Hemorrhagic lesions and its clinical correlation based on venous and arterial damage in Traumatic Brain Injury

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Introduction: Traumatic Brain Injury (TBI) is a major cause of death and disability all over the world. Hemorrhagic blood is a clinical diagnosis biomarker. Susceptibility Weighted Imaging (SWI) is most sensitive non-invasive method to detect any bleed [1]. During TBI veins and arteries undergo significant level of stresses and strains. It can easily cause a vessel wall to break down. Recovery after vessel breakage is significantly different depending on the type of vessel, location of the rupture and severity of the damage. The main objective of this study is to investigate the spatial relationship between hemorrhagic bleed and different types of vessels, e.g. veins vs. arteries, as well as its relationship with TBI patients' clinical and outcome information.

Materials and Method: A total of 28 TBI patients were recruited with written consent. Patients' group mean age was 40.51 ± 15.72 years. Patients were scanned 360.19 ± 490.21 days post injury. Mean Glasgow Coma Scale (GCS) score was 8.46 ± 4.37. Mean Extended Glasgow Outcome Scale (GOSE) score was 6.21 ± 1.54. All MRI data were collected on a 3-Tesla Siemens Verio scanner with a 32-channel radio frequency head coil (Siemens Medical Solutions, Erlangen, Germany). SWI parameters were: TR/TE of 30/20ms, Flip angle of 15 degree, bandwidth of 100 Hz/Px, field of view (FOV) of 256x256 mm2, 25% oversampling, slice thickness of 2 mm, total 64 slices, 20% distance factor, GRAPPA iPat factor of 2 and resultant voxel size of 0.5x1x2 mm^3.

All SWI images were analyzed using our in-house software SPIN. 4 slices (8mm) were minimally intensity projected (mIPed) onto one slice to visualize the continuity of vessels. All hemorrhagic bleeds were confirmed by our neuroradiologist. In a robust semi-automatic approach, 25% of the mean background signals intensity was decided as a threshold to quantify volume. If a bleed is connected with a vein, it is being defined as venous bleed; otherwise, called free standing bleed. If more than 50% of bleeds in a patient is associated with veins, this patient would be classified as venous bleeding patient; otherwise, freestanding bleeding patient. IBM analytical tool SPSS 21.0 (SPSS, Inc., Chicago IL) was used for the statistical analysis. Correlations between number of bleeds and bleeding volume with GCS and GOS-E scores were performed. Group comparison was also performed using by using ANOVA. Groups were divided based on venous association of the bleed and freestanding bleeds.

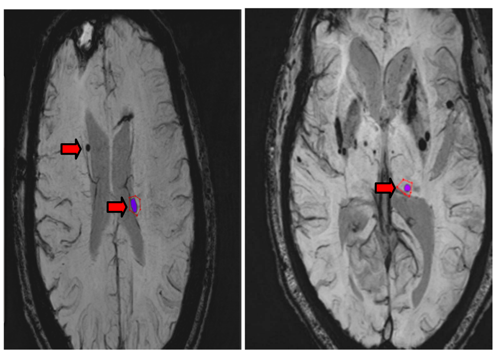
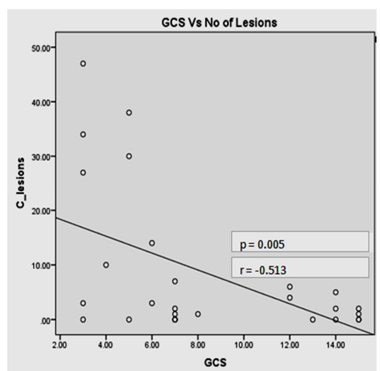
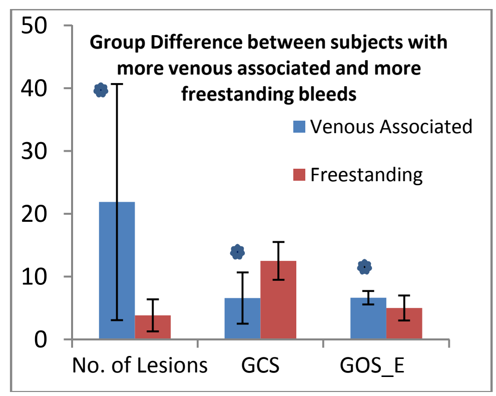


Fig.1: (Left) Bleed associated with veins (Right) Freestanding bleed



Plot 1: Correlation between GCS score and Number of lesions associated with Veins (p=0.005, r= -0.513)



Plot 2: Group Difference between subjects with more venous associated and more freestanding bleeds

Results: Total number of lesions including freestanding bleeds, number of lesions associated with veins and volume of lesions associated with veins were inversely correlated with GCS (p = 0.009, 0.005 (Plot 1), 0.011 respectively). Number and volume of freestanding bleeds did not show any correlation with GCS or GOS-E. In group analysis, the group with more venous associated bleeds showed significantly high number of bleeds, lower GCS and higher GOS-E score (p=0.03,0.007,0.03 respectively, Plot 2). Also significantly high number of lesions were observed in the group with GCS lower than 9 with p=0.039. No significant lesion volume difference between the two groups with different GCS was observed.

Discussions and Conclusion: Number and volume of the lesions associated with veins are inversely correlated with GCS score. Also, group with lower GCS has higher number of lesions. This suggests that number and volume of the lesions could be an indicator of the injury severity in early stages. Arteries face continuous high blood pressure compared to veins. So structurally they are more robust and contain more elastic fibers and smooth muscle. Higher number of bleeds associated with veins suggests higher degree of venous fragility. This is in line with earlier published data suggesting that arteries can withstand almost double amount of stress compared to veins before breaking down [2]. The group with more free standing bleeds has worse GOS_E outcome score compared to the group with more venous associated bleeds. This might indicate that once damaged, recovery is slower on the arterial side. One possible explanation could be that unlike arterial system, venous system shows some degree of redundancy in blood drainage. But there is no 'bypass' way for arterial blood supply. Few more comprehensive studies are required to observe the role of different vessels in the event of trauma and how different insults lead to different levels of injury severity and different outcomes. This could be very valuable information while assessing the injury severity at early stage and also in deciding future medication.

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