

Background

Limited research has focused on the relationship between post acute rehabilitation (and functional outcome) and alterations in cerebral structure following traumatic brain injury (TBI). As a preliminary investigation, a retrospective analysis was performed to examine the relationship between volume of cerebral structures and functional outcome following post acute TBI rehabilitation. The purpose was to examine anatomical correlates of recovery and rehabilitation to assess factors that may mediate successful rehabilitation.

Method

Subjects

A sample of 36 patients with a history of traumatic brain injury who received cognitive rehabilitation were included. These patients ranged in age from 16 to 58 with a mean of 36 years (SEM=2.18; at the time of injury) and had an average of 12.7 years of formal education (range=8-20 years; SEM=0.55). Of these 36 patients:

- Severity (Mild=5, Moderate/Severe=31)
 - Mild TBI was determined by a loss of consciousness (LOC) 0-30minutes AND/OR Post-traumatic Amnesia (PTA) less than 24 hours AND/OR a Glasgow Coma Scale (GCS) score of 13-15.
 - Moderate to Severe was determined by LOC greater than 30 minutes AND/OR PTA greater than 24 hours AND/OR a GCS score less than 13.
- Chronicity (M= 153 days, SEM=33.6)
- History of Psychiatric Disease (pre-injury; n=16 with 14 having dx of depression and/or anxiety)
- History of Substance Abuse (pre-injury; n=10)
- Medication (n=16 for mood/anxiety; n=18 for pain; n=5 on stimulants, n=17 for sleep)

Outcome Measures

Six outcome measures were administered upon admission and discharge to a post-acute traumatic brain injury rehabilitation program.

- Disability Rating Scale (DRS)- assesses a person's general level of *disability* on a 30 point scale allowing for categorization of level of disability ranging from "none" to "extreme vegetative state" in areas of awareness, self-care, dependence on others, and employability (Rapport et al., 1982).
- Centre for Neuro Skills Rating Scale (CNS)-assesses *ability* in the areas of cognition, withdrawal, agitation and aggression, physical therapy, occupational therapy, speech, language, education, and vocation on an 80-point scale (Ashley & Persel, 1999).
- Mayo-Portland Adaptability Inventory (MPAI)-assesses physical, cognitive, emotional, and social participation problems commonly experienced after TBI on a 34 item scale (Malec, 2005).
- Community Integration Questionnaire (CIQ)-assesses home integration, social integration, and productive activities after TBI on a 29 point scale (Willer et al., 1994).
- Living Status Scale (LSS)-assesses living situation on an ordinal scale that ranks the patient from 1-10. High numbers indicate living situations that require a high level of supervision (Ashley et al., 1990).
- Occupational Status Scale (OSS)-assesses *vocational involvement* on an ordinal scale that ranks the patient from 1-16. High numbers indicate vocational situations requiring a high level of supervision or no vocation (Ashley et al., 1990).

Image Acquisition and Analysis

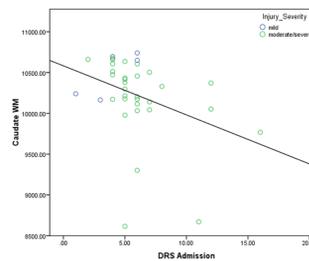
- Imaging was conducted on a 1.5 T Siemens MRI
 - T2 Imaging: TR =5850 ms, TE = 86.24 ms, image matrix = 512x256, FOV = 24x24cm², number of slices = 25-40, slice thickness/separation = 3-5 mm
- The structural data were reoriented, co-registered to the T1 template, segmented into gray matter (GM), white matter (WM), and cerebral spinal fluid (CSF), and then transformed into MNI space using SPM5.
 - Individual data were examined for quality prior to inclusion for motion and other artifacts. Structures were traced in MNI space and volumes extracted. Volumetric data were extracted from frontal, parietal, temporal, and occipital gyri, hippocampal and parahippocampal gyri, thalamus, cingulate, caudate, and putamen.

Results

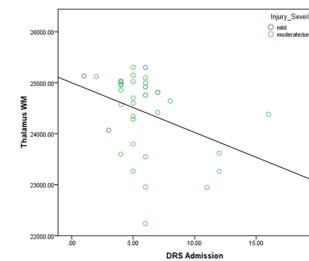
- A set of one-way ANOVAs were used to examine gross differences between severity classifications (although only 5 mild TBI were included). In all cases below moderate-severe show lower volumes.
 - Frontal Gray Matter, $F(1,35)=4.915$, $p=0.033$
 - Whole Brain White Matter, $F(1,35)=5.447$, $p=0.026$
 - There were trends for reductions in volume for moderate-severe relative to mild in all other structures with the exception of hippocampal gray matter.
- Correlation analyses were performed to examine the relation between anatomical structures and outcome measures

Anatomical structures associated with baseline function

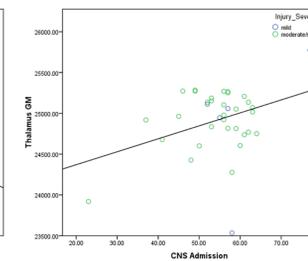
Caudate WM
and DRS Admission
 $r = -0.354$, $p = 0.034$



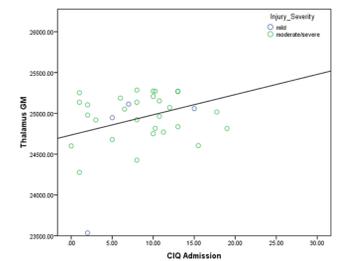
Thalamic WM
and DRS Admission
 $r = -0.362$, $p = 0.030$



Thalamic GM
and CNS Admission
 $r = 0.350$, $p = 0.036$

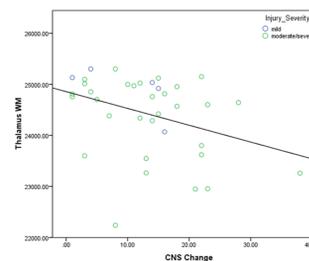


Thalamic GM
and CIQ Admission
 $r = 0.386$, $p = 0.024$

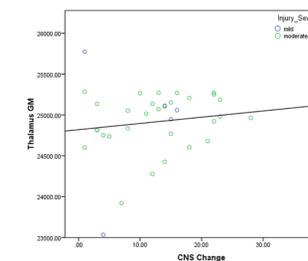


Anatomical structures associated with change in function

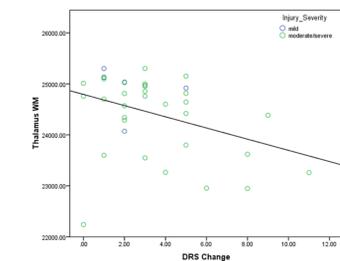
Thalamic WM
and CNS Change
 $r = -0.359$, $p = 0.032$



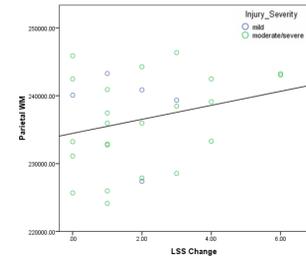
Thalamic GM
and CNS Change
 $r = 0.453$, $p = 0.006$



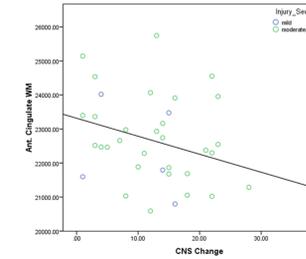
Thalamic WM
and DRS Change
 $r = -0.369$, $p = 0.027$



Parietal WM
and LSS Change
 $r = 0.397$, $p = 0.018$



Anterior Cingulate WM
and CNS Change
 $r = -0.342$, $p = 0.041$



Discussion & Conclusions

This study extends previous human and animal findings by showing an association between various neuroanatomical structures and functional outcome measures. These associations may provide further indication that certain structures including the thalamus may not only play a role in mediating cognitive function but also functional ability. These data also support the role of structural MR imaging in rehabilitation programs.

References

- Ashley MJ et al. Brain Injury. 1997;11(9), 677-90.
 Ashley MJ & Persel CS. Journal of Rehabilitation Outcome Measures. 1999; 1(5), 33-41.
 Malec, J. The Center for Outcome Measurement in Brain Injury. 2005
 Rapport M et al. Archives of Physical Medicine and Rehabilitation. 1982; 63, 118-123.
 Willer B et al. American Journal of Physical Medicine and Rehabilitation. 1994; 73, 103-111.

Acknowledgements

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