

# Sequelae of Mild Closed Head Injuries

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Thirty-nine minimal to mild closed head injuries without neurological signs were evaluated by a series of clinically available psychometric tests to determine the presence of identifiable intellectual deficits, rate of recovery, and personality or occupational changes. Even minimally head-injured patients suffer measurable cognitive deficits and occupational and behavioral changes.

The incidence of head injury is conservatively estimated to be four of 1,000 people per year in the United States. Twenty-five percent of these injuries are considered serious. The number of persons with residual deficits following head injury at large is unknown.<sup>1,2</sup> The outcome and prognosis of severe head injury has been well documented.<sup>3-10</sup> There is increasing evidence that the major barriers preventing return to preinjury occupational and social function are personality and intellectual deficits rather than neurological or physical disabilities. The former can exist without the latter.<sup>11,12</sup>

It is the so-called mildly to moderately head-injured group (post-traumatic amnesia for less than 24 hours to less than one week or hospitalization for less than one week) who most likely will escape neurological or physical disabilities. This group is typically not seen by health care professionals as disabled and after discharge is left to its own resources. This group, however, is the one most likely to have psychological, social, and behavioral problems,<sup>11,13,14</sup> and an estimated 20 percent of this group will ultimately be considered disabled. The most obvious, costly manifestation of this disability is failure to return to work.<sup>9,15,16</sup> The potential disabilities go unrecognized at the

time of injury, and there is an absence of programs directed at identification, modification, or prevention of disability in this group.

This paper addresses a practical method of identifying and monitoring the minimally to moderately brain-damaged person.

## Methods

A prospective study using psychometric tests thought to be sensitive to cognitive deficits following minimal brain injury was constructed. The population consisted of subjects who entered Harborview Medical Center with a closed head injury; were retained in the hospital for at least 24 hours; demonstrated initially lethargy, mental confusion, unconsciousness, amnesia, or disorientation; were thought to be employed at the time of the traumatic event; and were discharged to their own care within two weeks of admission without neurologic sequelae to the head injury.

The sample was drawn from consecutive admissions to the Harborview Medical Center over a period of 28 months from May 1978 to September 1980. The subjects were interviewed and tested within one week of their injury and again at six months after the injury. The following tests were used:

1. The Wechsler Adult Intelligence Scale (WAIS), the most commonly used, standardized, individually administered test of intellectual abilities. Subtests used were information, comprehension, arithmetic, similarities, digit span, digit sym-

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bol, picture completion, and block design.<sup>17</sup>

2. The Erickson Memory Scales, a paired-associate learning task in which pairs of words and pictures are learned to criterion and recall is tested 20 minutes later. A subject's score consists of the number of trials necessary to reach criterion.\*

3. The Paced Auditory Serial Addition Test (PASAT), a test purported to evaluate the rate of information processing. The test consists of four trials of 61 digits recorded every 2.4, 2.0, 1.6, and 1.2 seconds, respectively. At each trial, the appropriate series of digits is played to the subject, who is instructed to add each digit to the one immediately preceding it and give the answer. In the digit string 2,4,8,9,3, for example, correct responses would be 6,12,17,12. The average time taken for each correct response on the four trials is averaged to give a complete composite time score.<sup>18</sup>

4. Trails A and B of the Trails Making Test, in which the subject is asked in Part A to draw lines to connect consecutively numbered circles, and in Part B to connect consecutively numbered and lettered circles, alternating between numbers and letters. The number of seconds required to complete the task correctly gives a subject score.<sup>19</sup>

5. Part 1A of the Edwards Personality Inventory Scales of the Rehabilitation Indicators Project, in which a close associate is asked to describe the subject. The Edwards Personality Inventory Scales is a true-false personality inventory consisting of 300 descriptive statements phrased in the third person.<sup>20</sup>

6. The Social Leisure Form of the Rehabilitation Indicators Project, a record elicited from the subject or a close associate indicating the frequency with which the subject engages in various social and leisure-time activities.<sup>21</sup>

The same psychometrist who administered the tests to the subjects and their close associates repeated the tests six months later at a home visit. At this time the subjects were questioned as to whether they had returned to a work position the same as or similar to that occupied before the injury. The subjects and the close associates were also asked whether they perceived the subjects to be functioning at a level similar to that prior to injury. The results were then statistically analyzed.

\*A copy of the test may be obtained from Richard C. Erickson, Department of Psychology, Veterans Administration Hospital, Portland, Oregon.

## Results

Sixty subjects were interviewed according to the criteria outlined above. Five subjects were eliminated from the study because their hospital stays extended beyond the two-week limit. Sixteen subjects either refused the evaluation or were lost at the six-month follow-up. Complete data were available on 39 subjects.

The population of the study consisted of 29 (74.3 percent) adult men and 10 (25.7 percent) adult women. Their mean age was 28.2 years (range 16 to 58 years), the mean education level was 12.46 years, the mean hospital stay was 5.92 days (range 2 to 13 days), and the mean period of post-traumatic amnesia (PTA) was 5.65 days (range 30 minutes to 3 months).

All tests pertaining to cognitive function showed a change toward improvement over a six-month interval. Statistically significant changes, however, were confined to those tests that were influenced by motor speed, efficiency of new learning, and memory—specifically the WAIS picture completion, digit symbol, performance IQ estimate and full-scale IQ estimate, the PASAT, the Trails Making Test, and the Erickson Memory Scales. No statistically significant differences were found among means on any of the Edwards Personality Inventory Scales. Only one of the Social Leisure Form activity scales means, the medical/social use scale, reached significance.

Table 1 displays the proportion of subjects classified as impaired by each test at the initial testing and at the time of follow-up. Cutoff scores have been suggested by the authors of each test for defining abnormal cognitive performances on the PASAT, the Erickson Memory Scales, the Trails Making Test, and the WAIS. On the PASAT anything under 3.20 seconds per correct response is classified as "normal." The range between 3.20 and 5.00 seconds is classified as "borderline," and "impaired" is classified as anything over 5 seconds per correct response.

On the Trails Making Test, a total score of more than 129 seconds is considered "abnormal." On the Erickson Memory Scales, a total score of greater than 59 trials is considered "abnormal."<sup>22</sup> The system used on the WAIS is a scatter index suggested by Selz and Reitan.<sup>23</sup> The index is the difference between the largest and smallest subscale scores divided by the mean of subscale

**Table 1. Proportion of Subjects Classified as Impaired by Each Test at Initial Testing and Follow-Up**

Test	Initial Test No. (%)	Follow-Up No. (%)
PASAT		
Normal	4 (11)	16 (43)
Borderline	13 (35)	9 (24)
Impaired	20 (54)	12 (32)
	$(\chi^2=40.43^*)$	
Trails (Total)		
Normal	19 (49)	29 (74)
Impaired	20 (51)	10 (26)
	$(\chi^2=10.26^*)$	
Erickson (Total)		
Normal	6 (17)	21 (54)
Impaired	30 (83)	18 (46)
	$(\chi^2=42.30^*)$	
WAIS Scatter Ratio		
Normal	35 (90)	36 (92)
Impaired	4 (10)	3 (8)
	$(\chi^2=0.36, NS)$	

\*P < .01

scores. A ratio of greater than 0.99 is considered "abnormal."

As can be seen in Table 1, the proportions of subjects classified as impaired improved with time. This improvement was significant for the PASAT, the Trails Making Test, and the Erickson Memory Scales. There were no significant differences between the proportions on the WAIS scatter ratio. It should be noted, however, that in spite of significant improvement, a large percentage of subjects were still classified as performing in the impaired range on those tests involving new learning (the Erickson Memory Scales), rate of information processing (the PASAT), and speed of hand-eye activities (the Trails Making Test) at follow-up.

The relationship between the length of PTA and measures of dysfunction was also examined. No statistically significant correlations were found between the length of PTA and performance on any of the tests. The same was true for correlations calculated between PTA and initial test scores, PTA and follow-up test scores, and PTA and change in test scores.

**Table 2. Personality Changes Reflected by PASAT Performance Categories vs Judgments of Others**

PASAT Category	Judgment by Associates			
	Initial		Follow-up	
	Changed No. (%)	Un- changed No. (%)	Changed No. (%)	Un- changed No. (%)
Normal	2 (5)	2 (5)	4 (11)	12 (32)
Border- line	5 (14)	8 (22)	7 (19)	2 (5)
Impaired	11 (30)	9 (24)	7 (19)	5 (14)
	$(\chi^2=1.57, NS)$		$(\chi^2=18.63, P < .01)$	

Table 2 illustrates the relationship between PASAT performance and adjudged change in the subjects' personality after injury. At the six-month follow-up, a significant relationship was found between judgments of change and performance on the PASAT. Those who performed in the borderline or impaired categories on the PASAT at follow-up tended to be seen by others as most likely to have changed. On the other hand, no statistically significant relationship was found between duration of PTA, scores on the WAIS, the Erickson Memory Scales, or the Trails Making Test, and any of the measures of personality in Social-Leisure Form Activity Scale and the change/no-change groups.

At the six-month interval, there was a significant decrease in the number of employed patients: 33 (90.9 percent) vs the previous number of 37 (94.9 percent) ( $\chi^2 = 8.43, P < .01$ ). This percentage of employment is greater than that reported by others,<sup>24</sup> but this study population differs in that employment is recorded at six months and the educational level, at a mean of 12.46 years, is higher.

## Discussion

There has been an increasing awareness that personality and intellectual changes are the major barriers to the return to preinjury level of function in those who are brain injured.

This study was undertaken to determine whether there were measurable personality and intellectual deficits in otherwise normal-appearing patients who suffered what was considered mild to moderate head injury. Clinically available tests

that could be administered in a community hospital or office were sought to identify important post-injury deficits and to monitor the evolution of recovery. It was hoped the study would also provide some insight into the presence or absence of behavioral changes and occupational status of the mildly brain-injured patient and a method to identify such changes objectively.

The majority of the subjects in this study did experience a significant decrease in cognitive function immediately following the injury. A surprising number (26 to 56 percent) were still showing signs of intellectual deficit six months following the injury. These deficits were identified by three clinically available tests: the PASAT, the Trails Making Test, and the Erickson Memory Scales. This percentage seems to agree with the judgment of the patients' close associates, who reported personality changes in 18 subjects (46 percent).

Duration of post-traumatic amnesia, however, was not found to be helpful in estimating the severity of deficits, rate of recovery, occupational status, or personality changes following the injury. These findings agree with those of Mandelberg and Brooks,<sup>7</sup> Russell and Smith,<sup>25</sup> and Wrightson and Gronwall.<sup>26</sup>

Of all the measures employed, the PASAT agreed most with the perception of subjects and their close associates regarding postinjury changes. None of the tests performed provided a basis for estimate of the time that might be required for recovery.

Despite the absence of neurological signs, there is evidence of significant brain dysfunction in those who suffer mild closed head injury. These deficits can be identified through use of simple psychometric tests. The battery of tests employed took approximately one hour to administer.

A delay in return to competitive occupation can be anticipated as the result of mild to moderate head injury. Patients and close associates can be forewarned that the injured person has suffered intellectual deficits and may not function at the preinjury level for six months or more. Despite deficits, the majority may return to work effectively, but a somewhat reduced efficiency can be expected.

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