REVIEW

The current status and problems of rehabilitation for TBI (traumatic brain injury) patients in Japan

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Abstract. Recently, traumatic brain injury (TBI) is one of the major topics of rehabilitation medicine. In the USA, a nationwide research project has already been underway since 1987. However, interest in the rehabilitation of TBI patients became a matter of concern in Japan from the 1990s. TBI patients do not only have physical impairments, but also impairments of higher cortical functions such as cognitive impairment and abnormal behavior, so both physical and cognitive rehabilitation are very important for TBI patients. The purpose of this paper is to report on the current status of and problems with TBI rehabilitation in Japan, and also to introduce a new TBI evaluation system that we originally developed in Japan. (Keio J Med 52 (2): 100–106, June 2003)

Key words: traumatic brain injury (TBI), higher cortical function, cognitive rehabilitation, rehabilitation medicine

Introduction

In the United States, traumatic brain injury (TBI) became a major topic of rehabilitation medicine from the early 1980s;[1] however, rehabilitation for TBI has only gradually become a matter of concern in Japan from the 1990s.[2] In other words, up until recently, patients with TBI had been treated in a similar manner to those with cerebrovascular accidents. However, in many cases of TBI patients do not only have disabilities as represented by motor and sensory impairments in hemiplegia, but also impairments of higher cortical functions such as cognitive impairment and abnormal behavior. Therefore the rehabilitation of TBI patients should be considered in its own independent category.[3] The purpose of this paper is to report on the current status of, and problems facing, TBI rehabilitation in Japan, as well as our attempts to establish a TBI database system model in Japan.

The Current Status of Rehabilitation Following TBI

TBI in the United States

In the United States, a large number of incidents of TBI are caused not only by vehicular accidents but also through interpersonal violence; an increasing tendency of TBI resulting from the latter reason has been especially noted.[4] The incidence of TBI in the United States is calculated at 4,000/100,000 per year, and more than 10% of these are serious cases. Mortality from TBI stands at approximately 20/100,000 per year, and about 150 people survive TBI but with severe impairments.[4] The age distribution is bimodal, with young adults and the elderly showing the highest incidence, and an alarmingly higher rate of incidence has been seen in young adults. The increasing activity in the investigation into and research on TBI patients is believed to be as a direct consequence of the high number of young TBI patients and attempts to reduce the social and economic losses as a result of these incidents.[5] It has also been reported that in Britain, 150/100,000 persons per year survive TBI but with severe impairments.[6]

In the United States, a contributory factor to the promotion of research activities on TBI patients was the sponsorship by the Department of Education, National Institute of Disability and Rehabilitation Research (NIDRR) for the establishment of TBI model systems in 1987. Initially, the establishment of databases began at 4 institutions, before expanding nationwide. Furthermore, the first edition of the traumatic brain injury model systems National Database Syllabus

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Table 1 Classification of Head Injuries[10]

Skull injuries	Focal injuries	Diffuse brain injuries
Vault fracture	Epidural hematoma	Mild concussion
linear	Subdural hematoma	Classical cerebral concussion
depressed	Contusion	Prolonged coma
Basilar fracture	Intracerebral hematoma	mild diffuse axonal injury
		moderate diffuse axonal injury
		severe diffuse axonal injury

was published in 1995,[7] and as described later this TBI Model System Syllabus was used as an evaluation base for developing a similar database in Japan.[8] With this background, rehabilitation of patients with TBI-related problems has recently become a major topic in the United States, and a significant proportion of both reports in scientific meetings and scientific papers is devoted to TBI.[1,2] Researched topics cover a wide range of areas, such as treatment, cause, prognosis, evaluation, outcome, etc., and there are also many reports on the mechanisms of functional recovery and on cognitive rehabilitation.

TBI in Japan

With regard to the frequency of incidence of TBI in Japan, the number of statistical investigations about its medical aspects is regrettably rather low, and there have been only sporadic reports of investigations performed independently by some medical institutions. Instead, it is the annual reports on population and on traffic accidents from public organizations, such as the Ministry of Health, Labor and Welfare, which have proved useful in obtaining statistical data for estimation of the prevalence of TBI. According to data from the Overall Analysis Center of Traffic Accidents (Transportation Statistics 2000),[9] TBI accounted for only 9.3% of 1,160,000 traffic accident injuries. However, of the 9,000 deaths in these data, 50.3% of them were in fact due to TBI. Even though the data suggested that the majority of TBI patients were seriously injured, even those with lesser injuries often suffer from complications which make it difficult for them to return to their normal social and workplace-related lives, and hence there is a painful necessity for statistical investigations on the medical and therapeutic aspects of TBI, based on a detailed analysis of its severity and pathological features.

One of the reasons for such a deficiency in medical material in this area is an inadequate follow-up systems for patients who have undergone neurosurgery during the acute stage. In TBI, follow-up during the subacute and chronic stages, which is the period leading to the patient's return to society, is even more important than that of the acute stage. In this sense, what is required is the active response of both rehabilitation medicine and medical care during this period; however, the consciousness of such a viewpoint has so far appeared to be lacking both in medical staffers and in patients. Psychiatrists are sometimes called upon to cope with the cognitive and intellectual aspects of TBI, and we expect a close cooperative approach by specialists in neurosurgery, psychiatry and rehabilitation medicine in the future.

It cannot be denied that rehabilitation of TBI patients in Japan has lagged behind that in the United States, but this has lately been taken up as a theme of symposia in scientific meetings, and has occasionally been a special theme in some journals.[1] Furthermore, the study group of cognitive rehabilitation has been founded, and investigation and research into TBI have started, supported by national research grants and sponsorship from The Marine and Fire Association of Japan, Incorporated. In Japan, TBI has now become a major topic in rehabilitation medicine and care, and is now becoming one of the important diseases, alongside stroke and spinal injuries.

Pathological Features of TBI

As shown in Table 1,[10] TBI can roughly be classified into focal injuries and diffuse brain injuries. Among focal injuries, cerebral contusion involves parenchymal injury of the brain, and in such cerebral contusion the inferior surface of the frontal lobe and the temporal cortex are particularly susceptible to damage (Fig. 1).[11] Among diffuse brain injuries, diffuse axonal injury has lately attracted special attention. This is a pathology caused by the shearing force of traffic accidents, and the main areas of damage are the corpus callosum and brainstem (Fig. 2).[11]

Furthermore, as a result of these primary injuries, brain edema and circulatory disturbance occur, and hypoxia due to increased intracranial pressure results in secondary brain injuries. In secondary injuries, the brainstem is damaged by cerebral herniation caused by increased intracranial pressure, and the neocortex and basal ganglia are damaged by hypoxia.

In these head injuries, extensive areas of the brain are damaged in various ways, and consequently patients show a constellation of clinical symptoms as will be described later. Hence, a specific rehabilitation strategy is required to cope with this diverse range of damage.

TBI-related Problems and Countermeasures

Medical problems

TBI seldom occurs in isolation, rather it is usually a part of systemic multifocal injuries. Accordingly, not only fractures of the extremities, but also possible systemic complications such as epilepsy, hydrocephalus, hypertension, cardiopulmonary disturbances and pituitary-endocrine disturbances must be managed.[11]

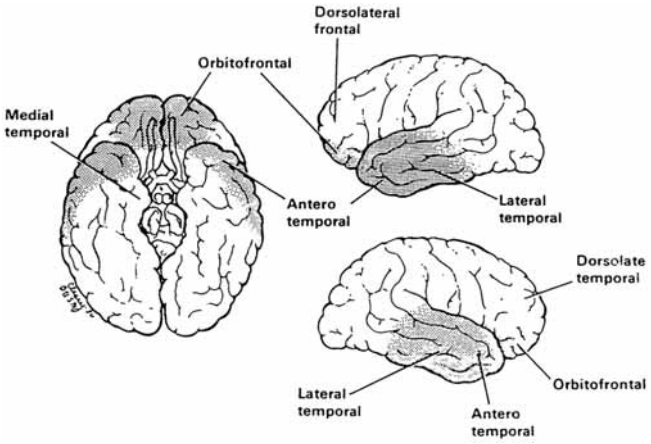

Fig. 1 Areas predominantly affected by cortical contusions. (Reproduce from Courville CB: Mythology of the central nervous system 1937, Copyright © (1937), with permission from Pacific Press Publishing Association)

Problems in rehabilitation at different stages of follow-up

Problems in the acute stage: In the acute stage, TBI is associated with various complications, such as disturbance of consciousness and multifocal trauma, and rehabilitation is directed towards the prevention of secondary complications, i.e., maintenance of the largest possible range of motion (ROM), prevention of decubitus, and maintenance of the greatest possible muscle strength. On the other hand, since excessive ROM training results in other problems such as ectopic ossification,[12] it is necessary to be careful in providing passive ROM training, particularly for patients with disturbance of consciousness.

Problems in the subacute and chronic stages: The outcome of TBI is highly variable. Some patients die or become severely disabled, falling into a vegetative state. Other patients survive TBI only with slight paralysis. However, even in cases with a fair prognosis for survival, various problems centering around the impairment of higher cortical functions occur during the subacute and chronic stages, thus leading to difficulties in rehabilitation.

In 1980, the World Health Organization (WHO) published the International Classification of Impairments, Disabilities and Handicaps (ICIDH).[13] Since then, these 3 classes, namely impairments, disabilities and handicaps caused by various diseases have become widely popular in the clinical practice of rehabilitation medicine.

Table 2[14] summarizes the problems associated with rehabilitation of TBI patients according to ICIDH. It shows that in TBI, vague impairments caused by diffuse brain injury are more frequent than localized focal symptoms at specific sites. However, decrease of initia-

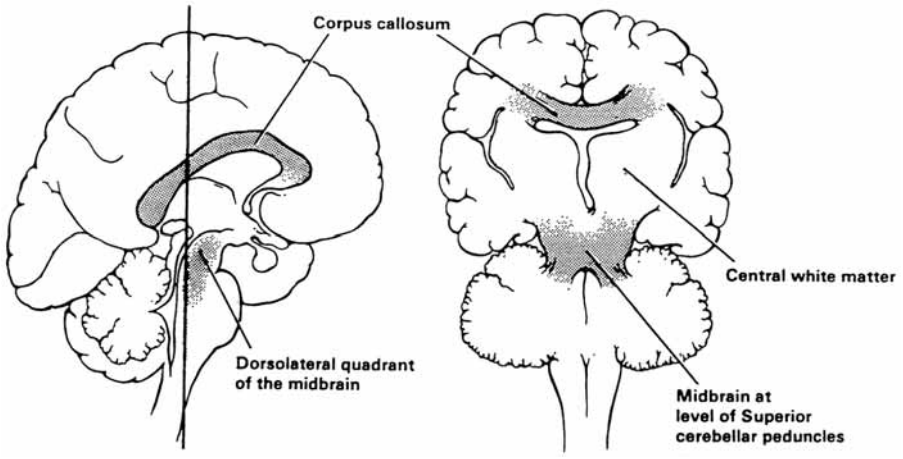

Fig. 2 Brain lesions particularly involved by diffuse axonal injury.[11] (Reproduce from Auerbach SH: Neuroanatomical correlates of attention and memory disorders in traumatic brain injury: an application of behavioral subtypes. Journal of Head Trauma Rehabilitation 1986; 1: 1–12, Copyright © (1986), requesting permission from Lippincott Williams & Wilkins)

Table 2 Major Problems of TBI Rehabilitation (from subacute stage to chronic stage)[14]

1. Impairments
   1) Motor disturbance: paralysis (hemiplegia, quadriplegia, triplegia, pseudobulbar palsy), ataxia, involuntary movements (chorea, athetosis, ballism, Parkinsonism, dystonia, tremor, myoclonus etc.)
   2) Spasticity
   3) Visual disturbance: visual loss, visual field defects
   4) Sensory disturbance: disorders of somesthetic sensation, auditory disturbance, olfactory disturbance
   5) Contracture
   6) Heterotopic osteosis
   7) Dysphagia
   8) Speech disturbance: aphasia, disarthria, etc.
   9) Bowel and bladder dysfunction
   10) Sexual dysfunction
   11) Cognitive disturbance: attention and concentration difficulties, impairments of executive functions (initiation of action and goal-orientation), impairments of cognition and judgment, impairments of learning and memory, slowing of information processing, impairments of communication
   12) Memory disturbance (retrograde amnesia, posttraumatic amnesia)
   13) Behavioral abnormalities: Psychological reactions (anxiety, depression, irritability, dullness, despair, apathy, anger, social retreat, fear)
   Sociopsychological symptoms (impulsivity, socially inadequate remarks and behavior, emotional lability, agitation, inactivity, despair, apathy, paranoia, indifference to injury, retrogressive behavior, lack of motivation, lowering of consciousness level)
   Reflection of personality (obsessive behavior, excessive diligence, estrangement, threatening other people, dependency, defiant attitude)
2. Disabilities
   1) Gait disturbance
   2) ADL
   3) Communication disturbance
   4) Disturbance of social intercourse
   5) Disturbance of problem solving capacity
3. Handicaps
   1) Occupation
   2) Family
   3) Psychological problems
   4) Economic problems

tive is due to damage of the prefrontal cortex, emotional and personality disturbances are due to damage of the orbitofrontal cortex, and attention disturbance is due to damage of the recessive hemisphere and/or the prefrontal cortex. Based on such a wide range of diagnosis of focal lesion causing various nervous symptoms, it is important to understand as well as to cope with such illnesses.

Among disturbances during these stages, it is the so-called higher cortical functions such as cognitive disturbance, memory disturbance and abnormal behavior, which are particularly important. Namely, disturbances of physical functions, such as hemiplegia, frequently recover in the long term, but in the chronic stage, disturbances of higher cortical functions become prominent, and develop into factors interfering with the patients' self-independence and also with their return to society. In particular, many patients are young males, inevitably resulting in problems both in the family and workplace. In the rehabilitation of TBI patients, a broad approach is necessary taking both social and economic aspects into consideration.

Major problems of rehabilitation and their managements

Motor disturbances: Among motor disturbances, hemiplegia is the most prevalent, but it is milder compared with stroke and insignificant at the chronic stage. Rather, ataxia, tremor and sluggish movement become problems with time, but disabilities of both gait and locomotion caused by these motor disturbances are also milder compared with stroke, and their functional prognosis is fair. ADL (activities of daily living) is at the self-independent level in many patients.

As actual rehabilitatory training methods, heavy weight loading, exercise using orthotics, and visually guided compensation methods are used for treating ataxia. However, in the evaluation of ADL in patients with brainstem damage, it is in some cases more effective to develop exercises using the upper extremity on the paretic side, instead of those using the upper extremity with ataxia on the non-paretic side.[15] In patients with oculomotor nerve paralysis, visually guided compensation is impossible, and hence a uniform approach to management is difficult.

Besides drug therapy, muscle reeducation, orthotics treatment and EMG biofeedback training are used in the treatment of involuntary movements such as tremor. However, it has been reported that locomotion training and ADL training are more effective than training of individual movements for removing excessive consciousness and for development of smooth engram.[15] We can conclude that the best approach is to choose an appropriate method on a case-by-case basis.

Cognitive impairments: Cognitive impairments include lowered attentiveness, memory impairment, lowered judgmental ability, communication impairment and so on. Since the problems are wide-ranging, management of cognitive impairments is difficult and rehabilitation for these problems has not yet been established. Various attempts are being made in both small-group and individual settings, such as direct training of the impairment itself, or other methods such as training in compensating the disturbance with other functions.

Behavioral abnormalities: There are also various forms of behavioral abnormalities which include amongst others emotional disturbance, emotional lia-

bility, impulsivity and hyperirritability. These are disturbances of self-controlling ability, developed on the basis of cognitive impairment, and frequently become a problem during the chronic stage of TBI. For behavioral abnormalities, psychotherapy at a mentally stable state, behavioral therapy to develop favorable behavior and group therapy are performed.[16]

Cognitive rehabilitation and its effects: With regards to cognitive impairment and behavioral abnormalities, cognitive rehabilitation along with drug therapy has been actively performed of late. To put it concretely, cognitive training can be classified into 4 categories; namely, (1) general stimulation using calling out, touch or orientation training, (2) functional recovery training of attention and memory, (3) adaptation training via learning a series of motions through repetition, and (4) compensatory strategy using schedule tables.[16]

With regard to the effects of cognitive rehabilitation, it was reported that neuropsychological rehabilitation of chronic patients reduced the amount of care and increased working time,[17] but another report casts doubt on the effects of cognitive rehabilitation on specific functions.[18] Lately cognitive rehabilitation has been evaluated from the point of view of Evidence-Based Medicine (EBM),[19] and its effectiveness has been reported.[20] The significance of psychological effects in therapeutic exercising, of improvements in intelligence, emotional welfare and sociality through communal living, and of psychological effects of creative activity in occupational therapy, rather than cognitive training itself, has also been pointed out.

Evaluation of Functional Prognosis

In the acute stage, the prognosis is estimated based on the degree of consciousness disturbance and the length of posttraumatic amnesia. It is said that any coma lasting more than 6 hours is severe, and that in parallel with prolongation of the coma, the prognosis becomes poorer. As indicators of consciousness disturbance, the Japan Coma Scale is mainly used in Japan, while the Glasgow Coma Scale (GCS) is widely used in Europe and USA. In the GCS, states of eye opening, verbal response and motor function are scored out of 15. A score of less than 8 is considered to be of poor prognosis. As for posttraumatic amnesia, it is considered to be a sign of poor prognosis when it lasts more than 14 days.[21]

On the other hand, as indicators of long term functional disturbance, the Glasgow Outcome Scale, which scores 5 degrees from good recovery to death, is widely used.[21] However, because of the lack of fine scoring of the scale, it is difficult to identify any delicate improvement during the period, or to evaluate the cognitive aspect. Additionally, other scales such as the Disability Rating Scale (DRS), or the Rancho Los Amigos Levels of Cognitive Function Scale have been devised,[21] but they are not necessarily crucial in practical rehabilitation.

With regard to disability, the Functional Independence Measure (FIM)[22] is widely used for stroke and other diseases. This assesses ADL including social cognitive capacity and communication capability within a 7-level scale. Furthermore, in order to apply the FIM to TBI patients, the Functional Assessment Measure (FAM)[23] has been developed, which has enriched the contents of cognitive evaluation. Although rather complicated, the FAM is used in the assessment of TBI.[24]

Preliminary Report of a TBI Model System Database in Japan

We have pointed out the lack in Japan of a TBI model system database which is collected from a medical perspective, but since 1997 comprehensive and continuous establishments of TBI model system databases has been attempted in Japan.[8] As mentioned before this basically conformed to the US TBI model system syllabus, but particular items with regard to differences in social system and culture were modified, reflecting the actual situation in Japan. Consecutive investigation from the acute stage through to the chronic stage was planned, and multidisciplinary data collection from departments engaging in the management of TBI, i.e. departments of neurosurgery, rehabilitation medicine, psychiatry etc., is has been in process. It is expected that the study will provide valuable research material in Japan. This is an on-going investigation, and only part of the data obtained from 78 patients was reported. Nevertheless, it revealed the present status and problems of TBI in this country. In the following, its outline will be described.[8]

The distribution of age at the onset of injury was double-peaked; that is, the first peak was in the twenties, and the second peak was in the fifties. By far the most frequent cause was traffic accidents. The next, but far less frequent cause was falls (Fig. 3). Brain imaging revealed brain contusion in about one quarter of patients, followed by subdural hematoma and subarachnoidal hemorrage (Fig. 4). Lesions in the cerebral cortex were located in the frontal lobe in the majority of cases, and less frequently, in the temporal lobe. After the hospitalization to rehabilitation units, scales of functional prognosis evaluation, such as the FAM, Rancho Los Amigos scale, DRS etc., tended to show an improvement. (Table 3).

With regard to psychobehavioral symptoms, decrease in volition was subjectively most frequent, followed by negligence, irascibility, indifference to injury, disorient-

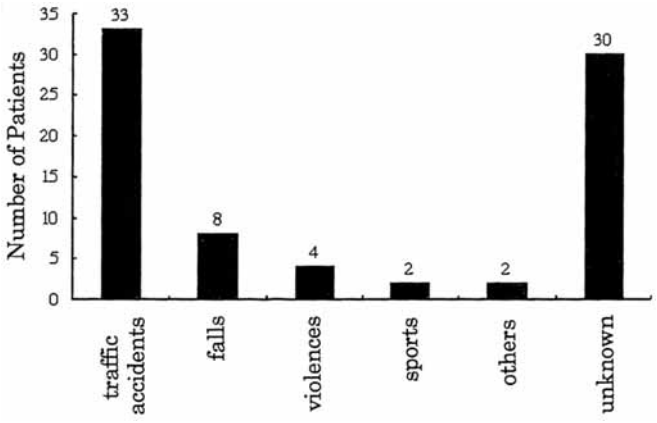

Fig. 3 Cause of injury. (Reproduce from Honda T, *et al*: Descriptive findings from the traumatic brain injury model system data base. Sogo Rehabil 2002; 30: 843–849 (in Japanese), Copyright © (2002), with Igakushoin)

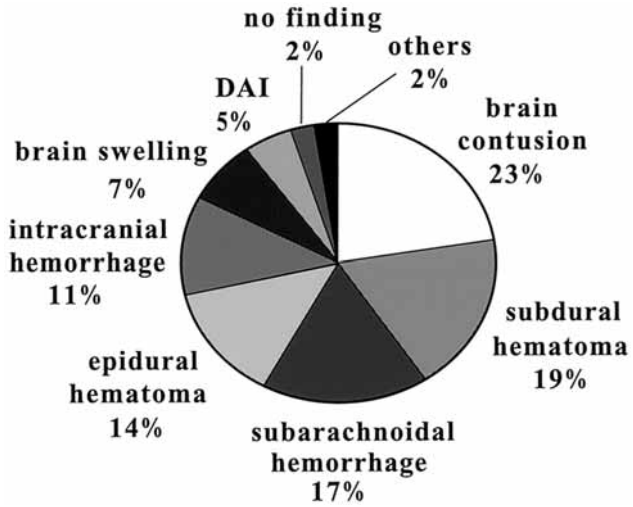

Fig. 4 CT findings. (Reproduce from Honda T, *et al*: Descriptive findings from the traumatic brain injury model system data base. Sogo Rehabil 2002; 30: 843–849 (in Japanese), Copyright © (2002), with Igakushoin)

Table 3 Changes of Some Functional Scores Due to Hospitalization to Rehabilitation Units[8]

	FAM	Rancho Los Amigos Scale	DRS
At the time of admission	115.8 ± 57.9	6.91 ± 1.41	6.3 ± 5.06
At the time of discharge	132.0 ± 53.7	7.22 ± 1.21	4.14 ± 3.94

ation etc. Many neuropsychological tests were carried out, and there were low scores in an attention test TMT(B), in an auditory recognition test Token Test, and in a frontal lobe function test COWA.

By and large these results were similar to those reported in the United States. Further accumulation of data and detailed analysis based on cultural differences appear to be necessary.

Conclusion

We have made an attempt to describe the rehabilitation of TBI-affected. In order to manage the many problems these patients face, the participation of not only physicians, physical therapists and occupational therapists, but also speech therapists, clinical psychologists and medical social workers is inevitable. Indeed, comprehensive medical care through the cooperation of members of a rehabilitation team is indispensable. Furthermore, long-term planning is important in order to medically promote the patient's return to society, and it is important to establish a system for cooperation involving not only medical but also economic, social and administrative support. In Japan, research on the rehabilitation for TBI patients has just begun to take shape, and the cooperative efforts of involved parties are highly expected.

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