



Wada

1

2

3

4

가

: Wada 10 ( 4 , 6 ) 9

, 1

. 1.5T MR EPI BOLD

SPM p<0.01

-p<0.001

Wada

가

: Wada 9 1

Wada

87.5%, 90%

87.5%, 75%, 80% Wada

87.5%, 87.5%, 80%

가

가

:

( fMRI) BOLD 가

fMRI

fMRI

(1-4), Wada

(5-15) Binder (13) fMRI , Desmond (12)

가 Wada

fMRI 가

가

1  
2  
3  
4

(HMP-98-N-1-0023)

1998 9 23

1999 1 25



1 2 3 p<0.01  
 2  
 ( :  
 .....). 2-3  
 ( : .....).  
 1 Lateralization Index = (L- R) / (L+R)  
 1-2 (L , R )  
 . 8 0 Wada  
 2  
 PC fMRI 가  
 statistical parametric mapping (SPM96, MRC  
 Cyclotron Unit, London, UK)  
 (misalignment)  
 Automated Image Reconstruction(AIR) (17) 10  
 gaussian filtering high pass filtering 가  
 ANCOVA (global nor-  
 malization) t-test (anterior cingulate  
 SPMt cortex), 가  
 T1  
 p<0.001 (Z score > 3.1)  
 가 p<0.01 (Z score >2.3) Wada 1  
 p<0.001 9 Wada (Table 1).  
 6 p<0.001 가

Table 1. Hemispheric Lateralization Index Calculated from Entire Hemisphere in Each Task

Case No*	Wada test**	Handedness	Reading	Noun	Verb	Total
1	Left	Right	0.29	0.04	0.21	0.18(0.13)
2	Left	Right	0.24	0.21	0.73	0.39(0.29)
3	Left	Right	0.05	0.45	0.65	0.39(0.31)
4	Left	Right	0.28	0.72	0.85	0.62(0.30)
5	Left	Left	0.46	0.35	0.37	0.39(0.06)
6	Left	Right	0.25	0.72	0.48	0.48(0.24)
7	Left	Right	0.86	0.84	0.99	0.90(0.08)
8	Right	R	0.29	0.83	0.89	0.67(0.33)
9	Left	Right	0.18			0.18
10	Left	Right	0.35			0.35

\* Number

\*\* Language dominance determined by Wada test

Reading: reading task, Noun: noun generation task, Verb: verb generation task

Table 2. Lateralization Index in Nine Patients with Left Hemispheric Dominance of Language by Wada Test

	Reading	Noun	Verb	Total
Hemisphere	0.33( 0.05 -0.86)	0.48( 0.04 - 0.84)	0.61(0.21 - 0.99)	0.46(0.28)
Frontal	0.34(-0.08 -0.81)	0.42(-0.02 - 0.82)	0.60(0.16 - 0.99)	0.44(0.29)
Temporoparietal	0.43(-0.04 - 1.00)	0.69( 0.12 - 1.00)	0.75(0.12 - 1.00)	0.61(0.37)

Reading: reading task, Noun: noun generation task, Verb: verb generation task

:

가

87.5%, 87.5%, 90%

Wada

1

Wada

가

87.5% (7/8), 75% (6/8), 80% (8/10)

가

가

가

가

87.5% (7/8),

87.5% (7/8), 80% (8/10)

Wada

(22)

. Bahn  
(Wernicke

가

(Broca area)

가

가

(Table 2).

7 3

가

가

가

가

가

Wada

Wada

(24-26)

(18),

가

가

가

가

가

가

(18-21). fMRI

(13).

Wada

가

가

(12-14). fMRI

fMRI

가

가

가

가

Wada

1

9

Wada

. Wada

fMRI

가

1

Wada

1

75%, 80%

1

(dysarthria)

가

가

(aphasia)

가

가

가

가

가

(22)

. Desmond (12) Bahn

가

Binder

, Binder (13)

(13)

, Yetkin (23)

Wada

Wada

(10)

Wada 87.5% 가 가  
 1 (Table 1). 가 가  
 (12,13) 가 가 가  
 가 가  
 가 가  
 (7,12,22), 2 1 가  
 1 가 , fMRI 가  
 가 가  
 PET (27-28)  
 가 , Bahn (22)  
 Wada )  
 6 가  
 1 80%  
 Wada 2  
 가  
 가  
 fMRI Wada fMRI가  
 Wada 가  
 가 ,  
 가 , Wada  
 가  
 fMRI가 Wada

fMRI 가 가 ,  
 가 Wada 가 가  
 가 가  
 가 가  
 1 Wada  
 fMRI가 가 가 fMRI가  
 Wada , fMRI 가

1. Belliveau JW, Kennedy DN, McKinstry RC, et al. Functional mapping of the human visual cortex by magnetic resonance imaging. *Science* 1991;254:716-719
2. Binder JR, Rao SM, Hammeke TA, et al. Functional magnetic resonance imaging of human auditory cortex. *Ann Neurol* 1994;35:662-672
3. Connelly A, Jackson GD, Frackowiak FSJ, Belliveau JW, Bargha-Khadem F, Gadian DG. Functional mapping of activated human primary cortex with a clinical MR imaging system. *Radiology* 1993;188:125-130
4. Rao SM, Binder JR, Hammeke TA, et al. Somatotopic mapping of the human primary motor cortex with functional magnetic resonance imaging. *Neurology* 1995;45:919-924
5. McCarthy G, Blamire AM, Rothman DL, Gruetter R, Shulman RG. Echo-planar magnetic resonance imaging studies of frontal cortex activation during word generation in humans. *Proc Natl Acad Sci* 1993;90:4952-4956
6. Binder JR, Rao SM, Hammeke TA, et al. Lateralized human brain language systems demonstrated by task subtraction functional magnetic resonance imaging. *Arch Neurol* 1995;52:593-601
7. Binder JR. Functional magnetic resonance imaging: language mapping. *Neurosurg Clin N Am* 1997;8:383-392
8. Cuenod CA, Bookheimer SY, Hertz-Pannier L, Zeffiro TA, Theodore WH, Bihan DL. Functional MRI during word generation, using conventional equipment: a potential tool for language localization in the clinical environment. *Neurology* 1995;45:1821-1827
9. Paulesu E, Connelly A, Frith CD, et al. Functional MR imaging correlations with positron emission tomography: initial experience using a cognitive activation paradigm on verbal working memory. *Neuroimag Clin N Am* 1995;5:207-225
10. Mapping: 1.5 T 1998;38:205-210

11. . . . . EPI  
1998;38:957-964
12. Desmond JE, Sum JM, Wagner AD, et al. Functional MRI measurement of language lateralization in Wada-tested patients. *Brain* 1995;118:1411-1419
13. Binder JR, Swanson SJ, Hammeke TA, et al. Determination of language dominance using functional MRI: a comparison with the Wada test. *Neurology* 1996;46:978-984
14. Van der Kallen BFW, Morris GL, Yetkin FZ, Erning LJTO, Thijssen HOM, Haughton VM. Hemispheric language dominance studied with functional MR: preliminary study in healthy volunteers and patients with epilepsy. *Am J Neuroradiol* 1998;19:73-77
15. FitzGerald DB, Cosgrove GR, Ronner S, et al. Location of language in the cortex: a comparison between functional MR imaging and electrocortical stimulation. *Am J Neuroradiol* 1997;18:1529-1539
16. Oldfield RC. The assessment and analysis of handedness: The Edinburgh Inventory. *Neuropsychologia* 1971;9:97-113
17. Woods RP, Cherry SR, Mazziotta JC. A rapid automated algorithm for accurately aligning and reslicing PET images. *J Comput Assist Tomogr* 1992;16:620-633
18. Dion JE, Gates PC, Fox AJ, Barnet HJ, Blom RJ. Clinical events following neuroangiography: a prospective study. *Stroke* 1987;18:997-1004
19. Hietala SO, Silfvenius H, Assly J, Olivecrona M, Jonsson L. Brain perfusion with intracarotid injection of 99mTc-HM-PAO in partial epilepsy during amobarbital testing. *Eur J Nucl Med* 1990;16:683-687
20. Malmgren K, Bilting M, Hagberg I, Hedstrom A, Silfvenius H, Starmark JE. A compound score for estimating the influence of inattention and somnolence during the intracarotid amobarbital test. *Epilepsy Res* 1992;12:253-259
21. Bouwer MS, Jones-Gotman M, Gotman J. Duration of sodium amytal effect: behavioral and EEG measures. *Epilepsia* 1993;34:61-68
22. Bahn MM, Lin W, Silbergeld DL, et al. Localization of language cortices by functional MR imaging compared with intracarotid amobarbital hemispheric sedation *AJR* 1997;169:575-579
23. Yetkin FZ, Swanson S, Fischer M, et al. Functional MR of frontal lobe activation: comparison with Wada language results. *Am J Neuroradiol* 1998;19: 1095-1098
24. Frackowiak RSJ, Friston KJ, Frith CD, Dolan RJ, Mazziotta JC. *Human brain function*. London : Academic Press. 1997;329-404
25. Deutsch G, Papanicolaou AC, Bourbon T, Eisenberg HM. Cerebral blood flow evidence of right cerebral activation in attention demanding tasks. *Int J Neurosci* 1988;36:23-28
26. Pardo JV, Fox PT, Raichle ME. Localization of a human system for sustained attention by positron emission tomography. *Nature* 1991;349:61-64
27. Wise R, Chollet F, Hadar U, Friston K, Hoffner E, Frackowiak R. Distribution of cortical neural networks in word comprehension and word retrieval. *Brain* 1991; 114: 1803-1817.
28. Frackowiak RSJ, Friston KJ, Frith CD, Dolan RJ, Mazziotta JC. *Human brain function*. London : Academic Press. 1997;301-328

## Language Lateralization by Functional MRI: A Comparison with Wada Test- preliminary Results<sup>1</sup>

Jae Wook Ryoo, M.D., Dong Gyu Na, M.D., Hong Sik Byun, M.D.,  
Chan Hong Moon<sup>2</sup>, Ph.D., Sung Wook Shin, M.D., Young Han Kim, M.D., Chul H. Paik, Ph.D.,  
Duk Woo Ro, Ph.D., Yeonwook Kang, M.D.<sup>3</sup>, Seung Bong Hong, M.D.<sup>3</sup>, Sung Moon Kim, M.D.<sup>4</sup>

<sup>1</sup>Department of Radiology, Samsung Medical Center, Sungkyunkwan University School of Medicine

<sup>2</sup>Korea Advanced Institute of Science and Technology,

<sup>3</sup>Department of Neurology, Samsung Medical Center, Sungkyunkwan University School of Medicine

<sup>4</sup>Department of Radiology, Asan Medical Center, College of Medicine, University of Ulsan

**Purpose:** To evaluate the usefulness of functional MR imaging (fMRI) for the determination of language dominance and to assess differences in language lateralization according to activation task or activated area.

**Materials and Methods:** Functional maps of the language area were obtained during word generation tasks (noun and verb) and a reading task in ten patients (9 right handed, 1 left handed) who had undergone the Wada test. MR examinations were performed using a 1.5T scanner and the EPI BOLD technique. The SPM program was employed for the postprocessing of images and the threshold for significance was set at  $p < 0.001$  or  $p < 0.01$ . A lateralization index was calculated from the number of activated pixels in three hemispheric regions (whole hemisphere, frontal lobe, and temporoparietal lobe), and the results were compared with those of Wada tests. The results for lateralization of language area were compared among stimulation tasks and regions and used for calculation of lateralization indices.

**Results:** During the Wada test, nine patients were left dominant and one patient was right dominant for language. Language dominance based on activated signals in each hemisphere was consistent with the results of the Wada test in 87.5% (verb and noun generation tasks) and 90% (reading task) of patients. Language dominance determined by activated signals in the frontal lobe was consistent in 87.5%, 75%, and 80% of patients in each stimulation task (verb generation, noun generation, and reading), respectively. The consistency rate of activated signals in the temporoparietal lobe was 87.5%, 87.5% and 80% of patients in each task. The mean value of the lateralization index, calculated on the basis of activated signals in the temporoparietal lobe was higher than that in the hemisphere or frontal lobe. The verb generation task showed a higher lateralization index than the noun generation or reading task.

**Conclusion:** The lateralization index was higher in the verb generation task and in the region of the temporoparietal lobe than in other stimulation tasks or regions. fMRI is a potentially useful non-invasive method for the determination of language dominance.

**Index words :** Brain, MR

Magnetic resonance (MR), motion studies

Address reprint requests to : Dong Gyu Na, M.D., Department of Radiology, Samsung Medical Center, Sungkyunkwan University, School of Medicine, #50 Ilwon-dong, Kangnam-Ku, Seoul 135-710, Korea.  
Tel. 82-2-3410-0516 Fax. 82-2-3410-2559 E-mail: dgna@smc.samsung.co.kr