Scand J Rehab Med 21: 71–79, 1989

RECOVERY OF FUNCTION DURING INPATIENT REHABILITATION FOR MODERATE TRAUMATIC BRAIN INJURY

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ABSTRACT. **This study evaluated the functional improvement of 189 patients with traumatic brain injury (TBI) who participated in a comprehensive rehabilitation program at a National Institute on Disability and Rehabilitation Research—designated Center for traumatic brain injury rehabilitation. Data were comprised of functional ratings reported by therapists in nine disciplines. Improvement in mobility, self-care, communicative, family, nursing, psychological, and recreation functions were observed. The relationship between functional level and length of stay, onset-admission interval, age, sex, education, and work history were examined. The benefits of rehabilitation are supported by this multidimensional study.**

Key words: traumatic brain injury, rehabilitation.

Brain trauma is a major cause of disability in the United States with incidence estimates varying from 200 per 100 000 persons per year (6, 15). Brain trauma is the major cause of death for persons younger than 35 years (1); approximately 55% of persons who incur head trauma survive more than one month with some degree of permanent impairment (15).

Recovery of function following head trauma has been documented in both simple and complex neuropsychological functions (8). The degree of initial deficit is an important predictor of subsequent recovery and residual deficit, with neurologic signs such as nonreactive pupils and oculovestibular deficits related to increased mortality (14). The greatest degree after recovery generally occurs during the first six months after injury with slower progress later (4, 11). Bond (3) describes a three stage process of recovery that includes unconsciousness, approximately a six month period of rapid recovery, and a many month stage during which the affected individual and relatives adapt to residual disabilities. This late period of recovery was examined by Oddy and Humphrey (17). They found that most persons had returned to work after two years, but fewer had resumed their premorbid level of leisure activities and social contacts.

Patient characteristics associated with recovery include length of coma and posttraumatic amnesia; age; location, extent and severity of cerebral damage; and medical complications (16). Duration of coma is regarded as the best predictor of functional recovery, and is assessed with the Glasgow Coma Scale (12, 13) via eye opening, verbal and motor responsiveness. Posttraumatic amnesia, the period following head trauma during which no continuous memory exists, is a useful predictor of verbal skills during the first six months after injury, and of nonverbal skills during the first year. Medical complications are associated with a poorer prognosis (5, 22). Duration of time between injury and commencement of rehabilitation is associated with extended length of hospitalization (7).

Preinjury characteristics and neurologic indices of injury severity are acknowledged as the principal determinants of head trauma outcome (16). The efficacy of rehabilitation in improving functional recovery following brain trauma has been studied in relation to language skills (2), activities of daily living (18) and return to work (9, 10, 21). Improvement in activities of daily living and wheelchair mobility were found by Panikoff (18) to continue two years post-injury.

Development of objective, sensitive and reliable functional assessment instruments for clinical, research and program evaluation purposes is still in its infancy. A useful instrument would describe the functional status of patients at entry into a program, the extent of functional gains made during hospitalization, as well as after return to the community. The focus of assessment for patients with brain trauma is usually upon cognition; activities of daily living; mobility; communication; and psychosocial and vocational adjustment. Often used scales in-

clude the Glasgow Outcome Scale (12), the Disability Rating Scale (19), and the Rancho Los Amigos Levels of Cognitive Function Scale. Unfortunately, the item content and weighting of individual items of these scales was done *a priori* without consideration for the psychometric properties of individual items. Scales that distinguish between various components of recovery appear to hold greater promise for predicting functional outcome.

In summary, the quality of life following brain trauma depends, in part, upon the degree of functional disability remaining after maximal neurologic and functional recovery has taken place. While several studies have suggested that participation in a comprehensive, multidisciplinary rehabilitation program after brain trauma minimizes medical morbidity and mortality; optimizes performance of functional communication, self-care, and mobility skills; improves the likelihood of returning home, and enhances social and vocational opportunities, it is difficult to distinguish natural recovery from benefits attributable solely to rehabilitation.

The present study examined a number of characteristics of patients who participated in comprehensive head trauma rehabilitation. Documentation of rehabilitation outcome, including demographic, medical and functional data, was by means of a locally-developed scale that assessed functions related to head injury care.

The objectives of this study were to:

1. Describe the demographic characteristics, social status, medical recovery, functional abilities, behavioral characteristics, neuropsychological status, vocational characteristics, and recreation decision-making at admission of patients with disability resulting from traumatic brain injury.
2. Describe medical, functional, social, behavioral, neuropsychological, vocational and recreation status at discharge and changes from admission.
3. Identify prognostic factors associated with various levels of function at discharge; these factors include admission functional abilities, age, sex, education and work history, onset-admission duration, and length of stay.

METHODS

Participants

A total of 189 consecutively admitted patients with closed head injuries were studied who were treated by the designated, comprehensive rehabilitation team for traumatic brain injury at a National Institute on Disability and Rehabilitation Research-designated center for head injury rehabilitation. The 38-bed unit is situated within a 176-bed free-standing hospital that draws referrals from urban, suburban and rural communities in the midwest. The Center provides a comprehensive, multidisciplinary program that includes physiatrists; rehabilitation nurses; physical, occupational, speech, and recreation therapists; psychologists; social workers, and vocational rehabilitation counselors.

Measures

This study investigated the measurement properties of a locally-developed functional rating scale. It is comprised of 34 items that were rated on a six-point scale by team members at the first team conference and at discharge. The scale ranged from zero (severe impairment) to 5 (normal function). Intermediate values were defined for every item. The physician team leader; psychologist; social worker; vocational rehabilitation counselor; and speech, physical, occupational, nurse and recreation therapists assessed functions related to their intervention focus. In addition, information about patients' age, sex, onset-admission duration, length of stay, educational and work history was collected.

The physician evaluated coma severity with eye opening, motor response and verbal responsiveness; these items were summed to form a composite score like the Glasgow Coma Scale (20). The speech therapist assessed receptive and expressive language skills as well as speech intelligibility. The physical therapist assessed ataxia, motor development, motor recovery in each of four extremities, and mobility skills. The occupational therapist assessed motor skills and sensation on each side of the body, posture, and sensory/perceptual skills. The nurse therapist assessed management of health care. The social worker assessed family constellation and financial status.

The psychologist assessed neuropsychological status, behavior, attention, orientation, mood and affect, coherence of thought, and judgment. The vocational rehabilitation counselor assessed work and educational history, performance of activities of daily living at work, vision and visual perceptual skills, and transportation to and from, as well as mobility within the work setting. The recreation therapist assessed decision-making ability relative to leisure involvement.

Inter-rater reliability of this scale was assessed by having the physician team leader independently rate 22 patients on the 19 medicine (the other rater was the resident physician), communicative disorders, physical and occupational therapy items. The correlations between the two raters ranged between 0.76 (receptive speech) and 1.00 (eye opening and right motor function); the average correlation was 0.94.

Data analysis

Differences between admission and discharge scores were examined with the Sign test, and group differences were compared with the Mann-Whitney or Kruskal-Wallis test, as appropriate. A p value of 0.001 was selected to guard against Type 1 errors.

RESULTS

Demographic characteristics

Men comprised 73% of the sample. The mean age of the sample was 29.4 years with a range from 17 to 63 years. Most individuals (28%) had a steady work history with lateral changes; others had a history of upward mobility (22%), employment lasting less than one year (20%), part-time work while a student or homemaker (19%), unemployment (7%), and short job tenure (4%). The sample's educational history included less than high school graduation (15%), high school graduation (48%), and post-secondary education (37%). Time to admission varied widely. While the mean duration was 428 days, most patients were admitted during the first year after injury. The mean length of stay was 83 days, though this ranged from zero to 412 days. The single person who was admitted and discharged on the same day was excluded from analyses of functional improvement.

Functional characteristics

Table I shows that significant improvements ($p<0.001$) were noted for all items with the exception of eye opening, motor responsiveness, right lower recovery, neuropsychological status, financial profile, work ADL, and visual perception. The absence of changes in eye opening and motor responsiveness reflects that few patients had deficits in this reflex. Neuropsychological status remained at a low level, and family finances were unchanged during this hospitalization, perhaps because the impact of employment changes and medical bills were not yet known. Figure 1 and 2 present the mean ratings on items with significant differences between admission and discharge.

Sex, age, onset-admission interval, and length of stay

Sex differences in functional ratings were examined using the Mann-Whitney U test; no sex differences with $p<0.001$ were observed.

Age was recoded to examine differences in work and education histories as well as functional status. Individuals younger than 20 formed one category ($N=20$), while individuals in their 20s ($N=94$), 30s ($N=48$), 40s ($N=16$), and older than 49 ($N=10$) formed other categories. Two statistically significant differences were observed using the Kruskal-Wallis one-way analysis of variance test. Lower educational and vocational attainments were achieved prior to injury by younger patients ($X^2=51.86$, $p<0.0001$, and $X^2=22.75$, $p<0.0001$, respectively).

Onset-admission intervals were recoded to form four equal size groups; patients with intervals of 8 to 67 days formed the first quartile; the other groups had intervals of 68 to 246 days, 247 to 587 days, and 588 to 2824 days ($N=47$ for each group). Table II shows that consistent onset-admission interval and functional rating differences were observed using the Kruskal-Wallis one-way analysis of variance test. Patients admitted in a shorter period of time had greater performance at admission and discharge on all items in which significant differences were observed. Higher ranks correspond to higher ratings which indicate better functioning. These items included all discharge ratings of communicative disorders, physical therapy, occupational therapy, nursing and therapeutic recreation items as well as six of seven psychology and three of five vocational rehabilitation items. In addition, differences at admission were observed in intelligibility, four of six physical therapy and three of seven occupational therapy items, educational history and recreation decision making.

The significant relationship between onset-admission interval and functioning led us to select patients with injuries occurring longer than one year prior to admission to determine if the improvement from admission to discharge observed for the entire sample would be found for these patients. Comparisons of admission and discharge scores for the 71 patients with injuries occurring more than one year prior to admission were made with the Sign test. Three significant differences were observed in this subset of patients; mobility, family constellation and attention improved during rehabilitation for these patients ($p<0.001$).

Lengths of stay were recoded to form four groups of equal sizes; these groups had lengths of stay from four to 41 days, 42 to 65 days, 66 to 107 days, and 108 to 410 days. At discharge, patients with shorter lengths of stay (in the first quartile) were rated as having better left lower motor recovery (Kruskal-Wallis test, $p<0.001$), while at admission patients with shorter lengths of stay were rated as having better performance on all speech items, motor development, left lower recovery, mobility, posture, right motor function, ADL skills, sensory/perceptual skill, left sensation, health manage-

Table I. *Descriptive statistics and sign test results (N=188)*

	Admission		Discharge		Number who			
	Mean	SD	Mean	SD	improve	Decline	Z^a	2-tail p
Medicine								
Eye opening	3.96	0.24	3.95	0.35	2	3		NS
Motor response	5.30	1.44	5.44	1.36	23	8	2.51	.01
Verbal response	4.29	1.41	4.57	1.12	28	4	4.07	<.001
Communicative disorders								
Reception	2.45	1.33	2.85	1.25	53	0	7.14	<.001
Expression	2.30	1.47	2.72	1.34	52	1	6.87	<.001
Intelligibility	2.96	2.02	3.20	1.94	32	2	4.97	<.001
Physical therapy								
Motor development	2.95	1.70	3.26	1.70	50	4	6.12	<.001
Recovery-R upper	3.67	1.78	3.86	1.61	27	3		<.001
Recovery-R lower	3.46	1.85	3.62	1.77	27	8	3.04	.002
Recovery-L upper	3.70	1.73	3.82	1.66	24	5		<.001
Recovery-L lower	3.49	1.81	3.71	1.66	29	4	4.18	<.001
Mobility	3.04	1.81	3.66	1.68	73	1	8.25	<.001
Occupational therapy								
Posture	2.55	1.37	2.97	1.46	69	6	7.16	<.001
Motor function-R	2.73	1.68	3.05	1.69	54	7	5.89	<.001
Motor function-L	2.72	1.66	3.03	1.66	55	7	5.97	<.001
ADL skills	2.54	1.60	3.18	1.68	80	9	7.42	<.001
Sensory/percept	3.19	1.08	3.54	1.08	61	9	6.10	<.001
Sensation-right	3.25	1.83	3.55	1.76	38	15	3.02	<.001
Sensation-left	3.12	1.81	3.49	1.71	44	16	3.49	<.001
Social service								
Family const.	4.02	0.82	4.34	0.79	67	20	4.93	<.001
Financial profile	4.18	0.72	4.17	0.84	27	25		NS
Nursing								
Health management	2.51	1.17	2.96	1.14	80	20	5.90	<.001
Psychology								
Neuropsych status	0.90	0.98	1.06	1.02	40	16	3.07	.002
Behavior	2.73	1.24	3.08	1.21	58	15	4.92	<.001
Attention	2.85	1.22	3.23	1.15	57	5	6.48	<.001
Orientation	2.77	1.51	3.32	1.47	69	8	6.84	<.001
Mood and affect	3.02	1.36	3.45	1.27	57	11	5.46	<.001
Coherence	2.62	1.28	3.09	1.29	64	8	6.48	<.001
Judgment	2.60	1.15	2.95	1.05	62	12	5.70	<.001
Vocational rehabilitation								
Work ADL	1.73	2.38	2.66	2.50	39	4		NS
Visual perception	1.58	2.32	1.71	2.37	16	10		NS
Transportation	0.78	1.13	1.42	1.48	72	8	7.04	<.001
Therapeutic recreation								
Decision making	3.29	1.42	3.80	1.39	68	8	6.77	<.001

[a] Binomial distributions were obtained where no Z values are listed.

ment, neuropsychological status, coherence, work ADL and transportation.

Figure 3 shows that onset-admission interval and length of stay were negatively related (X^2 (df=9, N=188) =38.21, p<0.0001), such that patients with longer onset-admission intervals tended to have shorter lengths of stay than did patients whose admissions occurred sooner after injury. Length of stay and onset-admission interval were unrelated to age or sex.

Table II. *Kruskal-Wallis one-way analysis of variance for onset admission-interval at admission and discharge*

	Admission						Discharge					
	Mean rank for quartile					2-tail	Mean rank for quartile					2-tail
	1	2	3	4	X^2	$p<$	1	2	3	4	X^2	$p<$
Medicine												
Eye opening	97	95	93	93	2.22	NS	97	92	94	95	2.04	NS
Motor response	114	81	83	100	18.89	.01	109	87	86	96	10.99	.01
Verbal response	111	79	96	92	14.76	.01	109	85	94	90	13.07	.01
Communicative disorders												
Reception	109	76	92	101	10.01	.05	130	79	84	85	29.34	.0001
Expression	113	75	96	94	11.86	.01	130	80	86	81	29.53	.0001
Intelligibility	126	83	86	83	21.97	.0001	135	86	82	75	38.59	.0001
Physical therapy												
Motor develop	121	82	87	88	16.32	.001	137	82	82	77	41.67	.0001
Recovery R upper	118	85	91	84	14.79	.01	119	92	88	80	17.28	.001
Recovery R lower	126	86	89	77	25.82	.0001	126	95	84	73	29.51	.0001
Recovery L upper	122	84	84	88	18.49	.001	127	84	84	83	27.83	.0001
Recovery L lower	125	85	85	84	21.42	.0001	129	86	86	77	29.31	.0001
Mobility	115	80	88	95	11.56	.01	131	84	84	79	33.22	.0001
Occupational therapy												
Posture	124	77	88	89	20.57	.0001	132	83	84	79	31.71	.0001
Motor right	124	83	89	82	20.05	.001	135	87	79	76	37.36	.0001
Motor left	126	75	90	88	23.87	.0001	130	79	88	81	29.22	.0001
ADL skills	115	75	93	95	13.11	.01	129	87	87	74	28.92	.0001
Sensory/percept	112	78	88	100	11.89	.01	129	84	79	86	30.30	.0001
Sensation right	114	78	93	100	11.24	.01	131	82	80	86	30.96	.0001
Sensation left	116	75	89	98	14.65	.01	126	77	80	95	25.59	.0001
Social service												
Family const.	93	90	89	106	3.90	NS	83	93	97	105	4.68	NS
Financial	88	87	100	103	4.28	NS	93	83	103	99	4.42	NS
Nursing												
Health management	96	88	98	96	0.93	NS	125	81	88	85	20.80	.0001
Psychology												
Neuropsych	116	81	91	90	11.63	.01	130	81	89	78	30.65	.0001
Behavior	111	80	88	99	9.10	.05	130	78	81	89	28.60	.0001
Attention	107	83	92	96	5.09	NS	116	85	87	89	10.98	.01
Orientation	112	80	91	96	8.82	.05	134	75	87	82	36.63	.0001
Mood and affect	106	80	89	102	7.03	NS	125	80	88	86	20.94	.0001
Coherence	117	77	85	99	15.57	.01	134	80	80	84	34.73	.0001
Judgment	107	74	94	103	10.95	.01	128	78	87	85	26.53	.0001
Vocational rehabilitation												
Work history	114	81	104	80	14.08	.01	111	84	101	82	9.73	.05
Education	119	94	82	82	16.39	.001	122	95	79	82	20.97	.0001
Work ADL	108	88	94	89	5.88	NS	125	93	89	73	30.26	.0001
Visual percept	110	85	87	96	9.49	.05	116	88	84	89	15.12	.01
Transportation	108	83	94	93	6.11	NS	141	80	85	72	50.64	.0001
Therapeutic recreation												
Decision making	121	77	87	94	17.67	.001	130	81	91	75	32.58	.0001

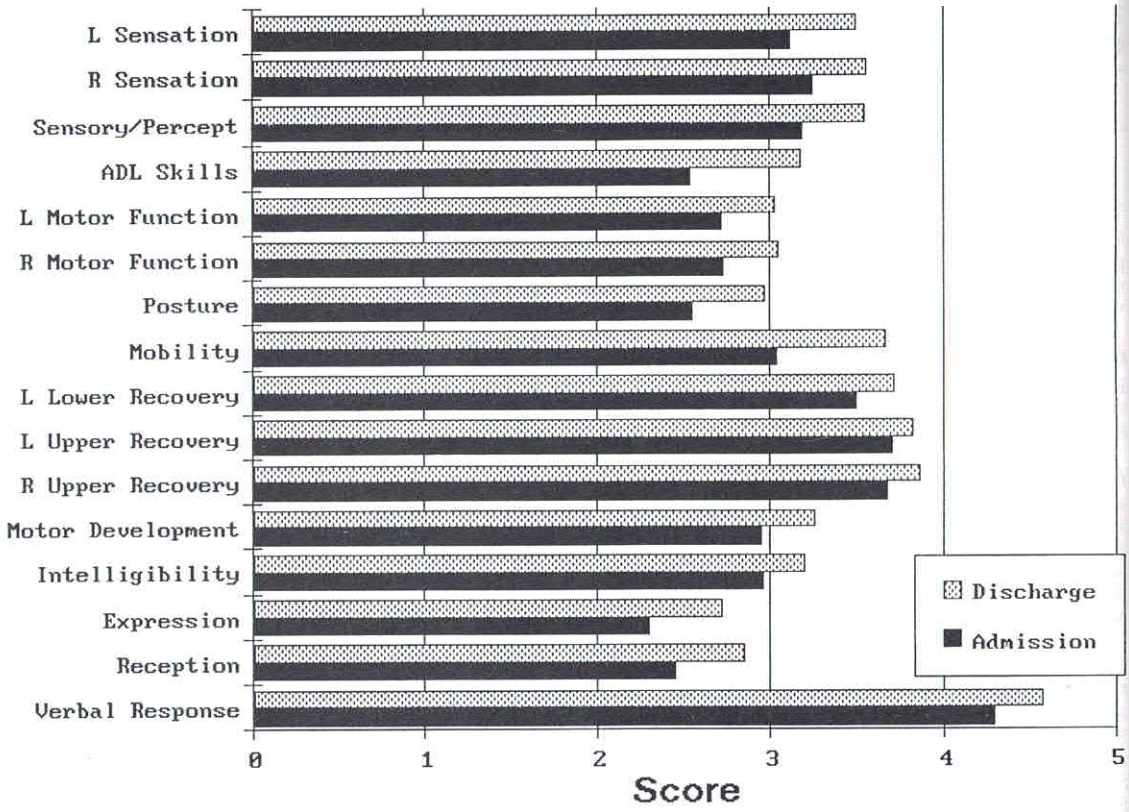

Fig. 1. Mean ratings for medicine, speech, physical and occupational therapy items.

Work and education history differences

The relationship between education and work history with functional status at admission and discharge were examined with the Kruskal-Wallis test; p values less than 0.001 were regarded as being important given the number of comparisons that were made. While education and work history were related ($X^2=49.66$, $p<0.0001$) such that individuals with greater education had steadier work histories, work history was unrelated to any of the functional items. However, greater educational attainment was associated with greater coherence at discharge ($X^2=26.63$, $p=0.0001$).

DISCUSSION OF RESULTS

In summary, patients admitted to this Traumatic Brain Injury Program were rated as having moderate medical impairment at admission and thus were able to participate in and make functional improvements during this inpatient rehabilitation program. However, they demonstrated severe deficits in language and cognitive functions, motor and sensory functions, ability to manage health care, behavior and affect, and readiness for vocational and avocational pursuits. During the average 83 day stay in this comprehensive rehabilitation program, significant improvements were seen in almost all areas. The only exceptions were areas in which minimal deficits were observed at admission (eye opening, motor responsiveness and financial profile) or were related to vocational readiness. As noted by other investigators (17), return to work is an outcome that is difficult to achieve, requiring months to years of preparation.

The design of this study does not allow us to attribute improvement to specific components of the program, nor to distinguish gains due to natural recovery from benefits derived through rehabilitation. While patients admitted with more acute injuries had better performance at admission and discharge than did patients with more chronic injuries

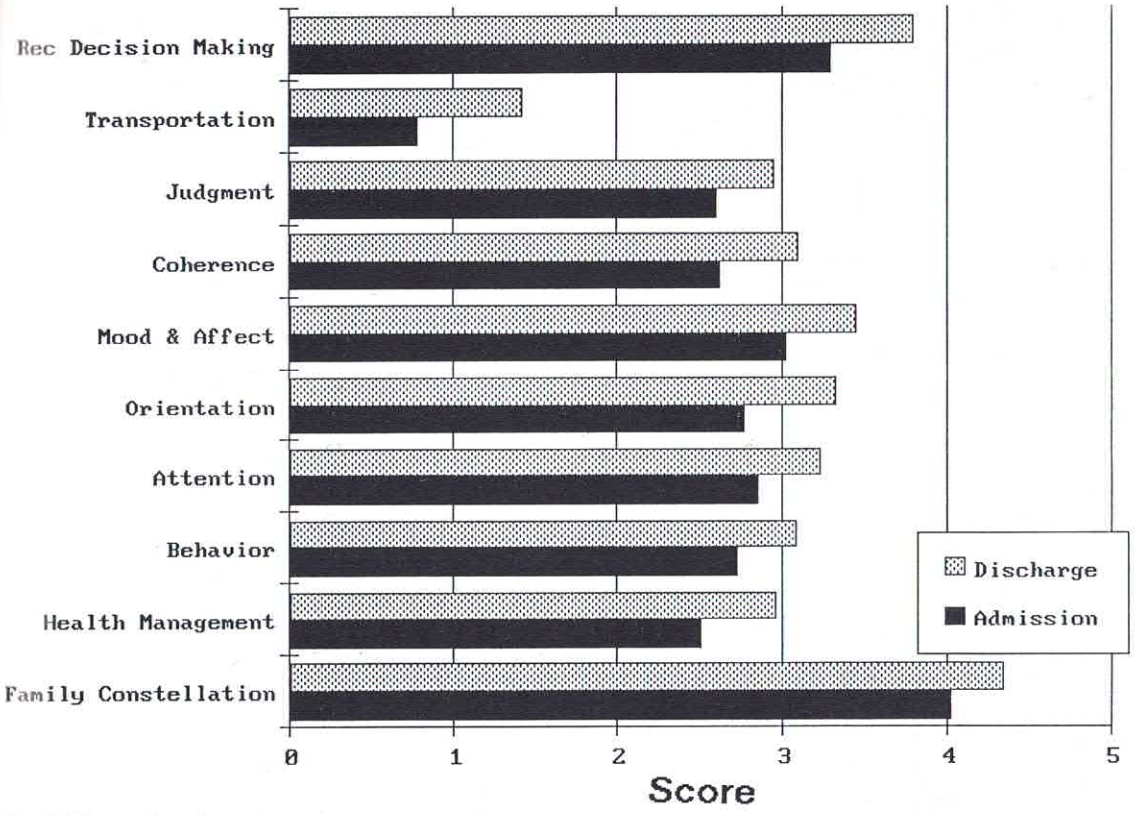

Fig. 2. Mean ratings for social work, nursing, psychology, vocational rehabilitation and therapeutic recreation items.

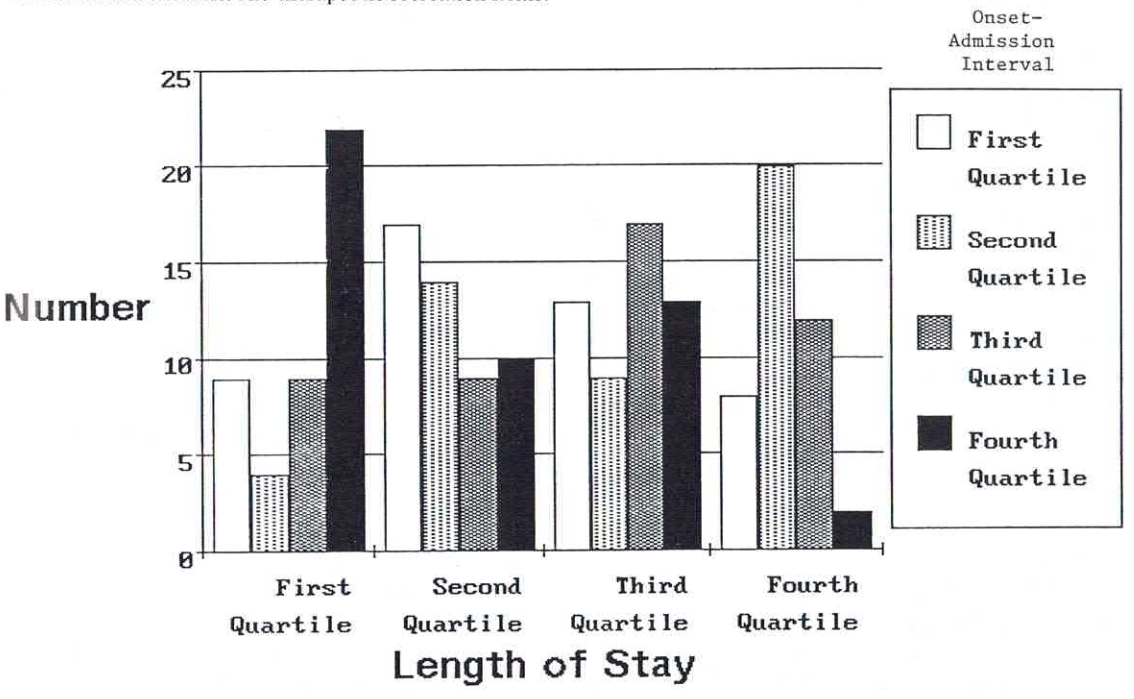

Fig. 3. Length of stay by onset-admission interval.

in nearly all areas assessed, even patients with chronic injuries improved in mobility, attention and family constellation. One would expect a negligible rate of natural recovery in patients with injuries that occurred more than one year prior to admission. Instead, we found improvement in three of the 26 areas in which improvement was found for the entire sample. This improvement, while not as extensive as for patients with more acute injuries, supports the benefit of rehabilitation beyond what occurs as a function of natural recovery.

The relationship between onset-admission interval and length of stay is important to note because of the different degree of improvement made by patients with various lengths of stay. Patients with more chronic injuries tended to have shorter lengths of stay, though the converse was not always true. Patients with shorter hospitalizations tended to be admitted and discharged with greater performance in all areas assessed. It appears as though early referral allowed persons to take greater advantage of their recovery potential.

Variables that were unrelated to function included age, sex, and work history. The provision of rehabilitation services regardless of age, sex or work history is supported by these findings. Prior educational achievement emerged as an important predictor of behavioral outcome as persons with greater education were rated as having steadier work histories and greater coherence at discharge. This finding supports Levin et al.'s (16) review that specific predisability characteristics are related to post-injury outcome. It is important to understand rehabilitation as a learning process with features similar to formal education programs if we are to understand how prior academic achievement is related to success during rehabilitation and are to provide programs that are responsive to individual needs.

A limitation of this study is the inclusion of participants from only one rehabilitation program. While the hospital receives referrals from hospitals in urban, suburban and rural communities, it is possible that the sample is biased in unrealized ways that limit the generalizability of these findings. Further, this study used a rating scale with only limited evidence of construct validity. The Glasgow Coma Scale components of this scale are well known. However, the extent of inter-rater agreement on other items has been studied only in one setting. The construct validity of this scale is supported by the pattern of correlations between items; however, further analysis of this scale is needed if we are to understand fully the patient characteristics that are measured.

Future research could 1) explore improvements made by patients with different injury etiology and pathology, 2) relate diagnostic findings such as EEG or CT scan to functional changes, and 3) examine post-discharge placement and vocational status. The scale described here could be a useful tool for describing these functional changes and the relationship between function shortly after injury and eventual outcome.

ACKNOWLEDGEMENTS

The investigators acknowledge the important contributions of the Brain Trauma Team members in collecting the data reported here. We also thank Helen George, Karen Ginsburg, Jeff Reznic, Margaret Gonzales and Margaret Caldwell for data management and literature retrieval.

REFERENCES

1. Annegers, J. F. & Kurland, L. T.: The epidemiology of central nervous system trauma. *In* CNS Trauma Research Status Report (ed. G. L. Odom), pp. 1–8. NINCDS, Washington, DC, 1979.
2. Basso, A., Capitani, E. & Vignolo, L. A.: Influence of rehabilitation on language skills in aphasic patients. Arch Neurol *36*: 190–196, 1979.
3. Bond, M. R.: The stages of recovery from severe head injury with special reference to late outcome. Inter Rehabil Med *1*: 155–159, 1979.
4. Bond, M. R. & Brooks, D. N.: Understanding the process of recovery as a basis for the investigation of rehabilitation for the brain injured. Scand J Rehabil Med *8*: 127–133, 1976.
5. Brooks, D. N., Aughton, M. E., Bond, M. R., Jones, P. & Rizvi, S.: Cognitive sequelae in relationship to early indices of severity of brain damage after severe blunt head injury. J Neur Neurosurg Psych *43*: 529, 1980.
6. Caveness, W.: Incidence of craniocerebral trauma in the United States in 1976 with trend from 1970 to 1975. Adv Neurol *22*: 1–3, 1978.
7. Cope, D. N. & Hall, K.: Head injury rehabilitation: Benefit of early intervention. Arch Phys Med Rehabil *63*: 433–437, 1982.
8. Dikmen, S., Reitan, R. M. & Temkin, N. R.: Neuropsychological recovery in head injury. Arch Neurol *40*: 333–338, 1983.
9. Dresser, A. C., Meirowsky, A. M., Weiss, G. H., McNeel, M. L., Simon, G. A. & Caveness, W. F.: Gainful employment following head injury: Prognostic factors. Arch Neurol *29*: 111–116, 1973.
10. Gilchrist, E. & Wilkinson, M.: Some factors determining prognosis in young people with severe head injuries. Arch Neurol *36*: 355–359, 1979.

11. Gruzzman, M.: Reversal operation after brain damage. Brain Cognition *1*: 331–354, 1982.
12. Jennett, B. & Bond, M.: Assessment of outcome after severe brain damage: A practical scale. Lancet *7993*: 480–484, 1975.
13. Jennett, B., Snoak, J., Bond, M. R. & Brooks, N.: Disability after severe head injury: Observation on the use of the Glasgow Outcome Scale. J Neurol Neurosurg Psych *44*: 285–293, 1981.
14. Jennett, B. & Teasdale, G.: Management of Head Injuries. F. A. Davis, Philadelphia, 1981.
15. Kalsbeek, W. D., McLaurin, R. L., Harris, B. S. H., & Miller, J. D.: The national head and spinal cord injury survey: Major findings. J Neurosurg *53*: S19–S31, 1980.
16. Levin, H. S., Benton, A. L. & Grossman, R. G.: Neurobehavioral Consequences of Closed Head Injury. Oxford University Press, New York, 1982.
17. Oddy, M. & Humphrey, M.: Social recovery during the year following severe head injury. J Neurol Neurosurg Psych *43*: 798–802, 1980.
18. Panikoff, L. B.: Recovery trends of functional skills in the head-injured adult. Am J Occup Ther *37*: 735–743, 1983.
19. Rappaport, M., Hall, K. M., Hopkins, K., Belleza, T. & Cope, D. N.: Disability rating scale for severe head trauma: Coma to community. Arch Phys Med Rehabil *63*: 118–123, 1982.
20. Teasdale, G. & Jennett, B.: Assessment of coma and impaired consciousness: A practical scale. Lancet *2*: 81, 1974.
21. Weddell, R., Oddy, M. & Jenkins, D.: Social adjustment after rehabilitation: A two year follow-up study of patients with severe head injury. Psychol Med *10*: 257–263, 1980.
22. Whitaker, H. A. & Ojemann, G. A.: Lateralization of higher cortical functions. A critique. Ann NY Acad Sci *299*: 459–473, 1977.

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