High resolution susceptibility weighted imaging (SWI) improves detection of hemorrhagic lesions in adults with traumatic brain injury: correlation with severity of injury and outcome.

K.A. Tong[1], B.A. Holshouser[1], L. Shutter[1], P. Chiou[1], G. Herigault[2], E. M. Haacke[2].

[1]Loma Linda University, Loma Linda University Medical Center, 11234 Anderson Street, Loma Linda, California U.S.A.;
[2]The MR Institute for Biomedical Research, 8706 Manchester Road, Ste. 102, St. Louis, Missori U.S.A.

High resolution susceptibility weighted imaging (SWI) was shown to be superior to conventional gradient echo (GRE) in detecting hemorrhages caused by traumatic brain injury (TBI). More lesions were present and were more visible on SWI compared to conventional GRE. Patients with lower Glasgow Coma Score (GCS) at initial evaluation were found to have a greater number of lesions and larger areas of signal loss in regions of hemorrhage. The number of hemorrhagic lesions detected shortly after injury also correlated with severity of subsequent outcome. SWI can improve diagnosis of hemorrhagic brain injuries and potentially predict outcome after TBI.

Introduction

Traumatic brain injury (TBI) is a leading cause of disability. The health care cost of brain injury remains high, even with improvements in treatment. Diffuse axonal injury (DAI) is a major complication of traumatic brain injury that can result in death or serious long-term morbidity. Unfortunately, DAI is difficult to visualize with conventional radiologic imaging due to its microscopic nature, and often remains an uncertain clinical diagnosis in the initial period. Although computed tomographic (CT) scanning and magnetic resonance imaging (MRI) have improved the diagnostic evaluation and initial treatment of acutely injured patients, both techniques have limitations in identifying shearing lesions associated with DAI, when compared to pathologic studies. As a result, neurodiagnostic imaging studies have shown poor correlation with clinical outcome in the setting of DAI.

Purpose

The purpose of this study was to compare a new high resolution susceptibility weighted imaging (SWI) sequence to conventional gradient recalled echo (GRE) imaging in their ability to detect hemorrhage caused by traumatic brain injury, particularly diffuse axonal injury. In addition, we evaluated the utility of this sequence to determine severity of neurologic injury and to predict outcome after TBI.

Material & Methods

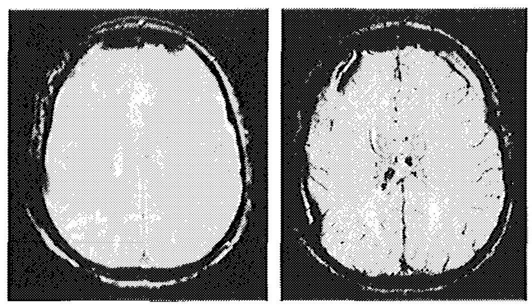
Eleven patients (aged 14 to 71) were imaged in the initial post-traumatic period (mean = 6 days). A standard MR protocol was performed, including conventional gradient echo imaging, to which a new SWI sequence was added. A high resolution SWI sequence was performed using a 3D GRE sequence with a TR=57 msec, TE of 40 msec, flip angle of 20 degrees, FOV = 160 x 256 mm^2 with a matrix size of 160 x 512, 32 partitions with 2 mm thickness, low bandwidth (78 Hz/pixel), and gradient moment nulling in all three orthogonal directions. Post-processing of the images was performed to enhance the signal loss caused by microscopic hemorrhage by multiplying the original magnitude contrast images by a normalized phase mask created from the corresponding phase-contrast images. The number of hemorrhagic lesions detected in the SWI sequence were compared to the number of hemorrhagic lesions detected on the conventional GRE imaging. The number of lesions and total volume of signal loss created by the hemorrhagic lesions on SWI were compared to the initial Glasgow Coma Score (GCS) as well as short-term outcome as determined by Glasgow Outcome Score (GOS) at 1 month after trauma.

Results

Lesions on SWI were more visible than conventional GRE. (see figure). The majority of lesions were small, measuring less than 5 mm in maximum dimension. The SWI sequence detected approximately 3.8 times more lesions than the conventional GRE sequence. SWI detected 1005 hemorrhagic DAI lesions compared to conventional GRE which detected 266 lesions. The number of hemorrhagic lesions determined by SWI correlated inversely with GCS at the time of initial evaluation. In addition, the degree of hemorrhagic injury correlated with severity of subsequent clinical outcome. Patients with severe outcome at 1 month (n=3) had a total of 157 hemorrhagic lesions; patients with moderate outcome (n=5) had a total of 77 lesions; and patients with mild outcome (n=3) had a total of 51 lesions.

Conclusion

There is improved visibility of hemorrhagic injuries using SWI compared to GRE. SWI demonstrates significantly more hemorrhages than conventional gradient echo imaging and therefore promises an increased ability to diagnose diffuse axonal injury. In addition, the correlation of hemorrhagic lesions to outcome suggests that this sequence will be beneficial in predicting long-term sequelae after traumatic brain injury.



GRE SWI