Serial MRI Studies of Mild Head Injury Indicate Significantly Increased Cerebral Atrophy within the First 6 Months

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Synopsis: Recent studies show that disability is common after even apparently mild head injuries. The extent to which this reflects direct sequelae of brain injury or social, psychological and environment factors is unclear. Measurements of change in brain volume between one and six months after injury were made in 40 patients referred to a Neurosurgical Department. In 30 patients whose injury was initially judged to be mild, the mean decrease in brain volume was by 16.3ml which was significantly greater than the decrease in volume that could be attributed to normal ageing over this period (0.6ml, p<0.001) and similar in extent to the change in volume in more seriously brain injured participants.

Introduction
The remarkably high rate of disability after what can appear clinically to be initially a mild injury has only recently been recognised (1). A year after injury almost 50% of survivors who did not have severe impairment of consciousness in the acute stage suffer either moderate or severe disablement. An understanding of the factors involved, especially the inter relationships between the consequence of brain injury and social, psychological and environment factors, is of immense clinical and economic significance. We report measurements of change in brain volume between one and six months after injury in a series of head injured patients.

Methods
Patients The patients studied had been admitted to the Glasgow Neurosurgical Unit. Judged by their Glasgow Coma Score on arrival at hospital, 30 had only a mild diffuse brain injury (GCS 13-15) and 10 had a more severe brain injury (GCS 3-12).

MRI studies were acquired at 1 and 6 months after head injury. 40 patients were studied (35 male, 5 female), with an average age of 33.4+/-13.4 years. This weighting towards males is reflective of the pattern of head injury in the West of Scotland. All patients were sufficiently well to be imaged as outpatients at both time points.

MRI This was performed on a 1.5T Siemens Magnetom using a sequence previously described (2). The sequence is an IR sequence with a series of 180 degree refocussing pulses providing a final TE of 600msec, a TI of 400ms and a TR of 5000msec. The slice thickness of the single slice acquired is 200mm to encompass the whole head in the sagittal orientation. The extended echo time, combined with the TI of 400msec which is midway between the null points of grey and white matter, serves to effectively eliminate signal from all brain tissue (3), producing a CSF only image. The signal level in each pixel is then proportional to the amount of CSF within it and this can be related to absolute volume by simultaneously imaging a calibration vial with a known quantity of CSF analogue (4).

The advantage of this single slice technique over the more conventional planimetric approach, where total brain volume is measured directly, perhaps 100 slices have to be analysed with the ROI in each having to be carefully defined to distinguish between these processes.

Results
Thirteen patients with an initially mild brain injury showed a mean total CSF volume at one month post injury of 121.6+/-33.5ml, increasing at 6 months to 137.9+/-38.0ml. For those with more serious injury the figures were 121.0+/-21.4 increasing to 138.2+/-36.8.

Loss of brain tissue, with the commensurate increase in CSF, is a natural consequence of ageing. A number of groups have investigated this and generally have found a small linear decrease between the ages of 20 and 60 (which encompasses the age range of the patients in this group) at which point the decrease tends more to the exponential (5). Overall the linear region losses have been estimated at 1% per decade or less for men, but with women showing losses of only 0.1%. We will take the higher 1% figure as more representative because of the preponderance of men in our patient group. Assuming a 1% loss per decade on an average brain size of 1400ml, represents a mean loss of only 0.6ml over a five month period.

The difference between the measured 16.3 ml loss (SD of difference 20.7) in the mild group and the expected 0.6ml loss associated with normal changes is significant at p<0.001. The 17.2 ml loss (SD of difference 29.7) in the more severe injury group was significant at p=0.05.

Discussion
These results show that progressive reduction in brain volume can occur between one and six months after head injuries of a range of initial severities. We think that this change in volume reflects progressive atrophy of cerebral substance as a result of degenerative processes instituted by the acute injury. Damaging processes in the acute stage include diffuse include axonal injury, contusions of the cerebral cortex and ischaemic damage to white and grey matter as a result of a range of intracranial and extracranial complications of injury. Post mortem findings in patients dying late after a head injury include diffuse atrophy of cerebral white matter due to resorption of injured axons and focal tissue loss due to resorption of injured tissue in areas of contusion and ischaemia. The present study does not distinguish between these processes.

Whilst swelling is well recognised in the acute stage of head injury, previous reports indicate that its resolution is largely completed within the first week of injury (7) and therefore is unlikely to be a factor in the first examination at one month. Indeed the volumes found at that time point are typical of the normal values for a group of predominantly male patients of this average age.

The occurrence of such brain atrophy after an injury that is apparently mild in the acute stage as well as after more serious injuries has not been previously reported. Our findings support the view that there should be considerable caution in categorising an injury as mild simply on the basis of consciousness on arrival at hospital and point to organic changes within the brain as playing a part in the sequelae that are now recognised to follow such injuries.

References