration ($\mu\text{g/dl}$)

Mn_p: plasma Mn concentration ($\mu\text{g/dl}$)

Mn_{RBC}: RBC Mn concentration ($\mu\text{g/dl}$)

Mn_u: urinary Mn concentration ($\mu\text{g/L}$)

3. MRI PI Mn PI ()
 Mn PI 가 (R²=0.426, p=0.003)(Table 4, 1). Mn
 PI (R²= Mn MRI T2
 0.385, p=0.030)(Table 4, 2). T1

Table 3. Pallidal index(PI) and manganese(Mn) concentrations by Child-Pugh classification

	Controls (n=10)	Child-Pugh classification		
		A (n=7)	B (n=9)	C (n=6)
PI	106.23 ± 7.94**	110.60 ± 13.77	128.48 ± 13.56 ^{§#}	127.87 ± 11.02 ^{§#}
Mn _{wb}	1.44 ± 0.49	1.88 ± 0.60	2.84 ± 1.27	2.14 ± 1.16
Mn _p	0.21 ± 0.06	0.17 ± 0.04	0.20 ± 0.06	0.18 ± 0.06
Mn _{RBC}		3.11 ± 1.31	4.17 ± 1.90	3.83 ± 2.48
Mn _u	0.78 ± 0.28	0.50 ± 0.18	0.73 ± 0.58	0.54 ± 0.26

Statistical significance test was done by Kruskal-Wallis(**: p<0.01). If Kruskal-Wallis show statistical significance, the difference between each subgroup was tested Mann-Whitney U-test(§: p<0.05 vs class A, #: p<0.01 vs controls).

Data are Mean ± standard deviation.

Mn_{wb}: whole blood Mn concentration (µg/dℓ)

Mn_p: plasma Mn concentration (µg/dℓ)

Mn_{RBC}: RBC Mn concentration (µg/dℓ)

Mn_u: urinary Mn concentration (µg/L)

Table 4. Results of multiple regression analysis modeling pallidal index

	Coefficient (95% CI)		P value	R ²
Model 1 (n=29)			.003	.426
Mn _{wb}	6.554 (2.232-10.877)	.487	.004	
Total bilirubin	2.146 (-.068-4.360)	.311	.057	
Age	-.457 (-1.188-.274)	-.196	.210	
Model 2 (n=22)			.030	.385
Mn _{RBC}	3.625 (.383-6.867)	.456	.030	
Total bilirubin	1.595 (-1.051-4.240)	.243	.221	
Age	-.767 (-1.682-.149)	-.330	.096	
Model 3 (n=29)			.087	.227
Mn _p	40.402 (-52.694- 133.498)	.158	.380	
Total bilirubin	2.899 (.396-5.401)	.420	.025	
Age	-.348 (-1.196-.500)	-.149	.406	

: adjusted relation coefficient

Mn_{wb}: whole blood Mn concentration (µg/dℓ)

Mn_{RBC}: RBC Mn concentration (µg/dℓ)

Mn_p: plasma Mn concentration (µg/dℓ)

MRI pallidal index

가 Mn Mn

(Markesberry et al., 1984), (Gomori et al., 1986), (Keen et al., 1983; Clegg et al., 1986) Mn

(Dell et al., 1988; Henkelman et al., 1991) (Milne et al., 1990). Mn

T2 T1 Mn

가 Mn Mn

Mn PI Mn 가

(Norman et al., 1978).

T1 가

T2 가

Mn 가

Mn Mn T1 9 가

가 Mn 93 % 가

1999). MRI가 (Kim et al., 가 , 92 %

MRI Mn 가 가 (Weissenborn et al.,

ICP-MS B 81.8 %

MRI

(species) (Mn) 가

Mn MRI T1

Mn(Mn , speciation analysis) 가 . Pujol (1993)

가

(Apostoli, 1998; Lison, 1999; Rodriguez et al., 1999). Thuluvath (1995)

T1 PI T1

Mn 가 가

Mn Mn

Mn 가 Child-Pugh score가 PI

Mn PI

Mn MRI 가
 Mn
 가 PI 122.62
 (Thuluvath et al., 1995) 106.23 (p<0.01).
 Child-Pugh 2.34 $\mu\text{g/dl}$
 PI 1.44 $\mu\text{g/dl}$
 Mn 가 (p<0.05).
 Pugh PI가 Mn Child-
 가 가 , AST가
 Mn 가 (p<0.05).
 가 가 (=0.489, P<0.01, n=29) (= 0.573, P<0.01, n=22) PI
 가 가 PI
 가 PI
 (=0.509, P<0.01, n=32).
 MRI : 가
 Mn 가 T1 MRI
 Mn T1 MRI
 , , , Kengo Ito.
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 1998;16:336-40.
 : T1
 (MRI)
 (pallidal index, PI) 1999;11:476-91.
 : B 1998;2:14-
 40 31 10 30.
 MRI 1998;10:534-47.
 41 가 /
 9 32
 1999;11:415-29.
 T1 MRI Apostoli P. Speciation of metals in occupational medicine. Med Lav. 1998;89:3-16.
 PI Baldwin S, Deaker M, Maher W. Low volume microwave digestion of marine biological tissues for the measurement of trace elements. Analyst 1994;170:1-4.
 PI Butterworth RF, Spahr L, Fontaine S, Layrargues GP. Manganese toxicity, dopaminergic dysfunction and hepatic encephalopathy.
 : 22 가 18 (81.8%)
 MRI 가 10

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