

Regional brain volume change following Traumatic Brain Injury

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Introduction

Traumatic Brain Injury (TBI) accounts for the majority of explosive blast injury and combat casualties in recent conflicts, with mild TBI being the most frequent pattern of injury among this group. It has been reported that TBI results in brain atrophy that takes for months, perhaps even years to develop after injury [1]. This atrophy can continue in the chronic phase of TBI and even during their clinical recovery from the initial injury. Quantitative analysis of brain volume might contribute to the understanding of TBI's pathogenesis. Quantitative studies using SIENA (<http://www.fmrib.ox.ac.uk/analysis/research/siena>) or Voxel-based Morphometry (VBM) on global and regional brain volume have been reported [1,2]. Our analysis was based on Freesurfer (Martinos Imaging Center, <http://surfer.nmr.mgh.harvard.edu/>) processing. First, we segmented all subjects' T1 image by Freesurfer. Then, regression between regional brain volume and time after injury and age was calculated.

Methods

Image acquisition: One hundred seventy four (174) documented TBI patients (166 males, 8 females, mean age=33.2±7.6 years, time after injury =919.4±711.8 days) and thirteen (13) healthy controls (HC) (mean age=30.9±8.3, 9 males and 4 females) were enrolled in this study. All participants were imaged on a 3T scanner (GE 750, GE Healthcare, Milwaukee, WI) equipped with a 32-channel phased array head coil. Whole brain high resolution structural MRI T1 images were acquired in the sagittal plane by a 3D BRAVO sequence with the following parameters: TR=6.64ms, TE=2.52ms, Flip angle=12 and FOV=24cm, acquisition matrix=512x512, 156 over -contiguous slice with thickness=1.2mm and an acceleration factor of 2.

Image analysis: Structural T1 images were segmented using Freesurfer 5.1 as described by Fischl et al., [3]. Volumes of 8 ROIs (accumbens, amygdala, caudate, hippocampus, pallidum, putamen, thalamus and ventricle) were calculated by Freesurfer. The volume comparison between health control group and TBI patient group was performed based on these ROI volumes. Linear regression between ROI volume of TBI group and their demographical data were calculated. In addition, ROIs volumes were also normalized by intracranial volume (ICV), which was also obtained from the Freesurfer data. And a subgroup of TBI patients (n=35) with time after injury less than 1 year were analyzed separately with the same method.

Results

Figure 1 shows the volume comparison between health control group and TBI group. There is no significant difference between these two groups. The whole TBI patients group didn't show significant relationship between ROIs volume and their time after injury (Figure 2. Top line). But the subgroup analysis of TBI patients with time after injury less than year showed significant relationship between some ROIs in the accumbens and putamen when correlated with their time after injury (Figure 2. Bottom line). Both accumbens and putamen region volumes showed decreasing volume with time since injury. This pattern was reported in previous study [1]. Subjects' regional brain volumes were normalized by the ICV data to remove the effect due to individual's brain size. And a multiple linear regression was performed between normalized volume and age and time after injury. The result is showed on Table I (red numbers indicate p<0.05). In Table I, both accumbens and putamen still showed strong relationship with time after injury, both volumes demonstrated decline as a function of time since injury. In addition, putamen and lateral ventricle regions also showed strong relationship with the age, putamen area volume showed decline with age, but the ventricle volume increased with age. This result was consistent with the previous report too [4].

Conclusion

Our study found that regional brain volume of TBI patient had a strong relationship with both time since injury and age. Volumes of some regions (accumbens and putamen) demonstrated decreases with time since injury. In addition some regions' volumes were also changed with age. Our result is consistent with previous studies, in which changes of global and region brain volume of TBI patients were observed. However, the relationship between the loss of brain tissue and the functional performance still remains unclear. It is possible that chronic stress or hyperactivity which is often described in TBI and PDST subjects contributes to the changes in volume over time. Future studies between TBI patient's regional volume and their clinical performance will be helpful to understand it.

References

1. A.Sidaros, A.Skimminge, et al., *Neuroimage*, 2009, 44: 1-8
2. B.B. Bendlin, M.L.Ries, et al., *Neuroimage*, 2008, 42, 503-514
3. B.Fischl, D.H.Salat, et al., *Neuron* 2002; 33: 341-355.
4. Y. Ostby, C.K. Tamnes, et al., *The J. of neuroscience*. 2009; 29(38): 11772-11782

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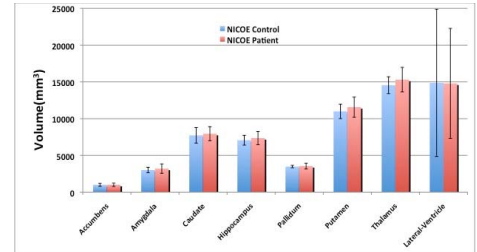


Figure 1 Volume comparison between HC and TBI

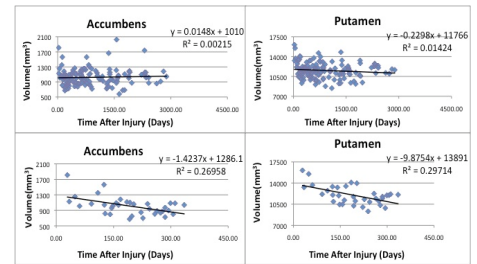


Figure 2 TBI patients volume linear regression with time after injury

	Beta (raw)	R2(raw)	P value (raw)	Beta (norm)	R2(norm)	P value (norm)
Accumbens	-0.2, -1.5	0.272	0.975, 0.004	-3.7, -1.2	0.260	0.4831, 0.0113
Amygdala	1.6, -2.3	0.117	0.913, 0.068	-12.5, -1.4	0.075	0.4621, 0.3231
Caudate	9.2, -4.2	0.136	0.702, 0.041	-19.9, -2.4	0.117	0.3676, 0.1973
Hippocampus	5.0, -2.2	0.045	0.829, 0.250	-22.3, -0.5	0.047	0.3224, 0.791
Pallidum	-0.3, -1.6	0.107	0.981, 0.089	-13.2, -0.7	0.103	0.204, 0.4473
Putamen	-55, -8.0	0.344	0.127, 0.008	-97, -6	0.419	0.004, 0.041
Thalamus	-6.0, -2.0	0.019	0.884, 0.522	-58, 1.0	0.107	0.070, 0.688
Lateral-Ventricle	433.7, 8.14	0.325	0.003, 0.476	400, 10.14	0.2997	0.0066, 0.3837

Table I Regression analysis with age and time after injury

changes of global and region brain volume of TBI patients were observed. However, the relationship between the loss of brain tissue and the functional performance still remains unclear. It is possible that chronic stress or hyperactivity which is often described in TBI and PDST subjects contributes to the changes in volume over time. Future studies between TBI patient's regional volume and their clinical performance will be helpful to understand it.