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The Relationship Between Magnetic Resonance Imaging and Motor Outcome Following Traumatic Brain Injury

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Thirty four adults with traumatic brain injury [TBI] who had magnetic resonance imaging [MRI] within three months were evaluated motor outcome 6 to 18 months after injury. MRI were classified into four groups according to the depth of abnormality detected and the motor function evaluated with revised Fugl-Meyer method. The results showed no positive relationship between motor outcome and the depth of lesion detected by MRI. It was different from the result of Wilson's studies which had positive finding between the depth of brain lesions detected by MRI and neuropsychological outcome. Better prognosis was found in nonparenchymal abnormality or no ventricular enlargement and worse prognosis in parenchymal abnormality or ventricular enlargement consistent with atrophy detected by MRI. Although MRI can show deeper and smaller detail of traumatic brain lesions, it is not much better than CT scan as far as prognosis prediction of motor function is concerned.

Key words: TBI, MRI, Motor outcome

INTRODUCTION

Traumatic brain injury has been identified as a major health problem in the United States and other countries where vehicular accident, sporting accidents and interpersonal violence are commonplace. The pattern and severity of TBI and resultant outcome are highly variable. The range of outcomes can be from death to complete recovery. The incidence of TBI requiring hospitalization is generally estimated to be 200 to 225 per 100,000 population in the United States. In all, approximately 500,000 new cases occur annually in the United states. Most of cases are minor injury within the United states, approximately 290,000 per year. There are 50,000 to 75,000 people who suffered severe injury. In most study, about half of patient with severe injury die and others left with a combination of physical, cognitive and interactive deficits. About half of all injuries are caused by transportation-related accidents. The other half are the result of fall assaults and other causes. There are some age and socioeconomic factor that affect pattern of causation [1]. The Glasgow coma scale is the widely used measure of severity and prediction of outcome. Most of TBI patients were examined by CT scanning and MRI during admission. It can showed the

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location, nature and extension. Can we predict the late motor outcome just from MRI finding? MRI was found to be superior to CT scans in the detection of the primary traumatic head lesions and some secondary forms of injury [2]. While T2-weighted images were most sensitive lesion detection, T1-weighted images proved to be most useful for anatomic location and classification [3]. Levin H et al reported upon the relationship of depth of brain lesions to consciousness and outcome after TBI by MRI. They found the depth of brain lesion observed on MRI positively related to the degree and duration of impaired consciousness consistent with the centripetal model of progressive brain injury proposed in 1974 by Ommaya and Gennarelli [5,6,7,9,10]. Wilson et al reported MRI in relation to neuropsychological outcome after head injury. They found deeper abnormalities detected by late MRI associated with worse neuropsychological test performance; late ventricular enlargement was particularly associated with poor outcome [4]. However, the significance in predicting motor outcome in relation to MRI has not been established. The purpose of this study is to assess the relationship between the depth of brain lesion detected by MRI and motor outcome in TBI.

MATERIALS AND METHODS

Seventy-one TBI patients admitted to The Adult Brain Injury Service at Rancho Los Amigos Medical Center from Jan 1 1989 to Oct 31 1990 were available for the subjects of this study after reviewing the medical records. Contact was established by letter. Thirty four patients followed up and received motor function assessment. All patients were examined by MRI within three months of their brain injury. Exclusion criteria included penetrating injury, anoxic encephalopathy, cardiovascular disease, post-craniotomy or a premorbid orthopedic or neurologic condition. MRI was carried out in picker "Vista" 0.5 Tesla MRI scanner and the following sequences obtained. Eighteen slices each 5 mm with a gap of 2.5 mm thick at spin echo sequences (SE 2500/20/80) in coronal plane. The MRI were read and classified by a neuroradiologist independently. The neuroradiologist did not know any clinical information. The scan will be classified into four groups according to the depth of abnormality detected: 1. No parenchymal abnormality; this group included patients with an extracerebral hematoma and negative finding. 11. Cortical abnormalities only. 111. Subcortical white matter abnormalities [in addition to any cortical abnormality] IV. Deep white matter lesions, basal ganglion, brain stem abnormalities, [IVa], or late ventricular enlargement consistent with atrophy [IVb], [in addition to any other abnormalities]. The motor function was evaluated with revised Fugl-Meyer method by physiatrist. The evaluation of Fugl-Meyer method comprises three different parts: 1. Motor function and balance. 2. some sensation qualities. 3. passive range of motion and occurrence of joint. The motor function and balance was evaluated in this study. The time in the coordination/speed part was revised because most of TBI were affected bilaterally. While Fugl-Meyer method compares the speed of non-affected side with that of affected, the revised method compares with the speed of examiner. The total score have 214 points. Each half side of body have 100 points [upper extremity: 66', lower extremity: 34'] according to the level of motor function. The balance have 14 points according the functional level of balance [12,13], (Fig. 1).

RESULTS

The subjects, including 28 men and 6 women, age from 18-58 with a mean of 28.2±10.2 years. All patients had MRI scan within three months with a mean of 43.7±20.4 days. Clinical motor assessment time ranged from 6 months to 18 months with a mean of 9.3±3.8 months (Table 1). MRI

UPPER EXTREMITY

A SHOULDER/ELBOW-FOREARM

I Reflex-activity — Flexors / Extensors

II a Shoulder — Retraction / Elevation / Abduction / Outwards rotation
Elbow Flexion
Forearm — Supination
b Shoulder — Add-/Inw. rotation
Elbow Extension
Forearm — Pronation

III Hand to lumbar spine
Shoulder — Flexion 0°-90°
Elbow 90° — Pro-/Supination

IV Shoulder — Abduction 0°-90° / Flexion 90°-180°
Elbow 0° — Pro-/Supination

V Normal reflex-activity

B WRIST
Elbow 90° — Wrist-stability
Elbow 90° — Wrist-flexion/extension
Elbow 0° — Wrist-stability
Elbow 0° — Wrist-flexion/extension
Circumduction

C HAND
Fingers — Massflexion
Fingers — Massextension
Grasp a
Grasp b
Grasp c
Grasp d
Grasp e

D COORDINATION/SPEED
Tremor
Dysmetria
Time

LOWER EXTREMITY

E HIP/KNEE/ANcLE

I Reflex-activity — Flexors / Extensors

II Hip — Flexion/Extension/Abduction
Knee — Flexion/Extension
Ancle — Dorsi-flexion/Plantarflexion

III Knee — Flexion
Ancle — Dorsi-flexion

IV Normal reflex-activity

F COORDINATION/SPEED
Tremor
Dysmetria
Time

G BALANCE
Sit without support
Protective reaction non-affected side
Protective reaction affected side
Stand without support
Stand on non-affected leg
Stand on affected leg

Fig. 1. Test form for assessment of the motor function of the upper and lower extremity in hemiplegia.

Table 1. General Data

Age	28.2±10.2 years
MRI time	43.7±20.4 days
Follow up time	9.3± 3.8 months
Sex (M:F)	28:6

classification revealed 18 patients in MRI-I, 1 patient in 11, 6 patients in 111, and 9 patients in IV (Table 2). Motor outcome revealed 12 patients 214 with.points [A], 12 patients 200-213 points [B], 5 patients 150-200 points [C], and 5 patients with less than 150 points [D]. (Table 3) The mean of motor

Table 2. MRI Classification Compared to Number of Patient

MRI result	I	II	III	IV	
patient				IVa	IVb
Numbers	18	1	6	5	4

Table 3. Motor Outcome Compared to Number of Patient

Motor outcome	A	B	C	D
Score	214	200-213	150-199	<150
N	12	12	5	5

outcome in MRI-I was 203.4±23.7, 182±0 in MRI-II, 171.8±60.8 in MRI-III, and 190.8±28.6 in MRI-IV (Table 4). The MRI compared with motor outcome score by by Mann-Whitney U test (p=0.75). There were no significant difference in depth of brain lesion detected by MRI to motor outcome (Fig. 2, 3). While MRI-I showed nonparenchymal abnormality, The MRI-II, 111, and IV showed parenchymal abnormality. The motor outcome A, B [>200'] represented less motor deficit and C, D [<200'] more motor deficit. The MRI were compared with motor outcome according to this classification by T-test. There were significant difference between nonparenchymal abnormality and parenchymal abnormality (Table 5). Nonparenchymal abnormality had bet-

Table 4. Motor Outcome Related to the Depth of Brain Lesions

MRI	I	II	III	IV
Score	203±23.7	182±0	171.8±60.8	190±28

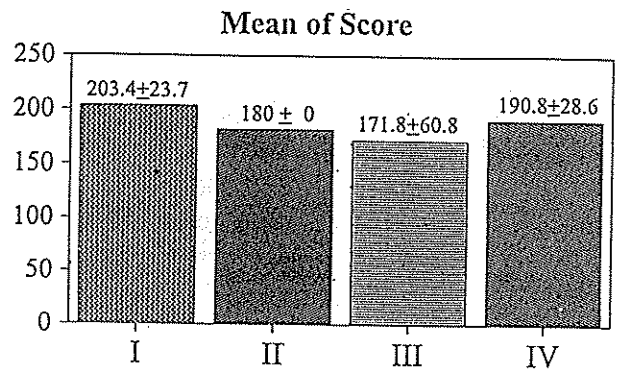

Fig. 3. Depth of Brain Lesions. (Mr Imaging)

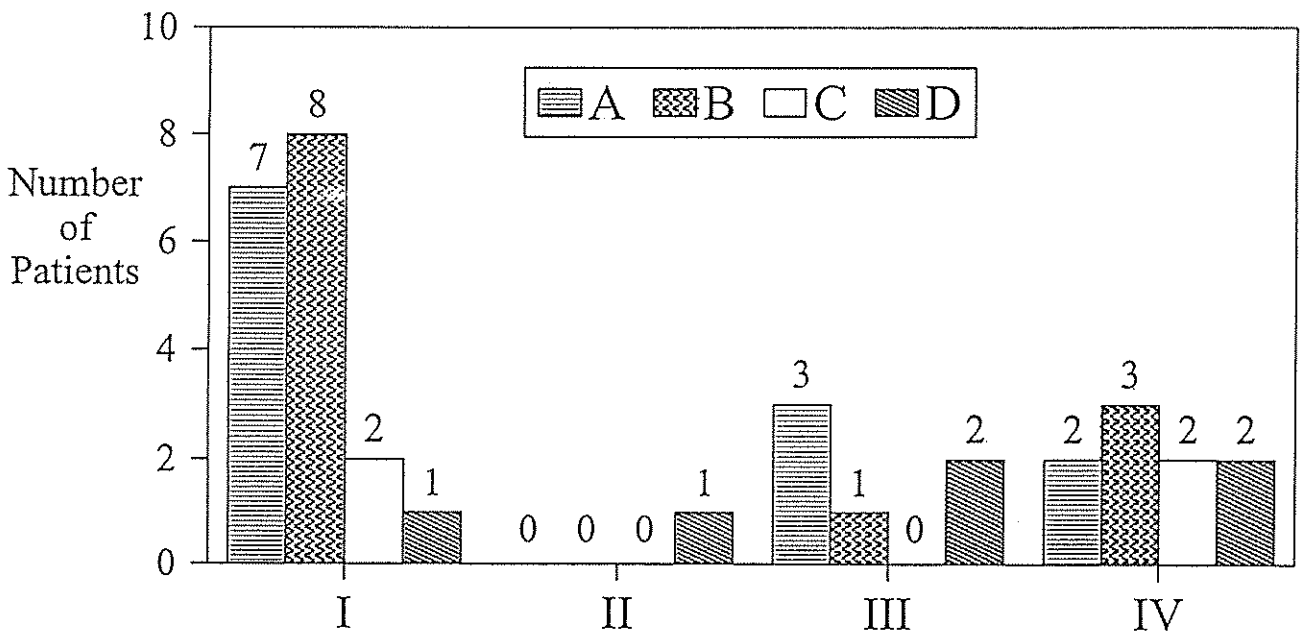

Fig. 2. Depth of Brain Lesions. (Mr Imaging)

Table 5. Motor Outcome Related to Brain Lesions

		Less Motor Deficit < 200	More Motor Deficit > 200
Nonparenchymal	N	15	3
lesion	%	62.5%	30%
Parenchymal	N	9	7
lesion	%	37.5	70%

ter motor outcome than that of parenchymal abnormality in MRI examination (Shown by Percentage). There are 4 patients with ventricular enlargement consistent with atrophy and 30 no ventricular enlargement. MRI were compared with motor outcome score according this classification by Mann-Whitney U test (p=0.03). There were positive relationship between ventricular enlargement consistent atrophy and motor outcome (Table 6). There are 5 patients with MRI IVa and 4 patients with IVb. Compared IVa and IVb to motor outcome, It gets significant difference (Fig.4)(p= 0.014)

Table 6. Motor Outcome Related to Ventricular Enlargement

MRI region	With Ventricular Enlargement	Without Ventricular Enlargement
N	4	30
Motor Outcome Score	167.8+3	197.3+34.8

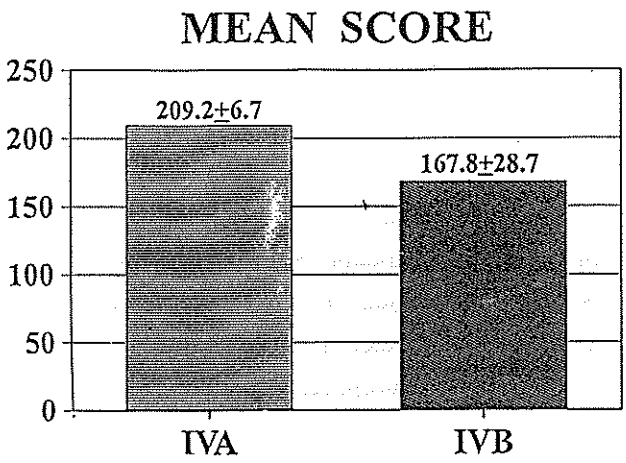

Fig. 4. Depth of Brain Lesions. (Mr Imaging)

DISCUSSION

The results show no relationship between late motor outcome and depth of lesion detected by MRI. It was different from the results of Wilson et al study which was positive finding between the depth of brain lesions detected by MRI and neuropsychological outcome [4]. For the following reasons, the results of our study may be reasonable. 1. The motor function is closely related to motor area which located at precentral gyrus, internal capsule and pyramidal tract [11]. Brain lesion located at frontal lobe and temporal lobe are more common because of bony structure of cranium and mechanism of injury [6]. In spite of MRI classification in 111, IV abnormality, the motor area might be spared. 2. Some brain lesions induced by secondary ischemia after TBI can not be detected [2,3]. There were two cases showed in MRI-I but

motor outcome in C, D respectively. They are shown poor perfusion at parenchymal area in Xenon CT blood flow study. 3. The small lesions in parenchymal area had been absorbed at the time of MRI taking but not large enough developed ventricular enlargement consistent with atrophy. MRI were examined with a mean of 43 days because Rancho is a rehabilitation hospital. Patient with nonparenchymal or extraparenchymal lesion is better motor outcome than that with parenchymal lesion. It can be explained the less involved motor area in patient with extraparenchymal lesion. The motor outcome in ventricular enlargement consistent with atrophy is worse than that in no ventricular enlargement. The results were the same as Wilson et al and Levin et al reports [4,14]. Since extraparenchymal or intraparenchymal lesions and cases with or without ventricular enlargement can be detected simply by CT scan, the prediction of prognosis of TBI motor function with MRI is not much better than CT. It should be the first choice to have CT scan for TBI patients because of its efficiency in time and economy. Levin et al reported that about 72% severe TBI with low Glasgow coma score developed ventricular enlargement one month after the injury by CT scan and the enlargement was related to the duration of coma after high-speed motor vehicle accident and to intellectual and memory defect [14]. There was always a rapid initial improvement of motor function recovery in TBI patients within 6 months followed by a much slower progression [11,18]. The follow up time determined 6 months after TBI could be accepted. The mean follow-up time of this study was 9.3±3.8 months. The subjects are not enough in MRI-II because most of intraparenchymal lesions were mixed. Revised Fugl-Meyer method had the disadvantage that each assessment item only included scores of 0, 1, 2 according to the degree of impairment. The patients with 214 points score did not completely represent normal motor function [12]. It is still worth using revised Fugl-Meyer method in TBI patients for clinical motor assessment besides in post-stroke hemiplegic patients because of it simplicity and reliability [13]. Low mean score of motor function in MRI-IV was rather due to ventricular enlargement consistent with atrophy [IVb] than the deepest lesions detected by MRI [IVa], patients with the deepest MRI detected lesions still had as good scores as MRI-I patients (Fig. 6). This result further supported no relationship between the depth of lesion detected by MRI and late motor outcome. It is difficult to predict the late motor outcome just from MRI like this classification I, II, III and IV according to the depth of brain lesion. Better prognosis was found in nonparenchymal abnormality or no ventricular enlargement and worse prognosis in parenchymal abnormality or ventricular enlargement consistent with atrophy detected by MRI. Although MRI can show deeper and detail of traumatic brain lesions, it is not much better than CT scan as far as prognosis prediction of motor function is concerned.

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腦外傷病人之磁振造影和運動功能之關係

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腦部傷害是一種常見意外傷害，而且病例愈來愈多，病人常留下許多後遺症，運動障礙是常見而且嚴重之一。

Wilson等人，曾以CT研究腦傷病人，發現傷害部位愈深，意識狀態恢復，神經心理測驗結果愈差，其結果和Mmaya等人動物實驗結果一致，即傷害部位愈深愈嚴重，但是在運動功能恢復後評估上，是否如此，尚無人研究。

磁振造影(MRI)目前已普遍用於腦外傷害病人，它的顯像效果優於大腦斷層攝影(CT)，能夠偵測較深，較小，甚至續發性腦組織傷害病灶。

醫師是否能夠以早期之磁振造影，來預測病人未來運動功能之恢復情況呢？

以34位成年腦傷住院病人做為研究對象，每個病人均行磁振造影，經復健治療6個月後再做運動功能評估，其結果是否和Wilson等人一致呢？

放射科醫師依腦部病灶位置深度差異分類成四級，作者以Revised Fugl Meyer法評估運動功能，利用電腦分析研究二者之間之關係。

結果顯示運動功能障礙與腦部傷害深度無關，但是顯示出無腦實質病灶，無腦室擴大者較有腦實質病灶，腦室擴大者為佳，碰振造影雖可提供較佳診斷，但在運動功能預後上并無超越腦部斷層攝影。

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