ORIGINAL PAPER/*ARTYKUŁ ORYGINALNY*

Early rehabilitation of comatose patients after traumatic brain injury

Wczesna rehabilitacja chorych w śpiączce po urazowym uszkodzeniu mózgu

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Neurologia i Neurochirurgia Polska 2010; 44, 5: 475–480

Abstract

Background and purpose: As a result of improvements in the rescue system and progress in intensive care therapy, an increasing number of patients have survived severe traumatic brain injury in recent years. Early and consistent administration of the correct rehabilitation programme is of crucial importance for the restoration and improvement of cerebral function, as well as social reintegration. This prospective study was conducted at the neurosurgical department of a university hospital to assess the one-year outcome of comatose patients after severe traumatic brain injury.

Material and methods: Twenty-seven patients were included. Patients received multimodal early-onset stimulation and continuous inpatient and outpatient rehabilitation therapy. One-year outcome was assessed by means of the Glasgow Outcome Scale, Barthel Index, Functional Independence Measure (FIM) and need of care.

Results: Seven patients died, 4 remained in a vegetative state, 7 were severely disabled, 6 were moderately disabled, and 3 achieved a good recovery 12 months after injury. Median Barthel Index was 65 and median FIM score was 84. The majority of patients were still at least intermittently dependent on care.

Conclusions: Despite intensive rehabilitation treatment, severe traumatic brain injury is still burdened with significant mortality and morbidity.

Key words: rehabilitation, coma, outcome, brain injury.

Streszczenie

Wstęp i cel pracy: Dzięki ulepszeniu systemu ratownictwa i postępom w zakresie intensywnej opieki medycznej, w ostatnich latach zwiększa się przeżywalność chorych po ciężkich urazowych uszkodzeniach mózgu. Wczesne i spójne zastosowanie właściwych programów rehabilitacji ma kluczowe znaczenie zarówno dla poprawy i przywracania czynności mózgu, jak i reintegracji społecznej. Bieżące badanie prospektywne przeprowadzono na oddziale neurochirurgicznym szpitala uniwersyteckiego w celu oceny rocznych wyników leczenia chorych w śpiączce w następstwie ciężkiego urazowego uszkodzenia mózgu.

Materiał i metody: W badaniu wzięło udział 27 chorych. Pacjenci byli poddani rozpoczynanej wcześnie wielokierunkowej stymulacji oraz ciągłej rehabilitacji prowadzonej w warunkach szpitalnych i po opuszczeniu szpitala. Wyniki leczenia oceniano po 12 miesiącach za pomocą *Glasgow Outcome Scale*, wskaźnika Barthel, *Functional Independence Measure* (FIM) oraz potrzeby opieki nad chorym.

Wyniki: Po 12 miesiącach leczenia 7 chorych zmarło, 4 pozostawało w stanie wegetatywnym, 7 było dotkniętych niesprawnością w stopniu ciężkim, 6 w stopniu umiarkowanym, a u 3 osób odnotowano dobry wynik leczenia. Mediana punktacji we wskaźniku Barthel wyniosła 65 punktów, a mediana punktacji FIM 84 punkty. Większość chorych nadal była co najmniej okresowo uzależniona od opieki innych osób.

Wnioski: Mimo intensywnego leczenia rehabilitacyjnego ciężkie pourazowe uszkodzenie mózgu jest obarczone istotną śmiertelnością i niesprawnością.

Słowa kluczowe: rehabilitacja, śpiączka, wynik leczenia, uraz mózgu.

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Received: 8.02.2010; accepted: 9.07.2010

Introduction

The increasing number of patients surviving severe traumatic brain injury (TBI) but with significant sensorimotor and neuropsychological deficits is a challenge to rehabilitation medicine. So far, most research initiatives have focused on mortality rates, or physiological or economic parameters to estimate therapeutic effects of rehabilitation strategies. Early and consistent administration of the correct rehabilitation programme is of crucial importance for the restoration and improvement of cerebral function, as well as social reintegration.

Early rehabilitation at this point is an integrated interdisciplinary therapy, which starts early and proceeds continuously with changing points of interest. Its aim is to support spontaneous recovery, to reduce the risk of early and late complications, and to make intensive use of the brain's own rehabilitative ability and plasticity.

At present, it has not been possible to make a reliable prognosis about recovery from the 'post-traumatic vegetative state', not even on the basis of clinical data or electrophysiological data such as evoked potentials. Consequently, other electrophysiological examinations such as event-related potentials or the analysis of changes in the EEG spectra are increasingly used to detect covert reactions to external stimuli. Until now, such diagnostics of sensory or cognitive abilities in comatose patients or patients with reduced consciousness has proven very difficult. Since patients appear to react to stimuli from their surroundings, a fact which is often observed by close relatives, it is believed that to a certain extent even comatose patients undergo experiences and react. Reuter *et al*. [1] showed that slow cortical potentials can be used to characterise mental functions as well as assess comatose patients' chances of recovery.

There is no satisfactory answer in the literature to the question whether further specific measures can contribute to the healing process and accelerate waking up out of coma [2,3]. Experiments carried out on animals have uncovered the possibility of changing neuronal structures and brain functions by means of external influences such as acoustic, tactile or visual stimulation [4]. Over the last years, sensory stimulation has played an increasingly important role in early rehabilitation therapy [5-7].

In the rehabilitative treatment attention should be directed to therapy which is focussed on initiating some form of communication with the patient as well as possibly enhancing brain plasticity [8,9].

Table 1. Localisation of brain lesions

Localisation	No. of patients
Acute epidural haematoma	8
Acute subdural haematoma	10
Subarachnoid haemorrhage	7
Cortical contusion	26
Skull base fracture	15
Brainstem contusion	14
White matter	19
Basal ganglia	9
Corpus callosum	6

Material and methods

This study focuses on the outcome of 27 patients who had sustained severe TBI and had been in a coma (Glasgow Coma Scale [GCS] ≤ 8) for more than seven days. Mean age was 39 years (range 17-76 years), 6 patients were female, 21 were male. The mean initial GCS was 4.8 (range 3-7), and the average length of coma was 32.1 days (range 7-55 days). All patients underwent magnetic resonance imaging (MRI) during the first week after trauma for the diagnosis of brain lesions (Table 1).

After controlled mechanical ventilation was completed and circulatory functions as well as intracranial pressure had normalized, all patients received complex early rehabilitative treatment in the intensive care unit. Rehabilitative treatment started after a mean time interval of 15 days (range 4-30 days). The duration of early rehabilitative treatment was 48.6 days on average (range 10-111 days). The rehabilitation programme includes prophylaxis to prevent complications and multimodal sensorimotor stimulation: acoustic, tactile, olfactory, gustatory, visual, kinaesthetic and proprioceptive stimulation [7]. Facial-oral tract therapy was performed to re-establish swallowing, physiotherapy aimed to improve sensorimotor functions, speech therapy at achieving a simple level of communication, and occupational therapy at achieving independence in the activities of daily living. The aim of neuropsychology was treatment of cognitive and behavioural deficits. Intensity and daily duration of this treatment were adapted to the individual condition of each patient and it was administered for an average of

4 to 5 hours a day. In all cases, therapy was scheduled individually. For every patient, 30-60 min of physiotherapy, 30-60 min of occupational therapy, and 90 min of multimodal early-onset stimulation (MEOS) were given. In rare instances, 30 min of speech therapy or of cognitive training were applied. The inclusion criteria for beginning stimulation therapy are presented in Table 2.

MEOS therapy consists of acoustic, tactile, olfactory, gustatory and kinaesthetic procedures, administered daily in two units of one hour each following a well-determined pattern.

Special demands have to be made concerning restriction of frequency and intensity of sensory stimulation in order to avoid straining the reduced possibilities of the injured brain. Controlled stimulation therapy should include low noise levels and adequate intervals between stimulation and medical and nursing activities. Furthermore, the patient's notion of time should be supported by alternating phases of activity with intervals without therapy. Rather than following a static pattern, stimulation units are based on dialogue answers and the actual function level achieved in the diverse sections. Stimulation therapy was applied until the following maximal values on the three subscales of the Glasgow Coma Scale were reached: undirected defending movements in reaction to painful stimuli (4 out of 6 points), verbal reaction with unrecognizable sounds (2 out of 5 points) and spontaneous eye opening (4 out of 4 points).

The team of therapists remained unchanged for all patients included during early rehabilitation treatment. After discharge from the hospital, subacute rehabilitation in centres for neurological rehabilitation was initiated for a mean period of 12 weeks (range 3-52 weeks).

The 12-month follow-up examination took place at the authors' department in all cases. It included a battery of scores and a detailed neurological examination (not completely possible in the vegetative state). The battery of scores contained the Glasgow Outcome Score (GOS), Barthel Index (BI), Functional Independence Measure (FIM), and an evaluation of the need for care.

The GOS, a brief descriptive outcome scale, is often used especially in studies investigating early acute medical predictors of outcome. The five categories of the original scale are: dead, vegetative, severely disabled, moderately disabled, and good recovery.

The BI consists of ten items that measure a person's daily functioning, specifically the activities of daily living and mobility. These items include feeding, moving from wheelchair to bed and return, grooming, transferring to and from a toilet, bathing, walking on a level surface, going up and down stairs, dressing, and continence of bowels and bladder. The assessment can be used to determine a baseline level of functioning and to monitor improvement in activities of daily living over time. The person receives a score based on whether they have received help while doing the task. The scores for each of the items are summed to create a total score. A higher score signals greater 'independence' of the person, the highest indicating no assistance in any part of the task. However, patients with severe brain damage cannot be differentiated appropriately as floor effects show up with increasing severity of neurological impairment, e.g. in comatose and near- or post-comatose patients in early rehabilitation. Aspects of functional deficits relevant in early rehabilitation patients have been introduced to the Barthel Index in a separate section, the Early Rehabilitation Barthel Index (ERI). These aspects are: state requiring temporary intensive medical monitoring, tracheostomy requiring special treatment (suctioning), intermittent artificial respiration, confusional state requiring special care, behavioural disturbances requiring special care, swallowing disorders requiring special care, and severe communication deficits.

Table 2. Inclusion criteria taken into consideration at the beginning of stimulation therapy

Severe head trauma with coma (GCS < 8) for at least 48 hours
Cardiopulmonary stability
Normal intracranial pressure
Lack of mechanical ventilation
Lack of sedation
Lack of severe infections

GCS – Glasgow Coma Scale

The FIM is the most widely accepted functional assessment measure in use in the rehabilitation community. The FIM is an 18-item ordinal scale, used with all diagnoses within a rehabilitation population. It is viewed as most useful for assessment of progress during inpatient rehabilitation. The FIM score is applied to the following areas: eating, grooming, bathing, dressing (upper body), dressing (lower body), toileting, bladder management, bowel management, transferring (to go from one place to another) in a bed, chair, and/or wheelchair, transferring on and off a toilet, transferring into and out of a shower, locomotion (moving) for walking or in a wheelchair, and locomotion going up and down stairs. The FIM score is also used for cognitive areas such as comprehension, expression, social interaction, problem solving, and memory. The specific FIM scores are as follows (from lowest to highest). A score of '1' means 'total assistance', in which the person contributes less than 25% of the effort necessary to do a task. A score of '7' means 'total independence', in which no helper is needed and the person performs the task safely, within a reasonable amount of time, and without assistive devices or aids.

Results

One year after trauma, 7 patients were dead (GOS 1), 4 continued to remain in a vegetative state (GOS 2), 7 were severely disabled (GOS 3), 6 were moderately disabled (GOS 4), and 3 had achieved a good recovery with only minimal disability (GOS 5). Median BI score of one-year survivors ($n = 20$) was 65 (interquartile range 20-75, range 0-100). Median FIM score was 84 (interquartile range 35-105, range 18-126).

The need of care was also addressed: 4 patients did not need any care, 2 patients demonstrated limited independence of care (limited mobility, independent in familiar surroundings, no nurse), 3 patients were dependent on help for selected activities (shopping, preparation of meals), 5 patients were intermittently dependent on care (selected activities, less than 8 hours per day), 3 patients were continuously dependent on care (all activities; more than 8 hours per day) and 3 patients were completely dependent on care (supervision and care for 24 hours per day).

There was no significant association between any type of brain lesion (Table 1) and the outcome scores. Spearman correlation analysis revealed a significant correlation of initial GCS score with Barthel Index ($r = 0.54$; $p = 0.02$) and with duration of early-onset rehabilitation ($r = -0.72$; $p = 0.001$). Furthermore, duration of coma significantly correlated with BI score ($r = 0.47$; $p = 0.049$), with FIM score ($r = -0.50$; $p = 0.03$), with GOS score ($r = -0.51$; $p = 0.03$) and with duration of early-onset rehabilitation ($r = 0.77$; $p < 0.001$).

Discussion

TBI constitutes the principle cause of death and disability mostly in persons under the age of 35 years [10,11]. With advances in pre-hospital and hospital medical care, the number of survivors from severe brain injury continues to rise [10]. Because of this lowered mortality, there is considerable concern that the number of patients with persistent vegetative state or severe functional deficits will increase [10].

Based on ethical and health policy principles, the medical objective is to support these patients in achieving the best quality of life and independence, enabling them to reintegrate into social life. The difference is obvious in comparing rehabilitation outcomes nowadays started already in the acute phase and continued until family, social and professional reintegration is achieved, with those performed with a long delay (if at all) in the nineteen sixties. The earlier the process is started and continuity maintained, the better the rehabilitation outcome [10-15].

The rehabilitation procedures commonly administered after a severe brain trauma take advantage of the optimal utilization of neural plasticity mechanisms. State-of-the-art knowledge is that intermittent multimodal sensory stimulation influences regeneration of the damaged central nervous system and advances its reorganization and functional recovery [16,17].

The therapeutic effect and the scientific basis of the stimulation therapy under discussion is controversial. LeWinn and Dimancescu [16] reported that 8 out of 16 patients who had received daily multi-sensory stimulation and passive movements of the limb completely recovered from a deep coma. Also the remaining eight patients eventually recovered from their comas: four of them were able to live largely independent lives at home. Similarly, Pierce *et al*. [17] showed that intensive multi-sensory stimulation led to significant improvements in comatose patients. Wood [18] emphasizes the importance of so-called 'sensory regulation', which consists of regulation of background noise levels and introduces silent periods and breaks between the therapy sessions. It aims at reaching the highest level of patient vigilance possible during purposeful stimuli presentation. Hall *et al*. [19] noticed that directed, person-related stimulation with individually meaningful stimuli seemed to evoke more significant reactions than undirected stimulation.

The use of behavioural parameters for the assessment of these reactions is a problem, because in most settings the person performing this task is also the one carrying out stimulation. For this reason the evaluation of electrophysiological parameters is crucial. Fast changes can be detected in a more objective way. Pfurtscheller *et al*. [20] detected significant changes in the EEGs of some comatose patients (GCS 4-6) after 10 minutes of tactile or visual stimulation. These results suggest that EEG frequency analysis may have some role in determining to what extent comatose patients can react. Besides the EEG analysis, the measurement of event-correlated vegetative potentials is important for the evaluation of coma stimulation.

Like neuropsychological and remedial educational early support of children suffering from severe brain damage, the early rehabilitation of patients having sustained brain injury should include an intensive unit to restore communication. Intensive care treatment should include offerings of dialogue based on aspects of the patient's life and preferences. These aspects will also be used in looking for possible answers to this dialogue. Because the communicative ability of the deep comatose patient is still deficient, these answers consist of vegetative symptoms, which are partly spontaneous, and partly caused by stimulation. It is possible to document these responses, e.g. by recording heart and respiratory frequency, blood pressure, and galvanic skin response, and by observing the patient's behaviour. The importance of the assessment of vegetative changes lies in the fact that non-visible ('covert') behaviour or autonomic potentials can be detected equally well as directly eye-catching ('overt') behaviour [21,22].

Contrary to popular belief, many seriously brain injured patients are able to be reintegrated into their family, social and professional life, if they receive efficient rehabilitation [23,24]. As is confirmed by the data presented above, duration of coma is one of the most important prognostic parameters, and seems to be inversely correlated with the extent of recovery [25-27]. Functional outcome of one-year survivors of severe TBI as described above parallel the results of Hawkins and coworkers [24] and those of Rhodes and collaborators [28], who found an average FIM score of 80-86% for all categories except for communication and social cognition. Mazaux and Richer describe a rather high proportion of severe TBI survivors reaching GOS levels 4 and 5 (about 83% in their sample) whereas only 17% experience an unfavourable outcome (GOS 1-3) [29].

Concerning the need of care, Hawkins and collaborators [24] found that 57% of cases were completely independent whereas only 16% still required continuous supervision 1 year after severe TBI.

Conclusions

1. Despite intensive rehabilitation treatment, severe traumatic brain injury today is still burdened with significant mortality and morbidity in terms of major disability and major dependency on care in the majority of cases.
2. Initial GCS scores and duration of coma allow for outcome prognosis to a certain extent.

Disclosure

Author reports no conflict of interest.

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