Article *NIMHANS Journal*

Neuropsychological and Clinical Recovery in Patients with Head Trauma

Volume: 05 Issue: 01 January 1987 Page: 23-31

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Reprints request

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Abstract

A prospective study of 42 patients with head trauma was conducted with the aim of determining the clinical recovery pattern and its relationship with the recovery of neuropsychological functions. Clinical evaluation was carried out at admission, fifteen days, one month, three months, and one year after the trauma. Neuropsychological assessment was made during the first month, third month, and at the one year follow up. Functions assessed were attentional processes, mental arithmetics, psychomotor functions, ideational fluency, visuospatial perception, and verbal and visual learning and memory functions. Results showed that maximum rate of clinical recovery was evident in the first month after the trauma, whereas neuropsychological deficits persisted. Significant recovery of ideational fluency, psychomotor functions, and verbal learning and memory functions occurred by the third month. Modality specific attentional deficits, impairment of visual learning and mental arithmetics were present in the third month assessment, and these deficits continued to persist even in the one year assessment. The findings are indicative of a discrepancy in the recovery rate of right and left hemisphere functions, with the right hemisphere functions showing slow or poor recovery.

Key words -

Head trauma,
Neuropsychological deficits,
Recovery,
Right hemisphere functions

Clinical recovery in patients who have suffered from head trauma often precedes recovery from psychological deficits. Subtle neuropsychological deficits are found to persist even in patients who have shown good overall recovery [1]. Inadequate recovery of psychological functions can disrupt occupational, scholastic, and social adjustment of the patient [2], [3], [4]. Several studies [5], [6], [7], [8] have established that the magnitude of trauma as shown by neurological

deficits and the degree and duration of unconsciousness are major factors that determine outcome in the patient.

The present investigation was carried out with the aim of determining the course and pattern of clinical and neuropsychological recovery in a group of patients with moderate to severe head trauma. Specific objectives considered were to determine

(1) if recovery of psychological functions would be parallel to clinical recovery, and if not, the extent to which it may diverge from the course of clinical recovery.
(2) and whether recovery of various functions will follow a uniform pattern.

Material and Methods

The patients were drawn from those who had suffered from closed head trauma and who were admitted to the hospital in an unconscious state or immediately after recovering consciousness. They were kept in the head injury ward and assessed for seven to fifteen days. Score on the Glasgow Coma Scale was determined at admission and changes in the clinical status of the patient during the stay in the hospital were regularly monitored. 42 patients who were followed up for one year constituted the patient sample . On the coma scale two patients had scores of 4 and 5 each, 24 patients had scores in the 6-8 range, and 16 had scores in the 9-11 range. The mean age of the patient group was 33.2 years(SD=11.2) and there were 40 men and 2 women. Neurological abnormalities were mainly those related to pupillary and motor responses. At admission 8 patients had eye movement abnormalities and 29 patients had abnormal motor responses. During the third month assessment none had deficits of the former type, whereas 7 patients continued to show minimal abnormalities of motor responses, which persisted in 2 patients to a lesser degree as observed in the one year examination.

Neuropsychological assessment was carried out one month, three months, and one year after the head trauma. The patients' data were compared with that of a control group of 26 normals matched for age (Mean age=30.4 years, SD=13.8) and education. There were 16 men and 10 women in the control group. All the subjects were right handed. The neuropsychological tests used are described below and they form part of the neuropsychological battery standardized at this Institute [9], [10].

1.Attentional Processes.

(a) Presence of observable attentional deficits such as absence of spontaneous arousal of attention, distractibility and fatiguability of attention.
(b) Visual scanning ability.

Subtests 1 and 2. The subject was required to serially score out numbers printed randomly. The subtest 1 had 20 numbers whereas the second item had 48 numbers. The total time taken to score out all the numbers was considered as the index of performance.

2.Mental Arithmetics:

Ability to delay. Contains 10 problems and each problem had two parts presented sequentially at a time. The subject had to mentally solve the first part, and hold on to the answer and solve the second part, and then carry out a further addition or subtraction using the two answers. The number of total correct answers was the score.

3.Rhythm test :

The subject was required to tap with the fingers of both the hands rhythmically on the table. A series of

rhythms were used. It was judged if the subject could maintain the rhythm or not.

4.**Ideational fluency :**

Structured free association of naming of objects made of wood and round objects. Allotted time was 2 minutes for each stimulus word. The number of average correct responses was recorded.

5.**Visuospatial perception :**

Presence of deficits like spatial distortion, spatial disorientation, micrographia, macrographia and constructional apraxia, if any, were elicited. This function was tested in the fifth trial of the visual learning and memory functions test in which the subject had to copy a complex visual design.

6.**Visual integration and performance intelligence:**

(a) Koh's block design test and

(b) Alexander's passalong test from the Bhatia's Battery of Tests for General Intelligence [11].

The method of administration and scoring was as per the instructions given in the original battery . A performance quotient could be derived from the scores on these tests and it could be compared with the normative data of the battery [12]. As the tests involve visual spatial analysis and synthesis, it was considered as appropriate tests to assess visual integrative functions.

7.**Verbal and visual learning and memory functions:**

(a) Verbal form: The test [9] consisted of a complex passage similar to the one used in the logical association item in the Wecshler Memory Scale. The passage was read out and the subject was instructed to reproduce it immediately. Three trials were given consecutively, and after the immediate recall in the third trial, the subject was told that he would be asked to reproduce the passage from memory 10 min later. The number of units of information correctly reproduced in the immediate and delayed recall were scored.

(b) Visual form: The test [9] consisted of a complex visual design printed on a 15cm × 10cm card. The design was displayed to the subject for 10 sec and he was instructed to reproduce it immediately from memory. Three consecutive trials were given as in the case of the verbal form with the same stimulus material, and after the immediate recall in the third trial he was told that he would be asked to reproduce the design from memory 10 min later. After the delayed recall he was instructed to copy the design and this performance was used to asses visuo-spatial perceptual functions. The number of units of the design correctly reproduced was scored other than the presence of focal deficits.

The patient and a close relative were interviewed in detail to elicit information regarding changes in the family and social interaction, occupational or scholastic interests and affective responses of the patient after the trauma.

Results

32 (76%) patients were neurologically normal at the time of the one month assessment. Comparision with the control group showed highly significant differences indicating poor performance of the patient group on the various neuropsychological tests. 18 patients could not be tested and the others performed poorly on the tests. Hence only the results of the third month and the one year assessments are presented here with statistical analysis. Other than the comparisons of the group means, number of

patients who had shown scores greater/lesser than 2 standard deviations of the means of the control group were also found so as to obtain an approximate picture of the incidence of impairment in the patient group.

Table 1 - Mean score (in secs) and standard deviations in the visual scanning test of the patients and the control groups, and X^2 values of the median test

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Table 2 - Mean scores and standard deviations on the ideational fluency test in the patients and the control groups and T values

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Table 3 - Mean and standard deviations on the mental arithmetics - delayed response ability test in the patient and the control group and T values

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Table 4 - Mean scores and standard deviations on the verbal learning and memory functions test in the patients and the control group and T values

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Table 5 - Mean scores and standard devations on the visual learning and memory functions test in the patient and the control groups and T values

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Tables 1-5 depict the means and standard deviations of the two groups on different neuropsycholagical tests during the third month and the one year assessments respectively and the results of T test or median test for significance of the difference between means.

During the third month examination 83% of the patients were found to be neurologically normal. Neuropsychological assessment showed impairment on tests of visual scanning, visuospatial organisation, mental arithmetics, delayed response, visual integration, and visual learning and memory functions. Compared to the control group, the patient group did not have significant mean differences in the ideational fluency, and verbal learning and memory functions tests (Tables 2 & 3). On the rhythm test 10 patients could not reproduce the rhythm. Though they performed poorly on mental arithmetics they did not have arithmetical difficulty when they were asked to carry out calculation on paper. The number of patients who had shown scores greater/lesser than two standard deviations of the control group in the direction of impairment, in the third month assessment, were 31 (73.8%) in visual scanning, 29 (68.3%) in mental arithmetics, 5 (12.4%) in verbal learning and memory functions, and 33 (78.6%) in visual learning and memory functions. With respect to visuospatial perceptual

organisation the most significant deficit was missing the contents of the complex figure. 18 (42.9%) patients missed more than 75 % of the contents. There was no evidence of any significant spatial-perceptual deficit in their copying. The mean PQ of the group was 76 (SD=36.5) and 21 (50%) patients had scored PQ less than 80.

Assessment one year later revealed that the mean scores of the patient group on various tests showed improvement. Group mean comparisons showed that performance on ideational fluency, rhythm test, visuo-spatial perceptual organisation, PQ and verbal learning and memory functions had normalised. Significant impairment continued to be seen on visual learning and memory functions test, visual scanning and mental arithmetics. The number of patients who showed impairment in terms of deviations greater than 2 standard deviations were 26 (62.0%) in visual scanning, 30 (72.0%) in visual learning and memory functions, and 23 (54.5%) in mental arithmetic-delayed response test, 8 (19%) patients continued to exhibit impairment in verbal learning and memory functions. With respect to spatial organisation 8 patients (19%) continued to have difficulty while copying the figure. All the patients successfully reproduced the rhythm in the one year assessment. The mean PQ was 90.2 (SD=27.8) and there were 10 patients who had PQ between 60 and 80 and none had less than 60.

Comparison of the delayed recall in the fourth trial with the third trial of both visual and verbal learning and memory functions tests showed that there was no loss of information during the interval of 10 min as they could reproduce as many units of information as they could in the third trial.

Interview with the patients and relatives during the one year assessment revealed that 29 patients had developed social inadequacy in terms of social withdrawal, social incompetence, and reduced self confidence. Though no gross emotional disturbances were reported, reduced affect, greater irritability and impulsivity were frequently reported in these patients.

Discussion

Clinical data showed that marked clinical recovery occurred during the first three months after the head trauma except in two patients who presented with minimal motor abnormalities even after one year. The rate of recovery was maximum during the first month and those deficits that persisted after this period disappeared gradually but the patients were totally asymptomatic, except two, by the end of the third month. A faster clinical recovery compared to psychological recovery was indicated by the first and the third month assessments. The first assessment carried out one month after the trauma revealed severe brain dysfunction followed by a marked improvement in the next two months as evident from the third month assessment. Improvement in verbal abilities especially verbal learning and memory functions was marked and comparison with the controls revealed no evidence of impairment. On the contrary, visual learning, visual scanning and mental arithmetics continued to be impaired with maximum disability seen on visual learning. That the patients could recall as many units of information in the delayed recall trial compared to the third immediate recall trial in visual learning and memory functions test suggests that the function basically impaired is a modality specific learning ability. During the short exposure time of the complex visual pattern the subject could only have an impression of the design in its totality rather than have an opportunity for serial or systematic examination of the stimulus material.Therefore simultaneous or parellel mode of information processing, which is considered to be an important attribute of the right hemisphere, was cheifly

involved in its performance. Similar findings as part of developmental learning disabilities have been reported by Weintraub and Measulam [13] using the Rey-Osterrieth Complex Figure, who have postulated a right hemisphere developmental syndrome consisting of impaired visual perceptual abilities, arithmetical skills and prosody. It is interesting to note that the patients in the present investigation have displayed a similar arithmetical difficulty, though none had dyscalculia. They could carry out complex arithmetical operations of divisions and multiplications involving large number of digits, whereas simple mental arithmetics involving independent calculations posed considerable difficulty.

The significant difficulty found on the visual scanning test raises two possibilities,
(a) if it was due to a primary attentional deficit, or
(b) a difficulty specific to searching of the visual space.

De renzi et al [14] reported that in unilateral lesion patients, visual search may be affected in the contralateral visual field. Attentional processes have been considered as an important frontal lobe function [15], with attentional deficits more frequently seen in right frontal lobe lesions [16], [17]. Stuss et al [1] suggested a basic divided attentional deficit in closed head injury patients which interfered with speed of information intake, thus limiting the channel capacity. They postulated that pathophysiology for this may be found either in the frontal lobes or alternatively in the frontal-limbic-reticular activating system brain circuit [18], a contention which would support a wider anatomical distribution of attentional processes. The attentional deficits observed in the visual scanning tests and the possibility of involvement of continued attentional processes in mental arithmetics may be thus suggestive of a basic slowing down of information intake, though this was not evident in any of the other tests including complex verbal learning and memory functions test. Examination of the visual scanning test material did not reveal evidence for a unilateral spatial difficulty in the patients. It was interesting to note that there were very few error scores, and all the patients completed the test though they took significantly longer time. Normal subjects who performed this test rapidly reported that they resorted to a random search of the visual space and attempted to allocate numbers seen in a topographical memory so that they could get back to that particular spatial location as the sequence of scoring progressed. The time taken and the quality of performance on both the block design test and the pass along test depicted difficulty in visual analysis and synthesis, that showed a marked improvement from the third month to one year. Visuospatial organisation also registered a similar trend. Performance on the visual learning paradigm further indicated that the main deficit was not one of disorganisation of spatial skills, but of inadequate information intake, since, in spite of repeated trials the number of components they could reproduce did not improve. Hence though a primary attentional deficit is not ruled out, it appears to manifest in a profound way mostly when the patient encounters a visual problem rather than a verbal one. This evokes the possibility that other than a functional dissociation of subcortical-cortical mechanisms which may disrupt attentional processes, there could be an independent right hemisphere source for some of the specific deficits observed in these patients.

Social adjustmental and emotional problems expressed by the majority of the patients 29 (69%) even after a period of one year suggest, in the light of the hypothesis put forth by Weintraub and Measulam [13], that the right hemisphere involvement continued and recovery of related deficits have shown a retarded course unlike those of the left hemisphere. A further supporting evidence [19] has come from the neuroradiological and developmental findings in children with congenital hydrocephalus. A

positive correlation has been found to exist between the increase in the thickness of the frontal cortical mantle and ratio of increase in social and adaptive functions on the Gessels Developmental Schedule after shunt surgery, whereas the correlation was poor between the two indices at the right parietal area and left frontal and parietal areas. A positive correlation was also elicited between the increase in the thickness of the cortical mantle at the left frontal and parietal areas and ratio of improvement in motor and language functions after the surgery. The two indices showed poor correlation on the left side.

In spite of a smaller control sample size, the differences that have emerged between the two groups on the various tests are conspicuously significant. Though the two groups were not matched on sex, there was no evidence of a sex effect on the performance in the control group. The findings are suggestive of a distinct discrepancy in the recovery rate of functions associated with the right and the left cerebral hemispheres. Verbal modality functions associated with the left hemisphere recovered faster, and their recovery, though slow, was more or less in parallel with the clinical recovery. On the other hand, some of the complex right hemisphere functions showed poor recovery even after a period of one year after the head trauma. The components of this right hemisphere syndrome, elicited in this study, are impairment in visual learning capacity, modality specific attentional deficit which affects continuous attentional processes, and inadequacies which may interfere with the social adaptive behaviour of the patient. Etiology for this discrepancy may be found in the greater and continuous utilization of the functions of the left cerebral hemisphere, which help their faster restoration, when impaired in an insult to the brain.

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