Inquiro, the UAB undergraduate science research journal

Volume 2013 | Number 7 Article 17

2013

Intact brain volume is related to therapy responses in chronic stroke and real-world arm use in hemiparetic multiple sclerosis patients

Ameen Barghi

Victor W. Mark

Tyler Rickards

Chelsey Sterling

Michelle Haddad

See next page for additional authors

Intact brain volume is related to therapy responses in chronic stroke and real-world arm use in hemiparetic multiple sclerosis patients

Authors

Ameen Barghi, Victor W. Mark, Tyler Rickards, Chelsey Sterling, Michelle Haddad, Gitendra Uswatte, and Edward Taub

Intact brain volume is related to therapy responses in chronic stroke and real-world arm use in hemiparetic multiple sclerosis patients

Ameen Barghi[1], Victor W. Mark[2,3], Tyler Rickards[1], Chelsey Sterling[1], Michelle Haddad[1], Gitendra Uswatte[1,4], and Edward Taub[1]

[1] Department of Psychology, [2] Department of Physical Medicine and Rehabilitation, [3] Department of Neurology, [4] Department of Physical Therapy
University of Alabama at Birmingham

Introduction

The Brain Parenchymal Fraction (BPF) is a measure of structural brain tissue integrity from standard MRI. It is the total amount of white and grey matter divided by the total intracranial space.[1] Previous research from this laboratory has shown that stroke patients with greater BPF show greater improvement in maximal movement ability following constraint-induced movement therapy (CIMT).[2] Previous studies have also correlated BPF with various measures of physical disability in multiple sclerosis (MS), including overall disability (EDSS score) and a composite score comprised of upper and lower extremity movement ability and cognitive function, the Multiple Sclerosis Functional Composite (MSFC).[3-5]

The purpose of this study was to evaluate whether BPF is associated with spontaneous hemiparetic arm use in MS. Additionally, we analyzed how these correlations compare to the BPF values of people affected by stroke. Due to the small sample size, rehabilitation outcomes after CI therapy in relation to BPF were not analyzed in the MS cohort; the study is ongoing.

Methods

Subjects

This study was composed of eighteen adults with chronic hemiparetic MS (aged 49.9 ± 8.0 years) who were randomized to undergo either CI therapy or a holistic program of Complementary and Alternative Medicine. The patients randomly received either CIMT (n = 18) or a comparison therapy (n = 25). The comparison therapy group received all components of CIMT except for the transfer package (described below).

Stroke Intervention: Constraint-Induced Movement Therapy

CIMT consists of in-laboratory training of the impaired upper extremity for ten consecutive weekdays for three hours each day. Therapy components include massed practice and shaping of movement. Additionally, a transfer package was administered to the experimental group. The control group received the same therapy without the transfer package. The transfer package involves an additional 0.5 hours spent in the laboratory and includes: 1) daily monitoring of real-world use of the more affected arm, 2) problem-solving with a therapist to overcome perceived barriers to using the extremity in the real world, 3) home practice of motor task exercises and selected activities of daily living (ADLs; changed daily), 4) a behavioral contract between the therapist and participant (and separately with the caregiver) in which they agree that the participant will use or try to use the more affected arm as much as safely possible outside of the laboratory, and 5) a daily home diary in which the participants record how much they have used the more affected arm for the activities laid out by the behavioral contract. CIMT involves restraint of the less impaired arm for a target of 90% of waking hours in a padded mitt that prevents arm use.

Outcome Measures

The Motor Activity Log (MAL) is a reliable and valid structured interview of use of the more impaired arm in real-world situations.[6-7] The MAL consists of both the Quality of Movement scale (QOM) and the Amount of Use scale (AOU). We were specifically interested in the QOM scale. The Wolf Motor Function Test (WMFT) is a validated laboratory measure of motor ability in prompted movement.[8-9]

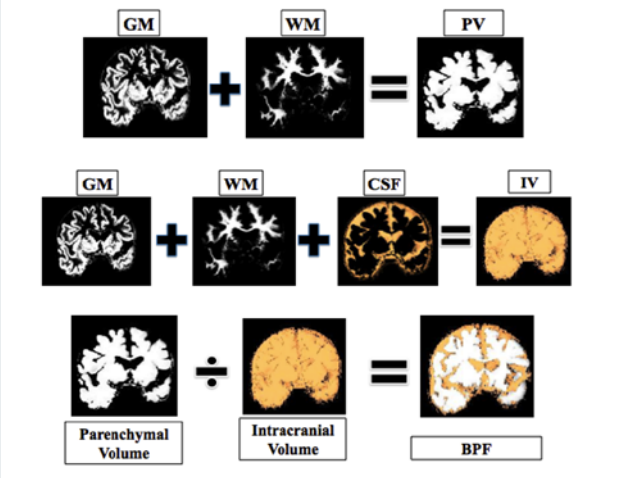

Figure 1. Structural depiction of the various components of the BPF calculation.

Imaging

T1 MRI scans were obtained from patients on a 3T Philips Intera MRI scanner immediately prior to treatment. Raw

T1 images were given a N3 inhomogeneity correction to improve differentiation/contrast between tissue and non-tissue.[10] Scans were segmented into grey matter (GM), white matter (WM), and cerebrospinal fluid (CSF) using SPM8, and viewed in FSL. Voxels in GM and WM segments (parenchymal volume, PV) divided by voxels in GM, WM, and CSF segments (intracranial volume, IV) is equal to Brain Parenchymal Fraction (BPF) (Figure 1).

Results

The CIMT and control therapy groups for stroke did not differ pre-treatment in their BPF values ($t(41) = 0.70$, $p = 0.41$), with BPFs of 0.754 and 0.769, respectively. The mean BPF for MS was 0.74. MS patients with greater pre-treatment QOM showed less change on the MAL (Table 1). A similar correlation was seen in stroke patients (Figure 2).

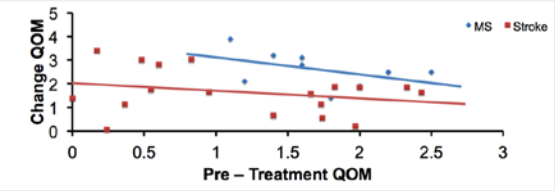

Figure 2. Correlations were found between pre-treatment QOM and change QOM in patients who received CI movement therapy.

Table 1. Pearson Correlations of Brain Parenchymal Fraction with Pre-Treatment and Treatment Change Motor Scores

	Motor Activity Log–Quality of Movement		Wolf Motor Function Test	
	Pre	Change	Pre	Change
CIMT	0.06	0.49*	0.022	-0.45+
Stroke				
Control	-0.13	-0.21	0.259	0.17
MS	0.21	-0.52	0.042	-0.081

*+ approaching significance (.1 > p > .05), * significant (p < .05); Significance tests were two-tailed.*

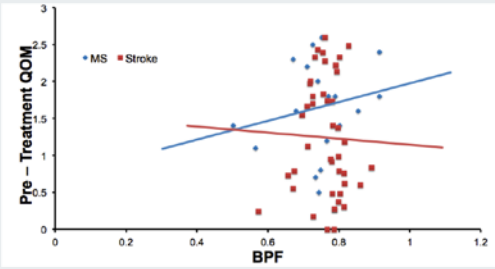

Figure 3. Pre-treatment QOM relationship with BPF.

Discussion

In this small sample study, MAL scores were not significantly correlated with BPF in persons with chronic MS. However, the results suggest that a larger volume of intact brain tissue in the chronic stroke phase (i.e. greater BPF value) predicts better quality of movement in the more-impaired arm during activities of daily living (Table 1). Additionally, it was found that patients in the chronic stroke phase with a larger volume of intact brain tissue have greater gains in maximum motor ability after CIMT, as revealed by the WMFT. There was no difference between groups in BPF values, and BPF itself did not change as a result of CIMT.

BPF may be considered a surrogate marker for overall CNS atrophy. It appears that the characteristics of non-infarcted tissues are important predictive factors for the potential of a patient to recover motor function following rehabilitation. It should be emphasized that previous studies on the relationship between BPF and functional status showed stronger correlations, but from much larger patient samples.

Acknowledgements

This research is supported by grants from the National Multiple Sclerosis Society RG 4221, NIH HD060157, and HD34273. It has been approved by the University of Alabama at Birmingham Institutional Review Board.

References

1. Rudick, R. A., Fisher, E., Lee, J. C., Simon, J., Jacobs, L. (1999). Use of the brain parenchymal fraction to measure whole brain atrophy in relapsing-remitting MS. *Neurology* **53** 1698- 1704.

2. Rickards, T., Taub, E., Sterling, C., Graham, M. J., Barghi, A., Uswatte, G., Mark, V. W. (2012). Brain parenchymal fraction predicts motor improvement following intensive task-oriented motor rehabilitation for chronic stroke. *Restorative Neurology and Neuroscience* **30**, 355–361.

3. Bakshi, R. *et al.* (2008). Predicting clinical progression in multiple sclerosis with the magnetic resonance disease severity scale. *Archives of Neurology* **65**, 1449-53.

4. Sanfilipo, M., Benedict, R. H., Sharma, J., Guttman, B., Bakshi, R. (2005) The relationship between whole brain volume and disability in multiple sclerosis: a comparison of normalized gray vs. white matter with misclassification correction. *Neuroimage* **26**, 1068-77.

5. Kalkers, N. F. *et al.* (2001). Optimizing the association between disability and biological markers in MS. *Neurology* **57**, 1253-8.

6. Taub, E., Miller, N. E., Novack, T. A., Cook III, E. W., Fleming, W. C., Nepomuceno, C. S., *et al.* (1993). Technique to improve chronic motor deficit after stroke. *Archive Physical Medicine and Rehabilitation* **74**, 347-354.

7. Uswatte, G., Taub, E., Morris, D., Vignolo, M., McCulloch, K. (2005). Reliability and validity of the upper-extremity Motor Activity Log-14 for measuring real-world arm use. *Stroke* **26**, 2493-6.

8. Taub, E., Uswatte, G., Mark, V. W., Morris, W. M. (2006). The learned nonuse phenomenon: Implications for rehabilitation. *Europa Medicophysica* **42**, 241-255.

9. Wolf, S. L. *et al.* (2001). Assessing Wolf motor function test as outcome measure for research in patients after stroke. *Stroke* **32**, 1635-9.

10. Keihaninejad, S., Heckermann, R. A., Fagiolo, G., Symms, M. R., Hajnal, J. V., Hammers, A. (2010). A robust method to esti- mate the intracranial volume across MRI field strengths (1.5 T and 3 T). *Neuroimage* **50**, 1427-1437.