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EARLY REHABILITATION AFTER SEVERE BRAIN INJURY: A FRENCH PERSPECTIVE

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Severely brain-injured patients often suffer from disabilities and psycho-social handicaps. Early rehabilitation aims at improving their motor and functional recovery while preventing or treating complications as soon as possible. In this review we look at some issues encountered in early rehabilitation. We illustrate our discussion with data from 876 French traumatic brain injury patients admitted over the course of 1 year at 18 rehabilitation units that were asked for details of their current practice. Preservation of vital functions follows standardized protocols, but rehabilitation is more controversial. Few controlled trials are available. Good agreement exists among clinicians about prevention of orthopedic complications and treatment for spasticity. However, little consensus exists concerning treatment of non-pyramidal hypertonia and spasms or about procedures that can be undertaken to improve arousal from a coma or vegetative state. Finally, we look at other specific issues of early rehabilitation, namely prediction of outcome, psychological difficulties of patients and their families, efficiency and cost-effectiveness.

Key words: severe brain injury, early rehabilitation.

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INTRODUCTION

Severe brain injury is recognized as a major public health problem in industrialized countries, one with increasing need for emergency and medical care, secondary rehabilitation and long-term psychological and social support. Severely brain-injured patients often suffer for years from disabilities and psycho-social handicaps. Rehabilitation aims at improving their functional outcome and re-entry into the community, and thus at improving their overall feeling of subjective well-being. It is a long, complex and expensive process which begins in the intensive care unit and continues in the community and home setting. Each phase of the process has its own goals and specificity. Rehabilitation may begin very early after admission to the intensive care unit, as soon as the patient's medical condition is stabilized, and is often pursued in specialized rehabilitation settings. This early neuro-rehabilitation aims at improving motor and functional recovery while preventing or treating secondary complications. Specific, difficult questions arise, which are considered herein in more detail.

CONCEPTUAL ISSUES AND DEFINITION OF EARLY REHABILITATION

Evidence accrued progressively during the 1970s to suggest that the interventions of emergency care, neurology or neurosurgery, and rehabilitation should be linked in the best possible way, and that it was of great benefit to undertake rehabilitation of brain-damaged patients as soon as possible. Excessive delays in rehabilitation and lack of coherence in healthcare policies resulted in considerable amounts of human and financial damage. Studies provided evidence that undertaking rehabilitation within the first days of evolution improved cognition, perception and motor recovery of brain-damaged patients, and lead to shorter lengths of stay (LOS) in rehabilitation units (1, 2). The concept of early rehabilitation emerged. Rehabilitation procedures began to be undertaken in neurosurgery departments and in intensive care units. Rehabilitation medicine specialists coordinated interventions with therapists and planned the forthcoming rehabilitation. New units and programs were introduced for treating patients with severe traumatic brain injury (TBI) or similar brain damage, i.e. subarachnoid or brain hemorrhage due to the rupture of an aneurysm, viral (herpes simplex) encephalopathy and anoxic or metabolic insult of the brain (3–6).

Scientific arguments also enhanced the concept of early rehabilitation. It was shown from animal experiments that early training (freedom to move) and an enriched environment (the presence of others) improved functional recovery, and recent papers have confirmed this fact (7). Experimental data obtained in animals suggested that adaptive neural plasticity may be enhanced using complex motor skills training (8). Similar findings were reported in training-induced visual field enlargement in brain-damaged patients (9). In humans, recovery from hemiplegia is accompanied by changes in brain activation in sensory and motor systems (10). These reorganizational processes may be critical for the restoration of function. Musso et al. (11) demonstrated in vascular aphasics that an improvement in auditory comprehension induced by specific training is associated with functional brain reorganization. Compensatory movement patterns are used in the recovery of motor function following cortical injury, even after relatively small lesions that produce mild, transient deficits (12).

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Biochemical data on ionic fluxes and calcium channels, free radicals and neurotransmitters such as glutamate provide the prospect of new drugs to improve brain recovery (13–15). Drugs modulating the levels of neurotransmitters, such as norepinephrine and γ-aminobutyric acid, may influence both the rate and amount of recovery after focal brain damage. Such drugs may be effective long after brain injury and the therapeutic window may be widened beyond the first few hours (16). Large multicenter studies will be required to determine whether diverse populations of patients will derive long-term benefit from these drugs.

Nowadays, in most neurological hospitals around the world, severely brain-damaged patients admitted to acute care units are immediately provided with rehabilitation care and transferred as soon as possible to specific rehabilitation units situated close to acute facilities. In these units, such as ours at the University Hospital of Bordeaux, brain-damaged patients who are either still comatose or experiencing arousal are treated by nurses, physical therapists, occupational therapists, speech therapists and social workers. These staff are specifically trained in neurological rehabilitation and work together with rehabilitation medicine specialists. Meetings with colleagues from acute units and discussions with family members help to build integrated and graduated programs of rehabilitation according to the general and neurological status of the patients (4, 17). In the US, up to 63% of Level I Trauma Centers have a dedicated rehabilitation floor within the center itself, in accordance with the recommendations of the American College of Surgeons Committee on Trauma (18, 19). Formalized programs are undertaken which involve multidisciplinary and goal-oriented approaches, with repeated discussions between professionals, education and involvement of the patient's family in all aspects of therapy and decision-making and early ongoing social support (2, 5).

Many difficulties remain to be faced. Some procedures are difficult to undertake because of fatigue, pain and/or lack of cooperation. Others are impossible to begin because of ongoing acute care or vital problems: what is good in terms of rehabilitation may be unsafe, and *vice versa.* Another major problem is that rehabilitation all too often still comprises empirical and miscellaneous methods. Few controlled trials are available in the literature and many treatments remain controversial. To address this issue, we asked for details of the current practice of physiatrists at 18 major French acute TBI rehabilitation centers, at which 876 TBI patients were admitted during the year 1998. Time between injury and admission was 1–4 weeks, depending on the facility and the severity of the case. Table I gives the general features of the admitted patients.

CLINICAL ASSESSMENT

Assessment is of major importance in rehabilitation medicine in terms of defining goals and priorities according to patients' needs and clinical status, and for allowing evaluation of recovery and the efficacy of therapy. The assessment tools currently used by French clinicians who participated in this study are shown in Table II. The Functional Independence Measurement (FIM) (20, 21), the Neurobehavioral Rating Scale—Revised (NRSR) (22, 23) and the Galveston Orientation and Amnesia Test (GOAT) (24) are the most frequently used (note that clinicians were not asked for coma or motricity assessment). In the literature, a lot of well-designed and validated assessment tools are available, all of which are well known to most clinicians. However, controversy still exists concerning which tool to use on which occasion. Obtaining complete information about patients' strengths and weaknesses, defining precise goals and the time of assessment are important factors to consider. Instruments used during early rehabilitation should at the same time be

- standardized, reproducible and sensitive to changes over time to allow for assessing outcome and recovery by comparing early (admission) and late (discharge and follow-up) data,
- pragmatic and concrete in order to help design goals for rehabilitation, and
- flexible and brief enough to be administered to patients suffering from fatigue and reduced alertness and who are not fully cooperative.

The Glasgow Coma Scale (25) is widely used for diagnosis, clinical management and prognosis in traumatic coma and the GOAT for assessment of cognitive functioning and prediction of evolution on arousal. However, these tools do not provide information for setting rehabilitation goals. Motor recovery may be documented by repeated use of impairment scales such as Fugl-Meyer's (26), the Motricity Index (27) or Ashworth's score for spasticity (28), and cognitive and behavioral recovery by the NRSR. All these scales provide standardized and reliable assessments and may be used from the early phases of evolution. In connection with extensive evaluation, articular range of motion, neuro-motor testing and psychometric tests of cognitive functioning are difficult to complete because of pain, fatigue and lack of cooperation and are generally used later on.

Disability scales are broadly used for assessing functional recovery, designing definite goals for rehabilitation, in association with impairment scales, and for assessing short- and long-term outcome and efficacy of therapy. Use of the Barthel Index (29) and the FIM is now nearly universal. Finally, global outcome scales such as the Glasgow Outcome scale and scores or gradings specific to the etiology of brain damage may be used as a summary for assessing outcome and recovery (30, 31). The European Brain Injury Society Document for evaluation of TBI patients (32) is a comprehensive summary tool, which has the benefit of including separate sections for impairment, disability and handicaps. It may be completed, at least partially, very early during rehabilitation, and allows for repeated measurements on evolution.

PRESERVATION OF VISCERAL FUNCTIONS

Preservation of visceral functions after severe brain injury is now undertaken according to well-standardized protocols.

Table I. *Features of patients with traumatic brain injury admitted to 18 French early rehabilitation units in 1998*

	Sample	*N*	Range
Admissions, 1998	876	876	5–150[a]
Still comatose	779	135 (17%)	0–60%
Arousal phase	779	362 (46%)	10–80%
Fully conscious	779	282 (36%)	0–90%
Free breathing	740	459 (62%)	30–100%
Tracheostomia	740	281 (38%)	
Oral intake	740	292 (39%)	0–100%
Nasogastric tube	740	350 (47%)	0–70%
Gastrostomia	740	98 (14%)	0–40%
Incidence of heterotopic ossification	836	105 (12.52%)	3–50%

[a] Mean = 46 per unit.

Table II. *Clinical assessments routinely used for patients with traumatic brain injury. Values shown indicate the number of hospitals using a particular assessment*

FIM	16/18
NRSR	13/18
GOAT	10/18
Local variation	4/18
EBIS	3/18
WHIM	3/18
LOCF	2/18
DRS	1/18

FIM = Functional Independence Measurement; NRSR = Neurobehavioral Rating Scale—Revised; GOAT = Galveston Orientation and Amnesia Test; EBIS = European Chart for Head Injury Assessement; WHIM = Wessex Head Injury Matrix; LOCF = Rancho Los Amigos Levels of Cognitive Functioning; DRS = Disability Rating Scale.

Nursing care and sophisticated beds and mattresses help to reduce the risk of pressure sores. The restoration or stabilization of myocardial function, hemodynamic regulation and blood pressure control are priorities. Maintaining a fair respiratory status is also a priority and involves rehabilitation, i.e. improvement of breathing by physiotherapy, alternative lateral and procubitus posturing, repeated removal of bronchial secretions and providing oxygen via a nasal tube to improve brain intake of oxygen.

Specific issues have recently been emphasized. The risk of deep vein thrombosis is as high as 20% in TBI patients on admission for rehabilitation and 60–75% in bed-confined hemiplegic patients, with 10–20% of these developing pulmonary embolism (33, 34). Little controversy exists in terms of prevention and treatment (35, 36). Nearly all teams use lower-extremity compression devices or elastic stockings and either subcutaneous low-dose unfractionated heparin or low-molecular-weight heparin for prevention and treatment, even soon after a hemorrhagic cerebrovascular accident. The choice of imaging technique remains a subject of debated: venography is painful, costly and invasive and therefore most clinicians prefer venous Doppler ultrasound scanning (37). Some clinicians prefer to use the cheaper plasma measurement of D-dimers, in spite of the high false-positive rates obtained with this technique after stroke (38).

Comatose patients often need tracheostomy, and the tracheostomy tube is still in place in 40% of patients admitted to French early rehabilitation units after a TBI (Table I). Removal of the tube should be planned as soon as no risk of swallowing problems, bronchial obstruction or neurogenic respiratory insufficiency remains; however, the decision of when to remove the tube remains empirical, and there is a need for documented and/or controlled data in order to help clinicians make this decision.

Sixty percent of TBI patients suffer from swallowing impairments which make oral intake impossible (39, 40). The development of standardized swallowing rehabilitation programs (41, 42) is emphasized by all clinicians as one of the most important advances in the rehabilitation of brain-damaged patients in the past 20 years. Swallowing rehabilitation programs should be undertaken according to repeated clinical examination of the pharynx, usually by videofluoroscopic recordings of swallowing (40). Positioning of the head, density of food and thickening of drinks play a great role in this rehabilitation. When the patient is unable to swallow for a long time, one can accept the transitory use of a nasogastric tube. However, gastrostomia is preferred by more and more clinicians as a safe and efficacious technique whenever the situation is long-lasting (Table I). This allows the feeding of high-calorie diets to comatose and severely brain-damaged patients who suffer emaciation after a long phase of emergency care (43, 44) and are exposed to hypometabolism and decreased immunological defenses (45). Endocrinological impairments may also enhance the risk of emaciation.

Finally, bladder and bowel control are important issues to consider. Everyone agrees that bladder probes should be removed as soon as possible, i.e. when emergency care no longer requires a precise balance of water exchange. Periodic catheterization or placement of a supra-pubis catheter may be used in cases of retention. Incontinence often ends with the recovery of full consciousness. Constipation may require specific assessment and diets.

AROUSAL FROM A COMA

Arousal from a coma is a very specific situation, which can cause perplexity and confusion to both family members and inexperienced caregivers (7, 45 46). Post-comatose patients often recover full consciousness only after a period of confusion and behavioral disturbances, with full dependence in activities of daily living, which is referred to as post-traumatic amnesia in TBI patients. Nearly half of these patients are agitated and restless and others are hypokinetic. They often exhibit regressive behavior and are unable to understand the aims of rehabilitation and to engage actively in it.

A vegetative state (VS), defined as “wakefulness without awareness”, develops in 1–15% of TBI patients with a Glasgow Coma Score (GCS) of ≤ 8 within 48 h of injury (47, 48), and data

Table III. *Treatment of arousal and behavioral disorders. Values shown indicate the number of hospitals using a particular treatment, with percentages in parentheses*

	Use of treatment		
	Often	Sometimes	Never
In cases of agitation during arousal			
Physical restraints	4 (22)	10 (56)	4 (22)
Neuroleptics, BZD	6 (33)	12 (66)	–
Mattresses on the floor	8 (44)	5 (27)	5 (27)
Presence of family[a]	10 (56)	8 (44)	–
Faced with akinetic mutism or similar states			
Sensory stimulation[a]	12 (66)	4 (22)	2 (11)
Dopaminergics	5 (27)	5 (27)	8 (44)
Antidepressants	5 (27)	8 (44)	5 (27)
Modafinil/adrafinil	–	5 (27)	13 (72)
Methylphenidate	–	1 (6)	17 (94)
Presence of family[a]	12 (66)	5 (27)	1 (6)

[a] Routinely used in >50% of centers.
BZD = benzodiazepine.

from the US Traumatic Coma Data Bank reveal that 10–15% of such patients are discharged from hospital after 1–2 months of evolution whilst still in a VS (49). VS is not an homogenous entity and Jennett and Plum acknowledged that a continuum may exist between VS and states of very severe disability. The International Working Party on the management of the VS outlined in 1995 the need for categorization to identify patients who are improving and those who are no longer in a VS (50). The Working Party proposed terminology to define coma, vegetative presentations (hyporesponsive state, reflexic responsive state, localized responsive state), undecided category (a transitional or borderline state) and non-vegetative states (inconsistent and consistent low-awareness states). However, full agreement on categorization and terminology was not reached by the Working Party and further clinical research is needed to resolve this issue. Other states, such as akinetic mutism and locked-in syndrome, should be distinguishable from VS by means of clinical features: although early rehabilitation is nearly the same, prognosis differs. It is especially important to distinguish between patients with transitory and persistent VS, as at least half of those in a VS recover consciousness within 3–6 months.

Improving cognitive functioning and behavior during the arousal phase has always been a challenge for rehabilitation, especially in cases of prolonged unawareness (46, 51, 52). French clinicians emphasize comprehensive and unobtrusive nursing and the constant presence of family members close to the patient (Table III). Tracheostomy tubes and venous and urinary catheters are painful and should be removed as soon as possible. Antalgics should be used. Nurses and therapists are aware that these patients need meaningful human relationships in addition to physical care (45). Enhancing the environment with sensory stimulation in cases of hyporesponsive state or VS remains a subject of debate, both among French clinicians as well as in the literature (53). Wood's concept of sensory regulation, integrating all kinds of stimuli, including those generated by daily living, in a common way for brain information seems promising (54, 55). With regard to immediate behavioral response to stimulation of 24 patients with VS, Wilson et al. (56) showed firstly that multimodal stimulation, in the sense of application in a graded and structured manner of stimuli to each of the senses in turn, was more efficacious than unimodal stimulation, and secondly that familiar stimuli, such as favorite food and songs, pictures, audio recordings of family members or favorite clothes, produced greater behavioral changes than neutral stimuli. Pharmacological approaches are slowly being developed (57). Amphetamine (58), levodopa/dopaminergics (59) and antidepressant drugs (60) have provided good results in single cases, but no convincing data have yet to emerge from group studies. French clinicians do not currently use such medications in >50% of cases. Adrafinil, modafinil and methylphenidate have been tried. Drugs that disturb catecholaminergic activity should be avoided. Anti-epileptic drugs should be used only in patients at high risk of seizure and within 1 week of injury (61), a recommendation that French clinicians are in agreement with. Aside from drug therapy, stereotaxic stimulation of basal ganglia is still in an experimental phase of application, but raises hope (62, 63).

In cases of major behavioral problems, e.g. disinhibition, aggression and agitation, French clinicians use, reluctantly, antipsychotics and benzodiazepines, while being aware of their limited efficacy and negative effect on general alertness and on the recovery process (64). Most clinicians prefer to let the patients lie down on mattresses on the floor where they can move and be agitated without danger, and emphasize again the presence of family members. Physical restraints are used in <50% of cases (Table III).

ORTHOPEDIC ISSUES

The risk of orthopedic complications depends on the severity of brain injury, the length and depth of the coma, the duration of stay in the intensive care unit and the severity of tonus disorders and paralysis. Whatever their nature, orthopedic complications cause pain, limb deformities and joint ankylosis, which induce limits for rehabilitation and increase the risk of pressure sores.

Association with limb fractures, which are sometimes not detected during acute care, enhances the risk of orthopedic complications. Recent advances in anesthetic techniques allow for early surgical fixation of many injuries, particularly fractures of the lower extremities, which require stabilization to allow early mobilization and rehabilitation (65). Contractures, which affect over one-third of patients (66), and spasms (decortication and/or decerebration) may to some extent be reduced by pharmacological sedation. Prolonged immobility and arthrogenic changes are critical factors in limiting the range of motion of joints, especially when the period of immobility exceeds 2 weeks (67) and involves a combination of muscular atrophy, hypertonia and regressive behavior on arousal from the coma. Ankle plantar/flexor contractures are a common problem following TBI. A combination of deformities of hips, knees, shoulders, elbows, wrists and hands as a result of brain-stem impairment is less frequent.

Measures to prevent orthopedic and cutaneous complications should be undertaken during the coma and especially when brain sedation is reduced at the beginning of the arousal period. Passive joint mobilization, intermittent and alternative posturing and casting combined with stretching have been emphasized in recent studies (68). Later on these methods have to be continued and associated with environmental adaptation in order to allow spontaneous and free motor activity. It is important to pay attention to painful manifestations during stretching and to provide an active analgesic drug (i.e. morphine) before the therapy session. There is wide agreement (>75% of current practitioners) among French clinicians in favor of posturing, early sitting and, less frequently (50%), early standing on electric tables. Early bathing may also be useful, even at this early phase of rehabilitation (Table IV).

Heterotopic ossification (HO) is a rare complication in patients with severe TBI which impedes the rehabilitation process (69). The mean incidence of clinically significant HO was 12.5% in our sample, and is 10–25% in the literature (65, 70 71). Approximately 10% of cases of HO are massive and cause severe restriction in joint motion, or ankylosis. The most frequent locations are the proximal limb joints—hip (>30%), knee (25%), elbow (22%) and shoulder (20%)—and the mean number of joints with HO in a TBI patient is 2.6 (71). Risk factors include prolonged coma, tone and movement impairment in the involved limb and associated fractures in adults, children and adolescents (71–73). Detection commonly occurs at 2 months: the most common symptoms are decreased range of motion and pain. Serum alkaline phosphatase level, urinary hydroxy proline concentration and urinary calcium excretion are all elevated. However, serum osteocalcine level is not a valuable adjunct for confirming the diagnosis of neurogenic HO (74). Ultrasonic echography and roentgenography provide firm, but late, confirmation of diagnosis. Therefore, a full-body ^{99m}Tc bone-scan MDP may be useful prior to beginning active rehabilitation in a TBI patient suffering from joint pain of unknown origin. As soon as possible, the treatment of clinically defined HO should include diphosphonate, indomethacin, X-ray therapy and mobilization, with a very high agreement for indomethacin treatment existing among French clinicians (Table IV). A small number of patients show some improvement with medical treatment; in cases of severe ankylosis HO removal by surgical excision should be considered. The mean delay for surgery is 1.5 years but remains controversial, at least in France, and further studies are needed to resolve this issue. Clinically defined HO is associated with a poor functional outcome as assessed by significantly longer inpatient rehabilitation LOS and significantly lower FIM score for mobility and activities of daily living on admission and discharge; however, it is not clear whether HO causes the poor outcome by itself or whether it is only an indicator of a patient who is incapable of improvement at this stage (75).

MOTRICITY REHABILITATION

Some post-comatose patients also suffer from severe and specific impairments of motricity, posture and muscle tone regulation, namely hypotonus and ataxia of cerebellar origin, rigidity as a result of brainstem and basal ganglia damage, spasms in flexion (decortication) or in extension (decerebration) with dysautonomia syndrome and, sometimes, dyskinesias, tremor and myoclonus. In patients who undergo long periods of emergency care and emaciation, devastating peripheral neuropathies may also be observed (76).

All of these disorders, in addition to hemiplegia and orthopedic impairments, serve to deprive patients with severe brain damage from motor autonomy. Precise assessments of motricity, balance and posture are very difficult. However, motor rehabilitation should begin as soon as possible. Posture recovery is emphasized, beginning with control of head, neck and trunk positions; rehabilitation is then conducted according to the successive stages of motor development in childhood. Traumatic brain injury patients are reluctant to make meaningless efforts and obviously motricity rehabilitation should always be directed towards functional autonomy and useful motricity for daily living. With regard to pharmacological treatment, dextroamphetamine has been shown to improve motor recovery in animals, probably by means of its catecholaminergic action. Crisostomo et al. (77), in a preliminary controlled study in 1988, provided evidence that a single dose of amphetamine, combined with accurate physical therapy, promoted recovery of motor function in eight stroke patients and Bach-y-Rita & Bjelke (78) suggested that this effect might be related to changes in c-fos gene expression. Unfortunately, 10 years later on, only one study (58) has confirmed these data. With regard to treatment of spasticity, strong agreement exists among our sample of clinicians in favor of passive mobilization, physical therapy concepts such as those described by Bobath, and oral drugs such as baclofen, dantrolene sodium and

Table IV. *Treatment of orthopedic and motor impairments. Values shown indicate the number of hospitals using a particular treatment, with percentages in parentheses*

	Use of treatment		
	Often	Sometimes	Never
In case of contractures, retractions			
Alternative postures[a]	13 (72)	4 (22)	1 (6)
Early sitting[a]	17 (94)	1 (6)	–
Early standing on electric bed[b]	9 (50)	3 (17)	6 (33)
Early bathing[a]	14 (77)	3 (17)	1 (6)
In cases of heterotopic ossification			
Diphosphonates, prevention	–	1 (6)	17 (94)
Diphosphonates, care	–	3 (17)	15 (83)
Indomethacin[a]	17 (94)	–	1 (6)
X-ray therapy	1 (6)	3 (17)	14 (77)
Heterotopic ossification surgical removal			
At 6–9 months	1 (6)		
At 9–12 months	7 (39)		
Depending on scintigraphy	7 (39)		
Depending on clinic only	3 (17)		
Surgery associated with			
Diphosphonate	6 (33)		
X-ray	7 (39)		
Indomethacin	5 (27)		
Treatment of spasticity			
Bobath's schemes[a]	16 (89)	2 (11)	–
Oral drugs[a]	17 (94)	1 (6)	–
Early botulinum toxin	2 (11)	8 (44)	8 (44)
Intrathecal baclofen	2 (11)	7 (39)	9 (50)
Treatment of rigidity, spasms and other disturbances of muscle tone			
Bobath's schemes	11 (61)	1 (6)	6 (33)
Neuroleptics	5 (27)	7 (39)	6 (33)
Benzodiazepine	8 (44)	10 (56)	–
Intra-thecal baclofen	3 (17)	4 (22)	11 (61)
Beta-adrenergic receptor inhibitors	–	4 (22)	14 (77)

[a] Routinely used in >75% of centers.
[b] Routinely used in >50% of centers.

diazepam (>75% of current use; Table IV). However, drugs have to be discussed with regard to the role of spasticity on progressive contracture, motricity restriction and potentially adverse brain effects. Tizanidin, which is now available in France, as in other European countries, seems promising, with similar efficacy to baclofen but with fewer side-effects. Despite potential side-effects on vigilance and cognition, and the risk of seizures, intrathecal baclofen infusion has been shown to be beneficial in spasticity after a TBI (79, 80); however, only 11% of French clinicians use it frequently. In the same way, injections of botulinum toxin, especially in the ankle, elbow, wrist and fingers, have been shown to be beneficial in chronic phases (81, 82) but few French clinicians (11% often, 39% sometimes) use botulinum toxin in early rehabilitation. Among new drugs in development, clonidine, L-threonine and new agonists of γ-aminobutyric acid (gabapentin, vigabatrin) provide hope for the treatment of spinal cord injury and multiple sclerosis but have not yet been trialled in TBI patients (83).

Paroxysmal sympathetic storms (or dysautonomia syndrome) occur frequently during the initial phase of a TBI and usually include severe non-pyramidal muscle hypertonia and spasms. Use of neuro-sedation and prevention of secondary brain damage of systemic origin by attentive control of blood pressure, respiratory function and sodium intake make these impairments less frequent. However, some of them occur later during evolution and their treatment is one of the most controversial and disappointing aspects of TBI (Table IV). Bobath's posturing is usually ineffective. Clinicians try neuroleptics or benzodiazepines with little hope of success. At present we are not far from thinking that no treatment is effective against these impairments. Some authors begin to use intrathecal infusion of baclofen, despite the risk of seizure. In four patients treated by neurosurgeons in our hospital with continuous intrathecal infusion of 150–600 μg/day baclofen, dysautonomic paroxystic episodes with hypertonia completely disappeared on Day 6 of treatment and only one patient relapsed at the end of the trial (84). Obviously our knowledge of the pathophysiology of traumatic damage in the neuronal circuits of muscle tone control and of related impairments in neurotransmitter secretion should improve in order to allow us to utilize future advances in pharmacological interventions.

EARLY PROGNOSIS

One of the most important questions which arises during early rehabilitation for patients, families, facilities and third-party payers is how to attempt an early prognosis of the long-term outcome. The purpose in this is threefold: (i) to allow rehabilitation teams to set realistic goals; (ii) to give the patient and his/her family adequate information; and (iii) to make the best possible use of healthcare resources. Early prognosis can be deduced for groups of patients but making an early prediction of an individual prognosis remains very difficult as most sensory, motor and cognitive consequences of brain injury are highly variable in terms of their effects on individuals, can occur either in isolation or in combination and often change in severity and presentation over time. The mechanisms involved for re-establishing appropriate and adaptive behaviors in TBI patients are prolonged and, in some cases, lifelong (85). Individual recovery also depends on overall family functioning and additional psychosocial consequences.

With regard to the major prognostic factors, age is well known to influence recovery independently of other factors. The GCS score is widely used in acute care settings based on its ability to predict mortality and morbidity. Nevertheless it may have limited value as a predictor of functional outcome in isolation: Zafonte et al. (86) found a significant, but modest, correlation between the initial lowest GCS score and outcome variables. Coma duration is predictive of outcome and work status after TBI (87) but duration of post-traumatic amnesia is more reliable in predicting outcome at the time of hospital discharge (88); these results support the usefulness of prospectively measuring the duration of post-traumatic amnesia after termination of coma. General health status, hypoxia, cognitive impairment (especially in terms of executive functions), emotional disturbances and disabilities in daily and social living are other important factors of prognosis. The best prediction of functional and vocational outcome can probably be found from multi-dimensional regression-type models which consider many relevant factors together (89).

The diagnosis of persistent VS is very difficult to make early in evolution and should be very cautiously argumented (45). As stated previously, at least half of these patients recover consciousness within 3–6 months. The British Medical Association recommended in 1992 that a firm diagnosis should not be made before 1 year of evolution [cited in Levin et al. (47)]. Factors said to predict outcome include age >40 y, low GCS, low pupillary reactivity to light, hypotension and hypoxia (in some studies), hydrocephalus, seizures, respiratory disturbance and decerebrate posturing; however, no clinical feature of prognosis is consistent across all studies. Event-related potentials and brain imaging are important prognostic aids. Data from the Traumatic Coma Data Bank showed that diffuse injury complicated by brain swelling (cisternae compressed or absent) and shift of midline structures on initial CT scan was twice as frequent in patients who were still vegetative at discharge than in patients who were not (49, 90). It was also shown that a >8 mm width of the third ventricle and a septum–caudate distance >11 mm were predictors of a poor evolution of patients with VS (91). Metabolic brain imaging may show neuronal dysfunction in brain regions which appear normal on conventional imaging: positron emission tomography revealed a reduction of 40–60% of brain blood flow in patients with persistent VS (92). Of course this technique is too expensive to be used routinely by clinicians; however, single-photon emission CT may provide helpful and cheaper information (47).

PSYCHOLOGICAL AND FAMILY ISSUES

Severely brain-damaged patients usually suffer confusion, reduced alertness, anosognosia and cognitive impairments which prevent them from achieving a clear and accurate self-awareness and a clear understanding of our explanations. Patients with frontal lobe syndrome are the most severely impaired (45, 93). This issue is extremely complex and has a major influence on rehabilitation: a confused or anosognosic patient does not feel impaired, therefore he/she does not understand why they are receiving rehabilitation and does not engage actively and willingly in it. As these impairments are usually most intense in the early stages of evolution, it is during early rehabilitation that they have the worst influence on the recovery process, although denial, which is of a different nature, generally occurs later on. Anxiety and mood disorders also interfere strongly with rehabilitation and often need medication and comfort.

Another very difficult psychological issue is to make family members aware of what happens, and to help them to cope with it (94). Much has been written on family distress and burden during the later stages of evolution (95–98), but few studies have emphasized the intensity of stress, emotional turmoil and feeling of misunderstanding that family members may suffer during the arousal phase from a coma. They will have already experienced an unbearable stress and fear of death at the time of injury and during the coma, together with shock, disbelief, denial or even anger (99). With arousal comes the hope of recovery and a return to the pre-traumatic status, with a fear of sequelae and questions about the effectiveness of rehabilitation. Most relatives have no idea of what a brain injury consists of, and to what extent recovery may occur. Therefore they need, above all, information, which should be reliable, consistent from one team member to another, easy to understand (i.e. non-medical terminology) and repeated. They want the team members to tell the truth and to give realistic predictions, without removing all hope. The International Working Group for the management of the Vegetative State recommended organizing training courses for nurses and rehabilitation teams in order to improve communication skills with families. Some teams organize weekly educational meetings, with a psychologist and the relatives of several patients attending together. In other places relatives associations meet, if necessary every day, family members in distress inside the hospital. Another aspect is that family members strongly wish to be useful to their relative. They want and need to be involved in rehabilitation care and in the decision-making process, and to offer counseling and support. The Working Group recommended involving the family at the earliest possible stage, including in the intensive care unit, and to provide help and support from psychologists, counselors, peers and relatives associations (50). In spite of these efforts, family members continue to describe misunderstanding and lack of support from the teams, and conflicts and lack of confidence often occur (100).

Advances in psychological research are developing and provide interesting results. Here are two examples. Careful documentation of the needs of families may help to improve understanding of the causes of conflicts and disappointments. Using the standardized Family Involvement Questionnaire, Shaw et al. (101) showed that family members and professionals differed on three of the four subscales of the questionnaire, despite agreeing on the necessity of this involvement. Family members felt significantly more need than staff members to participate directly in rehabilitation planning, to be notified of all, even minor, problems and changes in the patient's schedule, to receive a copy of all test results and to make visits and communicate by phone as often as desired. Interestingly, the staff attached a greater importance than family members to attending educational meetings and marital and sexual counseling sessions. One can imagine how beneficial further discussions between professionals and family members may be. Another interesting approach comes from family therapy. A psychiatrist in our team, who has considerable experience in systemic family therapy in TBI, regularly meets family members in the presence of their relative and other team members. The goals are: (i) to make family members accept that the family system will not work as before and to make them understand that nobody but them is competent to change it to overcome the present crisis; (ii) to assess to what extent misunderstanding from professionals may impair this process, and how to remedy it; and (iii) to look for a symbolic sense of the accident with regard to psychological family problems that existed prior to the TBI, and to provide psychological support (102).

TOWARDS A BETTER QUALITY OF CARE

Does early rehabilitation work? To what extent does it achieve more than active rehabilitation undertaken later? Some convincing studies can help answer these questions. Morgan [cited in Cope (103)] provided evidence that undertaking rehabilitation within 7 days post-injury improved cognition, perception and motor recovery of brain-damaged patients, and produced a shorter length of hospital stay (24 days, compared with 45 days for patients treated later). Mackay et al. (2) compared 17 severe TBI patients who received an early, formalized intensive rehabilitation during acute hospitalization (from the second day post-injury) with 11 others matched for GCS score and other indicators of severity who received acute care services and some physical therapy only after 23 days post-injury in 10 different hospitals. Coma duration and rehabilitation LOS for the early rehabilitation group were approximately one-third of those of patients in the non-formalized program. Cognitive level at discharge (as assessed by the Rancho Los Amigos scale) and percentage of discharges to home were also higher in the formalized program group. Similar results, in terms of better functional outcome after early treatment, have recently been confirmed in stroke rehabilitation (104). Another difficult issue concerns the cost-effectiveness of early rehabilitation. In recent years cost management has become nearly as important a component of rehabilitation services as the quality of care itself. Active inpatient rehabilitation with a full complement of professionals has been questioned with regard to less-costly alternative facilities. Few data exist for early rehabilitation. In 1982, Cope & Hall (1) studied 36 severe TBI patients matched for initial severity and retrospectively divided into early (<35 days post-injury) and late (>35 days) rehabilitation admission groups. In the late admission group, patients required twice as much active rehabilitation as those in the early group, despite achieving the same functional outcome. Cost savings were evaluated as US$ 40,000 per patient for inpatient care. Cope mentions (103) that Hall and Wright replicated these findings in 1990: mean rehabilitation LOS was 28 days for patients admitted before the 22nd day post-injury and 60 days for patients admitted later. The other studies discussed earlier also found that early rehabilitation made active rehabilitation cheaper by way of reducing the rate of complications that are expensive to treat, shortening inpatient LOS and reducing the rate of transfer to nursing home facilities. We think it is very difficult at present to have a definite opinion on this issue; perhaps cost savings are even greater than those found in the studies above when all the late costs of living with severe disability are considered.

Reducing LOS is obviously not the objective of rehabilitation. Rehabilitation is first and foremost intended to improve the functional outcome and quality of life of disabled people, and saving money should remain a welcome by-product of quality of care. Better care is often associated with cheaper care as complications and long-term expensive disability are reduced. We think that the question should not be is it worthwhile and cost-effective to engage in early rehabilitation? Better questions to ask might be what kind of rehabilitation, with what content, should be undertaken early, and what kind should be undertaken later on, for which patients, and how do these data relate to direct costs? Therefore, improving the quality of rehabilitation is a priority for us. Developing standards of care and rehabilitation will help clinicians to work better. We acknowledge that most of the products of rehabilitation are difficult to assess firmly in terms of evidence-based medicine because rehabilitation involves a lot of different people and a lot of very different processes, many of them taking place more in the fields of psychology and sociology than in the field of "hard" sciences, and because rehabilitation develops and change over long periods of time. Rehabilitation content is often poorly described, and although one can read numerous papers very little is often said about what exactly happened during the patient stay and what was undertaken. Moreover, prospective health payment systems and insurance conditions differ greatly from one country to another, and what has been shown to work in one system is not directly applicable to another. However, clinical research is ongoing, good studies have been done and some robust data have been provided. Clinicians should take these into account in daily practice. In this context, guidelines and consensus statements are being developed (85, 105). At present these provide mostly general rules, few of which concern early rehabilitation, but efforts are ongoing. A consensus conference is planned in France in 2001 on this topic.

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