Educational Module - 3

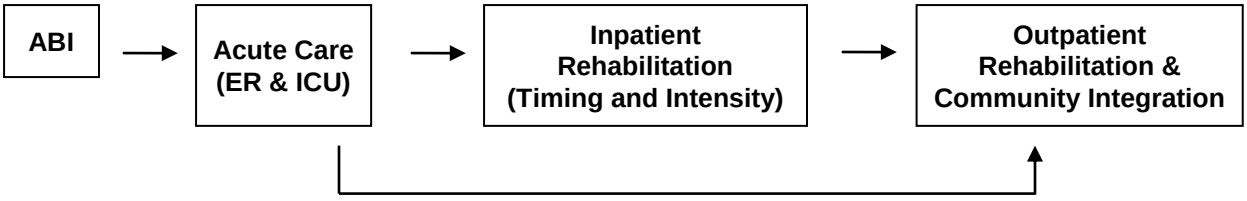
Efficacy and Models of Care Following an Acquired Brain Injury

Acquired brain injury presents unique challenges that make rehabilitation difficult to standardize. The development of best-practice principles has been hindered by limited access to adequate sample sizes and appropriate comparison groups in ABI patients within a clinical, rehabilitation environment [1]. As a result, a consensus on optimal models of care for brain injured patients has been elusive.

In October of 2007, a workshop was held by the National Institute of Neurological Disorders and Stroke (NINDS) to develop a classification system for Traumatic Brain Injury (TBI) designed to direct therapeutic interventions [2]. Traditional classification systems have been problematic given the diversity of brain injury needs. This international group of experts emphasized that we have merely begun to scratch the surface in understanding brain injury care. Nevertheless, a model of the pathway that patients should follow has evolved.

Generally, patients with an ABI receive pre-hospital care, acute care (with neurosurgical intervention if necessary), ICU management, inpatient rehabilitation, and are then discharged to the community with varying levels of support [3] (Figure 1). Additional components of this pathway may include cognitive and behaviour rehabilitation programs, community living opportunities, rehabilitation services in the home, and care management and prevention initiatives [4]. Despite effective triage programs, best-evidence-based protocols and progress in the management of secondary complications of severe TBI, significant regional differences in practice continue to exist [4].

Figure 1: A schematic depiction of the progression of ABI management.



Internationally, rehabilitation care of brain injured patients is extremely diverse. Care is dictated by local health care policy, local culture and resource availability. This in turn has made development of internationally applicable systems challenging. In 1965, the World Federation of Neurosurgical Societies formed an “ad hoc” Committee on Head Injuries which was followed by the formation of the Committee of Neuro-traumatology in 1977 [5]. This provided one of the first published international discussions of brain trauma care. The formation of the International Brain Injury Association (1993) and the International Association for the Study of Brain Injury (1998) continued to expand opportunities for the sharing of information [6]. In 1995, the Brain Trauma Foundation developed the first *Guidelines for the Management of Severe Traumatic Brain Injury* which has since been revised in 2000 and 2007 [7].These guidelines are maintained in conjunction with the American Association of Neurological Surgeons and the Congress of Neurological Surgeons and other stakeholders such as the European Brain Injury Consortium. Since their inception, countries as diverse as Italy, Mexico, Ireland, and Japan have adapted Brain Trauma Foundation guidelines to suit local needs [8-10;10]. The WHO has also expanded its focus to assess the need for effective global rehabilitation programs. It has estimated that although over 80% of the world’s people with disabilities live in low to middle income countries (LMIC), only 2% have access to rehabilitation services [11]. This is especially disturbing when we

consider that the highest rates of TBI due to road traffic incidents (RTIs) are in the Latin American and Caribbean regions with rates in Sub Saharan Africa not far behind [11].

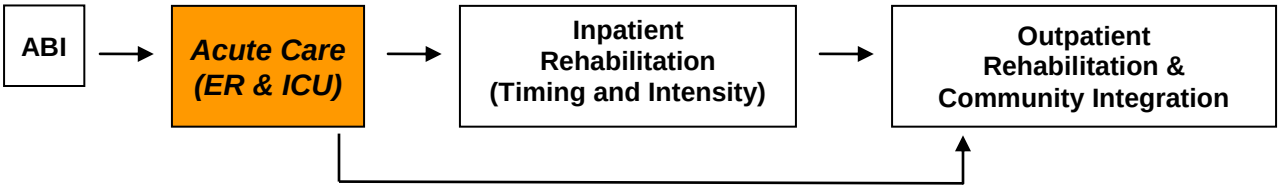
One of the most comprehensive national Brain Injury systems has evolved in the US. In 1978 the National Institute on Disability and Health Research (NIDHR, now the National Institute on Disability and Rehabilitation Research) provided funding to New York University's Rusk Center and the Santa Clara Valley Medical Center (San Jose, California) to develop a model of dedicated, interdisciplinary, acute inpatient rehabilitation coupled with post-acute rehabilitation intervention and cognitive and behavioral approaches [12]. By August 2004, ABI care in the USA included 123 accredited hospitals, 9 skilled nursing facilities (acute inpatient rehabilitation), 153 outpatient programs, 51 home and community programs, 212 long-term residential programs, 231 residential programs and 86 vocational programs [12]. While there is no one body which oversees brain injury rehabilitation specifically, several organizations have developed to attempt to improve the cohesion of the system. Some of the more influential organizations include the Brain Injury Association of America which was established in 1980 and currently works with 40 state run Brain Injury affiliates [13] to provide community services to brain-injured individuals. The National Association of State Head Injury Administrators developed in 1990 as a forum to provide information to State governments and policy makers regarding brain injury [14] while the Center for Disease Control collects epidemiological information and sponsors research through the Public Health Injury Surveillance and Prevention Program [15]. The Traumatic Brain Injury Model Systems of Care was developed in 1997 as a prospective, longitudinal multi-center study to assess rehabilitation of patients through a coordinated system of acute care and inpatient rehabilitation with a 15 year long term follow-up [16]. Although these four organizations and others like them, work together to provide guidance regarding brain injury care, ultimate decisions are still left to individual institutions and their clinicians, resulting in regional differences in care.

In Canada, brain injury rehabilitation has steadily developed in a way similar to the American system. During the 1980's and 90's Brain Injury rehabilitation evolved as a specialization of rehabilitation medicine. However, in Canada there are still no national standards of care [17]. Rehabilitation hospitals work within provincial health care systems and as a result some provinces, particularly the more scarcely populated ones, have more limited ABI rehabilitation. Moreover, within provinces there is often a disparity in services between larger urban centers and smaller rural areas. While access to care is universally available, private services can be utilized by those with private funding [17]. In 2003, the Brain Injury Association of Canada was established to provide a national forum for sharing brain injury information. Currently, only Prince Edward Island and the territories lack provincial/territorial level brain injury associations[18]. In an attempt to standardize care, Accreditation Canada, a not-for profit organization, assesses health care institutions in Canada for quality of care and now specifically includes brain injury services [19]. The Canadian Institute for Health Information (CIHI) was established by National, Provincial and Territorial governments to collect and disseminate health information including information regarding rehabilitation facilities. Rehabilitation information is drawn from all Ontario centers as well as 17 national facilities [20]. A separate database has also been established at the Toronto Rehabilitation Institute, which is modeled after the American Model systems. The Canadian database was expanded in 2002 to uniquely include individuals with non-traumatic brain injuries as well, which differs from the American system [17].

Europe presents some unique cultural and political challenges in brain injury. The European Brain Injury Society was formed in 1989 [21] and now has 152 institutional members from all nations in the European Union as well as Switzerland. The European Brain Injury Consortium (EBIC) was formed in 1994. *"This reflected the realization that numbers of patients required in*

the design of definitive Phase III studies of severe head injury demanded European-wide recruitment" [22]. While nations were encouraged to continue to develop their own strategies, value was placed on international collaboration. In 1997 the EBIC developed guidelines for management of severe head injury in adults to attempt to provide some clarity and standardization in brain injury care[22] . With similar collaborative goals, the European Brain Council was formed in 2002 in Brussels to attempt to coordinate research in the area of brain disease, including brain injury [23]. Despite these attempts at standardization, national models of ABI care are still dictated by regional health care policies.

3.1 Acute Management



The most severe consequences of an acquired brain injury are often not due to the initial trauma itself. Secondary brain injury can result in edema, ischemia, elevated intracranial pressure and inadequate cerebral perfusion pressure as well as a cellular cascade resulting in calcium imbalances, excitatory amino acid release and free radical production; all of which can lead to cell death [24]. For this reason, the speed and intensity with which patients are cared for is of the utmost importance. Assessments of how to acutely treat ABI patients generally fall into one of four categories; pre-hospital care, hospital facility type, adherence to acute care guidelines, and discharge destination. Each of these areas presents a unique challenge.

Pre-hospital care can be the difference between life and death. Concerns regarding the time to intervention are perhaps the most obvious component of pre-hospital care but debate has also arisen regarding the types of treatments that are suitable prior to hospital arrival. In 2000, the Brain Trauma Foundation released guidelines for pre-hospital management of brain injured patients. An Emergency Medical Service task force developed a consensus based algorithm [25]. Nevertheless, Bulger et al. [26] writes "*the variability in the out of hospital treatment of patients after traumatic injury in the United States is unknown.*" Similarly, this is the case in other countries that have begun to examine protocols for out-of-hospital care [27;28]. Research has been conducted regarding the efficiency of transfer and access to trauma centers in general [26] but little to no research has been performed relative to Brain Injury and related sequelae specifically.

Facility type is also of prime interest relative to the specific needs of the patient. Trauma care facilities have proven to be superior to general care facilities for emergency medical care. MacKenzie et al. [29] noted patients with an abbreviated injury score (AIS) ≥ 3 to the head showed a 90% survival rate at 12 month follow up in trauma centers compared to only 64.3% in non-trauma centers. However, the availability of trauma centers tends to be dictated by local needs and resources. In the absence of such a facility, local centers must be able to handle ABI effectively and transport them when necessary to a properly equipped center.

Guidelines have been established by organizations such as the Brain Trauma Foundation (BTF) and the EBIC to try to develop standardization of treatment and to aid in the dissemination of information. Audits of guideline implementation can help to ensure that a proper level of care is

provided in all types of medical centers. In the US alone, it is estimated that a modest improvement to 50% adherence of BTF guidelines from 33% would result in 989 lives saved annually [30].

The final stage of acute care involves the transition to post-acute care. Once patients are medically stable they are transferred to one of three places: home, long term care or a rehabilitation unit. Rehabilitation units for ABI patients can consist of hospital-based inpatient rehabilitation centers or specialized rehabilitation units that often focus on behavioral issues. How and by whom this decision is made may greatly affect the type of care that is received by patients. Several factors, such as availability of rehabilitation spaces, the patient's support needs and the patient's financial situation may play a role in this decision. In the US, Medicaid patients were 68% and HMO patients were 23% more likely to be discharged to a skilled nursing facility than those on a fee-for-service plan [31]. In Canada, patients injured in a motor vehicle accident were 1.6 times more likely to be discharged home with support services than those who were injured in a fall [32], likely due to the greater availability of resources accompanying the former injury.

Q1. What is the evidence supporting the guidelines for care received while patients remain in acute care?

1. There is Level 2 evidence that patients cared for in a Level I trauma center achieve better outcomes than patients cared for in a Level II center.
2. There is Level 2 evidence that staff with more dedicated commitment to trauma care leads to better patient outcomes.
3. There is Level 2 evidence suggesting that a reduction in the time spent in acute care and in a rehabilitation facility does not have a negative impact on overall patient outcomes.
4. There is Level 4 evidence indicating the overall cost of care is higher for those who sustain a severe TBI versus those who sustain a moderate TBI.
5. There is Level 4 evidence that adherence to BTF guidelines for acute care results in improved outcomes and decreased mortality.

Discussion

Nine studies were identified that empirically compared outcomes related to different acute care strategies. Three papers assessed the implementation of BTF guidelines in acute care practice [33-35], one assessed implementation of SIGN guidelines [36], two assessed facility structure [37;38], one compared outcomes between centers in developed and developing countries [39], one looked at the outcomes of 2 groups patients each treated in an acute care facility then transferred to rehabilitation but for different lengths of time[40], and one looked at the treatment received and cost of care for TBI patients over a 2 year period [41].

Fakhry et al. [34] undertook a pre-post design to evaluate the benefits of BTF guideline implementation. ***Patients treated under guideline conditions showed improvements in Glasgow Outcome Scale score, length of stay, cost per patient and mortality rates. The use of a non-TBI control group adds credibility to these results.*** Similarly, **Palmer et al.** [35] also performed a pre-post analysis of BTF guideline implementation. ***Patients in this study showed a 9.13 times greater odds ratio in favor of "good outcome" in 6 month GOS***

scores. The authors noted that there was a $97,000 increase in acute care costs associated with guideline care, which they claim was justifiable in light of the improved outcomes.

Bulger et al. [33] identified ICP management as an indicator of the aggressiveness of acute care management. Centers adhering to an "aggressive" protocol were significantly more likely to administer ICP monitoring, provide neurosurgical consultation, use osmotic agents and perform head CT scans. While these centers reported decreased mortality rates, the division was arbitrary and further study into potential confounding factors is necessary. In a similar study conducted in the UK, patient outcomes were compared after implementation of the SIGN guidelines for head injury management in 2000. **Jones et al.** [36] reported that after 2000, fewer patients made full recoveries (GOS 5) and more incidences of CCP insult were recorded. They also noted significantly more children being referred from tertiary care centers and fewer from Emergency Departments.

McGarry et al. [41] looked that the outcomes and costs associated with care for those who had sustained a moderate or severe TBI. As one might expect higher costs for care were associated with severity of injury, with costs being much higher for those who had sustained a severe TBI ($8,187 to $50,438). Of those included in the study, 80% had had a MRI or CT scan; nearly one third were on ventilators; and another two-thirds were treated in an intensive care unit. Mortality rates were also higher for those who had sustained a severe TBI.

In two studies evaluating facility structure, DuBose et al.[38] evaluated hospital designation and Mains et al. [37] assessed trauma team composition. **DuBose et al.** [38] reported that ***patients cared for in a Level I trauma centre showed decreased mortality rates, fewer complications, and were less likely to experience progression of neurological insult relative to patients care in a Level II trauma centre.*** These results were maintained even after adjusting for patient severity. **Mains et al.** [37] evaluated patient outcomes during three timeframes corresponding to systemic changes in a Level I trauma center. During time 1, the ward was staffed by in-house general surgery residents and attendings. During time two, a core trauma panel was established so that the ward was staffed by in-house trauma surgeons, which remained during time three except for the addition of physician's assistants. Patients managed during time two showed decreased mortality and median ICU LOS. Patients care for during time three saw further reductions in overall mortality and mean and median hospital LOS. The authors suggest that staff commitment to trauma care may play a role in improving patient outcomes.

Hawkins et al. [40] looked at outcomes of two groups of patients. The first group (Group 1) underwent hospital care for a total of 82 days (36 days in acute care and 46 days undergoing rehabilitation), while the second group (Group2) remained in hospital for a total of 51 days (26 days in acute care followed by 25 days in rehab). At time of discharge from acute care, FIM scores between the two groups were found to be different (51-Group 1 and 57-Group 2) but not significantly so. Patients in Group 1 did require more physical assistance and had significantly lower scores on the communication and social cognition subscales of the FIM then those in Group 2. When looking at FIM scores of those with GCS </=8 (n=39-Group1 and n=32-group2), those in Group 1 were found to be more independent in mobility and locomotion then Group 2 at time of discharge from rehabilitation. At the one year follow-up FIM scores between the two groups showed no significant differences overall nor were there differences on the scores of the subcomponents of the scale. Shorter lengths of stay in hospital did not adversely affect functional outcomes of patients. Age rather than GCS seemed to play a strong role in predicting who returned to work, with those in the youngest category (<30 years) returning to work faster. Overall 25% of patients were able to return to work. The reduced length of stay in hospital

placed greater demands outpatient rehabilitation services and family members or primary care givers.

Finally, **Harris et al.** [39] compared outcomes of patients treated in a Level I trauma center in the United States to those of patients cared for in two Jamaican hospitals. Interventions provided to patients were significantly different between countries. Patients cared for in the USA received more CT scans, were more likely to be admitted to an ICU and were more likely to undergo ICP monitoring. Although overall mortality was the same between countries, patients who were severely injured were more likely to survive in the USA. Interestingly, patients cared for in Jamaica showed greater improvements in both GOS and selected FIM outcomes. The authors suggest that the clinical significance of these findings are unknown and that further research is necessary.

The remainder of the studies identified provided descriptive observations of acute care management in diverse settings. Their observations can be summarized within the four groups identified earlier; pre-hospital care, hospital facility type, guideline adherence and discharge destination.

Three of the studies identified made reference to pre-hospital care of ABI patients [8;27;42]. **Baethmann et al.** [27] was the only study to specifically focus on pre-hospital and early hospital care. They used medical students as observers during primarily helicopter rescues of suspected brain injured patients. In 75% of cases, the rescue team arrived at the accident scene in less than 11 minutes after dispatch center alarm; intubation was made within 37 min; admission to the hospital was within 74 min; and the CT scan was completed within 120 min. The use of helicopter rescue with an on-board emergency physician made transfers more efficient as well as referrals to neurotrauma centers more accurate. **Citerio et al.** [8] found patients admitted directly from the accident site to a neurotrauma center in Italy took 79±149 min to reach the first emergency room. Those patients not admitted directly to a neurotrauma center only took 59±137 min to reach the first emergency room but averaged 300±254 min before reaching the neurotrauma center. **Myburgh et al.,** [42] showed variation in vital sign documentation in Australia. The mean time to admission at the first hospital was 63±58.4 min and 56.4% of these patients were admitted directly to a tertiary trauma center. The time of arrival to a trauma center versus a non-trauma center was comparable. No papers compared differences between groups, so no comparison of pre-hospital strategy can be made.

None of the papers further evaluated outcomes of patients admitted to trauma centers compared to non-trauma centers but many made comments regarding facility type. Patients were cared for in trauma centers or neurosurgical units in 66% [9] and 62% of cases [43] in the UK and Japan respectively. Some key differences between neurotruama units relative to general wards were coordination by a neurosurgeon or neurologist, presence of a specialized ICU unit for TBI patients and higher guideline adherence rates. Future study into the efficacy of neurotrauma centers relative to ABI patient outcomes is warranted.

Guideline adherence was the most highly analyzed component of acute ABI care. Most of the papers identified guideline adherence as an acute care goal. In addition to the Fakhry et al. [34] and Bulger et al. [33] papers, some interesting comparisons were seen. In the survey by Rusnak et al. [44] only adherence to the recommendations regarding BP, oxygenation resuscitation, and cerebral perfusion pressure maintenance were seen to be significantly related to ICU survival in Austria [44]. In the USA, Level I centers were significantly more likely to adhere to most AANS guideline recommendations [45]. One encouraging outcome of this adherence was the decreased use of contraindicated treatments such as corticosteroids. Goodacre [46] reported that after

implementation of the NICE guidelines in the UK, admission rates increased while LOS remained the same resulting in increased costs of care. In Norway, Heskestad [47] reported that despite guideline development, over triage of CT scans and admissions were often seen in patients with minimal and mild injuries however, 100% compliance was seen in patients with moderate injuries. In a similar study, Palchak et al. [48] retrospectively compared a decision rule for CT scans and admissions to physician suspicion of TBI. They noted that the decision rule was more sensitive and could have resulted in 289 fewer CT scans being performed. However, the physician's suspicion was more specific. The decision rule would have missed one TBI in a child that was discharged home from the Emergency Department. More definitive studies linking guideline adherence to beneficial outcomes need to be performed to further compare their effectiveness.

The final stage of acute ABI is the discharge of medically stable patients. Discharge destination varies significantly based on regional differences. Factors such as the health care system, regional funding, rehabilitation facility availability, and the patient's specific needs can all play a role in the final decision. We identified four articles with descriptions of discharge disposition. Chan et al. [31] showed these US patients with Medicaid health insurance were significantly more likely to go to a skilled nursing facility than those who were covered by HMOs or fee-for-service plans. Esselman et al. [49] analyzed discrepancies between US patients injured violently versus those who were non-violently injured. They saw no difference in referral rates to rehabilitation or skilled nursing facilities for violently injured patients relative to non-violently injured patients even though they were more likely to be funded by Medicaid. In Canada, universal health care is designed to allow for equal access to healthcare resources but there is variability based on different provincial health care plans and the availability of additional third-party insurance funding. Kim et al. [50] found that relative to rehabilitation, this is not always the case. Patients injured in a motor vehicle accident were 1.6 times more likely to be discharged home without support services than those injured in falls with similar injuries. This suggests that insurance supplementation can influence resource access. Finally, Foster et al. [51] found Australian patients who were younger and treated in a designated brain injury rehabilitation unit were more likely to be referred for inpatient rehabilitation.

The rehabilitation of acquired brain injury (ABI) patients involves a comprehensive effort by several members of an interdisciplinary team including physicians, nurses, and occupational therapists. Considering the incidence and consequences of ABI, it is important to understand the effectiveness of rehabilitation. Efficacy, as measured by functional outcome, will be assessed in this chapter across the continuum, from inpatient rehabilitation to community interventions. The question, 'does rehab work?' will be addressed.

3.2 Inpatient Rehabilitation

While many ABI victims are discharged directly home or to a long term care facility, many will benefit from discharge to a dedicated inpatient rehabilitation service. These services vary from institution to institution but generally include some type of intensive therapy program for physical, social, behavioral and cognitive difficulties. However, deciding who should receive inpatient rehabilitation remains a major challenge. Patient referral decisions are inherently complex and need to be understood as a dynamic phenomenon shaped by characteristics of the individual. However, they also rely on the interactions and interpretations of health professionals who operate within unique organizational and broader health care contexts [52]. These discrepancies are confounded by social and funding issues. For example, in the US patients insured by Medicaid or an HMO were more likely to go to a skilled nursing facility rather than inpatient rehabilitation relative to people with commercial fee-for-service plans [31]. In Canada, patients aged 36 – 45 with more co-morbid conditions are more likely to end up in rehabilitation than those older than 65, rural dwellers, non-English speaking people and people with mental health, alcohol and/or drug problems [53]. The diversity of patient needs has also led to the formation of differing systems of rehabilitation. In Calgary, for instance, the Halvar Johnson Centre for brain injured patients has established a program to treat TBI and non-TBI patients in a slow stream rehabilitation program for individuals who may require slightly extended care. According to Cullen [54] rehabilitation in Canada, on average, discharges 80% of patients home.

Due to the unique challenges posed by ABI, the structure of inpatient rehabilitation is extremely diverse. Patients are generally rehabilitated in one of two centers; a general rehabilitation unit or a coordinated multidisciplinary neurorehabilitation unit. Some argue that an effective rehabilitation service requires a multidisciplinary team, which includes nursing care, physician monitoring, psychologist and social work intervention, physiotherapists, occupational therapists, and speech language pathologists among other things [55] In reality, differences in care often amount simply to the availability of neuro-rehabilitative beds and facilities. Limited resources mandate decisions regarding which patients will most benefit from inpatient rehabilitation compared to community-based programs.

Debate also exists about appropriate targets of rehabilitative care. Traditional rehabilitation models in other disciplines such as stroke, spinal cord, and polio have focused on orthopedic and neuromotor impairments [12]. Brain Injury rehabilitation initially followed a similar path until focus on cognitive and behavioral remediation [56] as well as coma stimulation [12] gained recognition. The greater emphasis on skill development in rehabilitation has not resolved the uncertainty regarding which patient groups are best suited to inpatient care versus community-based programs. Patients in need of skill application training are increasingly being discharged to community based services while inpatient rehabilitation has focused more on intensive, short term physical or cognitive rehabilitation [57]. Furthermore, some inpatient facilities are recognizing the need to divide patients into different streams during rehabilitation. At the Toronto Rehabilitation Institute, patients have been streamed into a Neurocognitive group and a

Neurophysical group since 2002 [54]. Patients in the Neurophysical stream showed similar FIM gains in a significantly shorter length of stay when compared to similar patients before streaming began.

Inpatient rehabilitation typically begins when a patient is medically stable enough to be transferred out of acute care and into a dedicated rehabilitation unit for a defined period of interdisciplinary rehabilitation. There is a great deal of variability in the length, type, and intensity of services provided in programs throughout the world. As such, we delineate the evidence supporting the various aspects of treatment for inpatient care delivery.

Q2. What evidence is there that inpatient rehabilitation improves the outcomes of ABI patients?

Answer

1. There is **no** Level 1 evidence (from at least one RCT) as to the efficacy or lack thereof of ABI rehabilitation units.
2. There is Level 3 evidence that over a quarter of patients admitted to inpatient rehabilitation experience good outcome or moderate disability six months post-injury as measured by the GOS
3. There is Level 4 evidence that inpatient rehabilitation significantly improves functional outcome, as measured by the FIM.

Discussion

Sahgal and Heinemann [58] conducted a pre-post study on 189 patients with TBI admitted to a National Institute on Disability and Rehabilitation Research-Designated Center in the USA. Using a locally developed functional rating scale as the main outcome measure, the authors noted improvements in the patients for self-care and mobility after discharge from the comprehensive multidisciplinary program.

Two case series evaluated patients' functional outcome after discharge from inpatient rehabilitation. Both used the Functional Independence Measure (FIM) as one of their main outcome measures and both noted significant improvements for patients on FIM measurement [59; 60].

Q3. Is there any evidence that readmitting a patient over one year after suffering an acquired brain injury would result in functional outcomes?

Answer

1. There is Level 2 evidence that readmission to inpatient rehabilitation at more than 12 months post-injury is related to statistically significant improvement at discharge for over 50% of patients.

Discussion

Two other case series assessed functional outcome after inpatient rehabilitation using the Glasgow Outcome Scale (GOS) and Barthel Index (BI) respectively. In the former, 35% of subjects experienced good outcome or moderate disability at six months post-injury, as measured by GOS scores [61]. In the latter, ***53% of patients readmitted to inpatient rehabilitation at more than twelve months post-injury showed statistically significant improvement (p = 0.0001) on BI scores from readmission to discharge*** [62].

3.2.1 Intensity of Inpatient Rehabilitation

While patients are undergoing rehabilitation the amount of therapy provided to them is potentially an important factor in promoting neurological and functional recovery. We review the evidence for increased intensity in this section.

Q4. What evidence is there that increasing rehabilitation intensity influences outcomes?

Answer

1. Based on the finding from a single RCT, there is Level 1 evidence that increasing rehabilitation intensity reduces length of stay.
2. There is Level 4 evidence that patients with a long length of stay who receive high-intensity rehabilitation fair better on the Rancho Scale at discharge than those who receive low-intensity rehabilitation.
3. Based on the findings from a single RCT, there is Level 1 evidence that intensive rehabilitation improves functional outcome as measured by FIM and GOS scores, at two and three months post-injury, but not necessarily at six month and beyond.
4. There is Level 2 evidence that therapy intensity predicts motor functioning but not cognitive gain.
5. There is a reciprocal relationship between cognitive function and community integration.
6. There is Level 4 evidence that earlier time from injury onset to rehabilitation admission results in improved functional outcomes.

Discussion

Two RCTs focused on inpatient rehabilitation of ABI patients [63;64]. Both studies assessed the effects of increasing therapy intensity levels. In the **Shiel et al.** [64] study, patients in the intervention group received additional therapy from a health care professional (a rehabilitation nurse at one centre and an occupational therapist at the other) who provided these extra services as necessary. Shiel et al. [64] found that patients showed improvements on discharge both the FIM+FAM measures; however these improvements may be related to the size of the rehabilitation facility and the amount of staffing available to the patients. The study authors noted that patients in the larger facility received more intensive therapy over a shorter period of time and saw significant gains. n contrast, patients in the intervention group at the smaller center actually experienced a longer length of stay than their control counterparts.

In the second RCT, conducted **Zhu et al.** [65], subjects were randomly assigned to either four hours (study group) or two hours (control group) of rehabilitation per day. Functional outcome was determined by monthly Glasgow Outcome Scale (GOS) and Functional Independence Measure (FIM) scores. The authors found that more subjects in the study group than in the control group achieved full FIM scores and good GOS scores at two and three months post-injury; however at the sixth month time period, despite initial improvements obtained in rehabilitation, the control group had made significant gains and were seen to be "catching up" [65]. Both studies noted a trend towards improvements in functional gains with increased intensity but recommend future study into more long term effects.

Study snapshot

Zhu XL, Poon WS, Chan CH and Chan SH. Does intensive rehabilitation improve the functional outcome of patients with traumatic brain injury? Interim result of a randomized controlled trail. *British Journal of Neurosurgery* 2001: 15(6):464-473.

- 36 individuals were randomly assigned to one of two groups (intensive treatment group or conventional treatment group.
- The intensive treatment group received 4hours of therapy 5 days a week while the conventional treatment group received 2hours.
- Those in the intensive treatment group achieved significantly better outcomes (40 vs 10, p=0.046), at the 2 month evaluation period than the conventional treatment group.
- At the 6th month time this difference was reduced.
- Significant differences were not found when looking at the results of the FIM.

Two studies examined the efficacy of the intensity of rehabilitation in relation to the length of hospital stay [64;66]. In both studies, one a prospective RCT and the other a case series, increased rehabilitation intensity resulted in decreased length of stay.

Spivack et al. [67], conducted at study looking at the combined effects of rehabilitation intensity and inpatient rehabilitation length of stay. ***In their comparison of patients who had a long length of stay and received either low-intensity or high-intensity rehabilitation, the latter group fared better on the Rancho Scale outcome measure at discharge.***

Semlyen et al. [68] compared coordinated multidisciplinary inpatient rehabilitation to single discipline therapy provided in a local district hospital. ***Patients treated in the multidisciplinary hospital showed greater improvement in Barthel, FIM and Newcastle Independence Assessment Form scores and maintained improvement at 24 months.*** However, the authors point out some methodological concerns. Patients were non-randomly divided between the two groups which resulted in less severe injuries in the single discipline group as well as shorter LOS. This may have resulted in a ceiling effect for these patients that could have hindered their recovery gains.

A multicenter, prospective, nonrandomized study also assessed the relationship between therapy intensity and functional outcome. ***While rehabilitation intensity was found to predict motor functioning at discharge (p<.001), it did not predict cognitive gain (p<.05)*** [55]. ***Intensive and structured cognitive rehabilitation therapy (group and individual) has been***

reported to cause significant improvements in client reported satisfaction when compared to standard multidisciplinary rehabilitation [69]. The intensive rehabilitation program participants showed significant effects on their cognitive functioning as demonstrated on their improvement on standard neuropsychological tests[69].

In all of the studies identified, trends towards improved function after multidisciplinary inpatient rehabilitation were seen. Several study authors noted that they saw no ceiling effect associated with increased intensity of therapy. However, all of the authors indicated concerns about outcome measurement tools. There seems to be consensus regarding the need for a more accurate, ABI specific measure of functionality.

Summary

Intuitively, it seems reasonable to assume that more therapy will result in more rapid and ultimately greater improvement in recovery from brain injury. Based on the available literature, greater intensity appears to result in quicker recovery and therefore shorter lengths of stay, but not necessarily better outcomes at six months. More studies are needed in this regard.

3.2.2 Timing of Rehabilitation

Q5. List some of the benefits of early admission of an ABI patient to rehabilitation?

Answer

1. Better outcomes overall
2. Improved functional outcomes
3. Shorter overall lengths of stay
4. Decreased overall costs
5. Higher cognitive levels at home
6. Greater likelihood of discharge home

Discussion:

Sandhaug et al. [70] looked at the benefits of having individuals who had sustained either a moderate or severe TBI participate in a sub-acute rehabilitation program. On average patients were transferred to a specialized rehab program 27 days after being admitted to sub acute rehab. Those with a severe TBI remained in rehab longer than those with moderate injuries and were discharged either to a rehab hospital or nursing homes for further treatment. ***FIM scores improved significantly ($p<0.001$) for all regardless of the level of injury. Patients diagnosed with a severe TBI showed a significantly ($p<0.001$) greater improvement in their overall FIM scores with, the greatest improvement, for both groups, being seen in the motor scores.*** Improvement on the FIM-COG subscale was also noted but in both groups the score improved by only 5 points. The authors suggest that the FIM score at admission to rehabilitation, together with the GCS and PTA, were positive predictors of functional level at discharge [70].

Wagner et al. [71] examined the proper timing for physical medicine and rehabilitation consultation. Using multivariate analysis, the authors found that ***when PM&R consultations occurred earlier (< 48 hours after hospital admission) patients experienced significantly better FIM scores with transfers and locomotion and significantly shorter lengths of stay (p = 0.001).***

In the other outcome study, **Edwards et al.** [72] compared 26 patients admitted to inpatient rehabilitation more than 200 days after injury to 264 patients admitted to inpatient rehabilitation less than 200 days after injury. Discharge BI and FIM scores were lower in the former group than in the latter (11 vs. 14 and 77 vs. 92 respectively). However, the differences were not significant. Rehabilitation length of stay was also similar for the two groups.

Mackay et al. [73] assessed the timing of inpatient rehabilitation during the earlier phase of recovery in their cohort study. They compared a formalized program (average of 2 days to initiation of therapy) with a non-formalized program (average of 23 days to initiation of therapy) using co-relational analysis. Number of days in coma, length of stay, cognitive levels, and discharge disposition were used as the main outcome measures. ***Overall, starting rehabilitation early was associated with shorter comas and lengths of stay, higher cognitive levels at discharge, and a greater likelihood of being discharged to home.*** **High et al.** [74] in a study of TBI patients the authors examined the amount of time that lapsed from diagnosis of injury to the start of rehabilitation and its effect on outcomes of rehabilitation. They found that ***those who began treatment within six months of their TBI scored higher on the disability rating scale indicating a decrease in their disability.*** These results were not noted for the other two groups. The supervision rating scale scores decreased for all groups indicating that they required less supervision after admission to rehabilitation and when tested again at follow up post discharge, again a decrease in supervision was noted. When analyzing the results of the community integration questionnaire an increase in scores could be seen from admission to discharge from the program for all groups.

Mackay et al. [73] **and Cope and Hall** [75] ***found that those who were involved in rehabilitation earlier in the recovery stage were discharged from hospital earlier than those who were not involved in the early rehabilitation program.*** Aronow [76], found that although there was no statistically significant differences on the individual outcomes there was a cost savings favoring those who were subjected to early interventions.

Tepas et al. [77] retrospectively reviewed patient charts to evaluate the effect of delays for admission to rehabilitation on functional outcomes. They ***report that delays in admission to rehabilitation resulted in significant decreases in total FIM gains as well as reductions in rehabilitation efficiency***. These findings were similar to those reported by **Kunik et al.** [78]**.** In this study individuals admitted sooner into rehabilitation (<1 week to 3 weeks post insult) were admitted with higher FIM scores (~59.8) than those admitted later (4 week or more post insult - FIM scores (48.29)). ***Overall those admitted sooner to rehabilitation were released on average 19 days post admission. Those admitted later to rehabilitation were released on average 26 days post admission.*** Kunik et al. [78] suggest that ***those who are admitted into rehabilitation sooner after injury perform better and faster and their overall cost of stay is less.***

Q6. In the absence of an RCT looking at the role of early rehabilitation, what is the primary complicating factor in linking early admission to better outcomes?

Answer

1. The primary complicating factor is the tendency to delay the admission of more complicated or more severely involved patients who are not likely to do as well in rehabilitation as those without such complications.

Discussion

The studies available on the timing of rehabilitation demonstrate that earlier rehabilitation is associated with better outcomes than later rehabilitation. Patients who have had recent brain injuries typically need much greater medical and nursing support in order to meet their basic care requirements. This evidence is consistent with theories of neuronal plasticity, which suggest that challenging the nervous system by means of therapy results in increased neuronal compensation and/or regeneration. However, delayed rehabilitation may reflect more severe or complicated brain injuries. There is an obvious need for an RCT to address this question.

3.2.3 Factors Affecting the Timing of Inpatient Care

3.3.3.1 Etiology and Inpatient Rehabilitation

Q7. What evidence is there for the efficacy of inpatient brain injury rehabilitation in different types of acquired brain injured individuals?

Answer

1. There is Level 3 evidence that inpatient brain injury rehabilitation results in significantly greater gains in total FIM change, self-care, and social cognition for patients with TBI than patients with brain tumors. However, there are no statistically significant differences between the two groups regarding FIM efficiency and length of stay.

Discussion

In a retrospective, descriptive, case-matched study by **O'Dell et al.** [79], forty patients with brain tumors were compared with 40 patients with TBI. They all underwent inpatient rehabilitation on a freestanding brain injury unit. Change in FIM scores, length of stay, and discharge disposition were used as the main outcome measures. ***Overall, the TBI patients made significantly greater gains in total FIM change (34.6 vs. 25.4), self-care (12.3 vs. 8.5), and social cognition (5.2 vs. 3.6).*** However, there were no statistically significant differences between the two groups regarding FIM efficiency (1.9 vs. 1.5 FIM points per day) and length of stay (22.1 vs. 17.8 days). See table 3.6 for details.

3.2.3.2 Age and Inpatient Rehabilitation

Q8. What is the impact of age on the outcomes of acquired brain injuries?

Answer

1. There is Level 3 evidence that inpatient rehabilitation results in a higher rate of change on functional measures in patients aged 18-54 than patents over the age of 55.

Discussion

In **Cifu et al.** [80] DRS, FIM, and RLAS scores were compared at inpatient rehabilitation discharge for 50 patients greater than or equal to 55 years of age and 50 patients aged 18 to 54. In this case-control study, subjects in the latter group showed a higher mean rate of change on functional measures than subjects in the former group.

3.2.3.3 Occupation and Inpatient Rehabilitation

Q9. What evidence is there to suggest that inpatient rehabilitation result in a successful return to work?

Answer

1. There is Level 4 evidence, based on the findings of one case series, that inpatient rehabilitation results in successful return to work and return to duty for the majority of military service members.

Discussion

In describing only one treatment arm of a RCT, **Braverman et al.** [81] evaluated military service members' return to work and return to duty after multidisciplinary inpatient rehabilitation. Multidisciplinary inpatient rehabilitation consisted of eight weeks of group and individual therapies geared towards returning the soldiers to duty. The rehabilitation team included a physiatrist, neurologist, neuropsychologist, and occupational therapist. The authors found that of the sixty-seven subjects who participated in the study, 96% and 66% had returned to work and duty respectively at follow-up of one year.

3.2.3.4 Transitional Living Setting and Inpatient Rehabilitation

Q10. What evidence is there for benefit of a transitional living setting at the end of inpatient rehabilitation?

Answer

1. There is Level 2 evidence that a transitional living setting during the last weeks of inpatient rehabilitation results in greater independence in activities of daily living than inpatient rehabilitation alone.

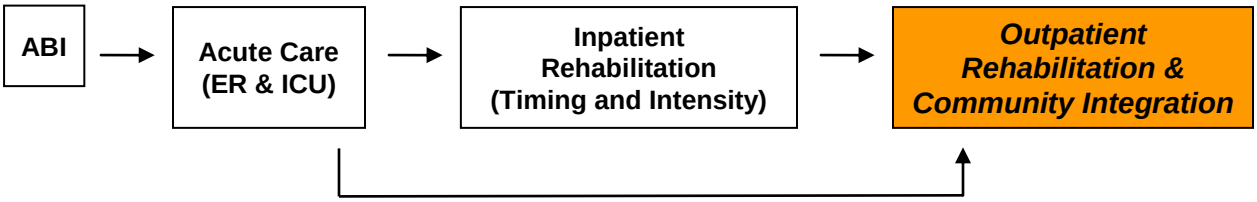
Discussion

In the study by **McLaughlin and Peters** [82] the effects of a transitional living setting during the last weeks of inpatient length of stay were evaluated using cognitive (Rancho) and functional (Barthel) levels as main outcome measures. Results from a follow-up survey showed that patients who participated in both inpatient rehabilitation and a transitional living setting reported greater independence in activities of daily living than patients who received inpatient rehabilitation alone.

Summary

Previous reviews in addition to literature presented here have delineated the extent of knowledge of the efficacy of inpatient rehabilitation, which is limited at best. There is reasonable evidence to support the use of interdisciplinary rehabilitation followed by a transitional living environment to assist in maximizing recovery. This suggests that a gradual return to the community is preferable to a sudden discharge from hospital to home. Not surprisingly, younger patients tend to make greater gains in rehabilitation than their older counterparts.

3.3 Outpatient Rehabilitation



Outpatient care is often the least organized branch of ABI care. Patients discharged home often receive no therapy or minimal support depending on their level of need and payment status. In a well structured outpatient facility in Canada patients typically attend therapy 2-3 times /wk and have access to OT, PT, SLP, SW, physiatrist, neuropsychology and neuropsychiatry [54]. At a similar facility in Hamilton, Ontario patients also receive the services of a rehabilitation counselor which has been reported to be effective. However, access to programs like these often relies on funding. Patients with private insurance from motor vehicle accidents are 1.6 times more likely to be discharged home with supportive services than those without [50]. A survey conducted in the United States was conducted to identify the availability of community

information resources post ABI in the US [83]. The authors made three recommendations for improvement: expand the population targeted for linkage to services, improve access to information about available services, and increase the availability of services. In a similar study by Leith et al. [84], focus groups of patients and families were questioned regarding their perceived post-discharge needs in South Carolina, USA Consensus agreement surrounded five areas of need; early, continuous, comprehensive service delivery; information and education; formal and informal advocacy; empowerment of persons with TBI and their families; and human connectedness and social belonging.

Residential care facilities are generally not-for-profit, government sponsored agencies that offer access to support in a secure environment with staff specifically trained in ABI care. Resources often include rehabilitation therapists, behaviour therapists, social workers and case managers with supervision by certified psychologists [54;85]. These facilities aim to allow ABI patients an extended system of support with opportunities for long-term rehabilitation. However, they are generally expensive and access is often limited by the patient's ability to pay for care. Alternatives include hospital based outpatient facilities where patients drop in several times a week for care [54] or mobile rehabilitation teams which visit patients at home [86].

Other programs aim at aiding less severely injured patients in community reintegration and independence. These services involve specifically targeted goals including social interaction [12]. driving [87] and competitive employment [88]. They generally take place on a one-to-one basis in home or in the community and patients often rate these final steps as the most important in returning to normalcy [57].

11. What evidence is there supporting patient participation in outpatient rehabilitation services post ABI?

Answer

1. There is Level 3 evidence that multidisciplinary outpatient rehabilitation may improve functional outcomes up to ne year post discharge.
2. There is Level 2 evidence that behavioral and cognitive skills post ABI can be improved by participating in neurorehabilitation or neurobehavioral programs

Discussion

Four non-randomized control trials were also located which assessed outpatient care. **Ponsford et al. [86]** compared patients treated in the community post-discharge to patients who returned to hospital for care. They found that patients who received hospital care were significantly less dependent on support from close others, more independent in mobility, displayed fewer inappropriate social behaviours and had less difficulty with motor speech and following conversations. However, community patients showed increased physical independence. **Cusick et al. [89]** matched patients receiving MEDICAID waiver community support to patients from a TBI database. They found very few differences within 4 outcome measurement scales. Patients in the waiver program showed higher levels of resource use as well as improved mental health status and less substance abuse. Patients not receiving waiver support showed increased levels of predominantly independence based measures (ie. physical, cognitive, and mobility independence). Similarly, **Willer et al. [88]** compared patients receiving residential inpatient

rehabilitation to a control group receiving in-home outpatient services. They found patients treated in a residential center improved in motor and cognitive function, but patients treated at home showed improvements in independence and social integration levels. All three studies identified differences in pressures placed on ABI patients. As would be expected, patients receiving care tend to improve in the skills targeted by that care while those receiving less structured care, or no care at all, improve in independence skills. Further study regarding appropriate target groups for differently structured programs is necessary.

Braunling-McMorrow et al.[90] looked at the benefits of participation in a weekly program that included both behavioural and cognitive therapies that would teach participants to respond to various life events appropriately and allow for greater independence. Individuals who participated were placed in two groups: those requiring neurorehabiliation (NR) and those requiring neurobehavioural (NB) treatment. Results from the FAOM (functional area outcome menu) indicated that both groups improved significantly pre to post assessment ($p<0.001$). Scored on the FAOM at the one year post discharge time period, indicate that those in the NB showed the greatest change. Individuals who were admitted to the program within the first 6 moths of injury did better than those admitted later. The study authors suggest that perhaps the severity of deficits may have played a role in the time of admission to rehabilitation with those with more severe deficits being admitted to rehabilitation sooner than those with fewer deficits. Those who entered rehabilitation at a later date may have already made improvements, thus those made in the program were not as significant [91].

We located one other study which focused on comparisons of outpatient rehabilitation services. Malec and Degiorgio [92] assessed three different outpatient intervention groups for competitive employment rates after one year. Patients were not randomly assigned, which led to those who were less severely injured and more independent initially being referred more often to a less intensive outpatient program. They noted that all three groups of patients reached the same level of employment at the end of the study after undergoing therapies of different intensity. The authors suggest that patients with diverse levels of disability can make similar gains with different intensities of therapy. However, too many confounding factors exist to draw such a conclusion from this study.

3.4 Community Rehabilitation

Following discharge from inpatient rehabilitation unit patients with moderate to severe brain injury typically receive ongoing therapy at a lesser intensity. While most patients move back to their former living environment with therapy intervention provided for them in the home or community, some go on to other facilities that may provide longer duration treatment for the slow-to-recover patient. The effectiveness of these interventions is reviewed in this section.

Q12. What evidence is there that ABI rehabilitation provided in the community improves outcomes?

Answer

1. There is Level 1 evidence that a fitness center-based program is not better than a home-based program for improving cardio-respiratory fitness.
2. There is Level 1 evidence that structured multidisciplinary rehabilitation in community setting can improve social functioning.
3. There is Level 4 evidence that community-based social and behavioral rehabilitation of at least six months results in greater independence, higher social activity levels and less need for care support.
4. There is Level 2 evidence from one RT that direct patient involvement in neurorehabilitation goal setting results in a significant improvement in obtaining goals from pre-test to post-test that are then maintained at a follow-up of two months.
5. Based on the findings from two pre-shot studies there is a Level 4 evidence that participation in a comprehensive day treatment program reduces impaired self-awareness and distress. It also improves societal participation at one-year follow-up.

Discussion

Powell et al. [85] randomly assigned TBI patients to an outpatient support program where patients received 2-6 hours per week for a about 27.3 weeks in a community setting. During this time the group was given assistance individually by a multidisciplinary team. The control group received a specially collated booklet with relevant resources highlighted. ***The Outreach group scored significantly higher on Barthel Index, the BIRCO and two sub-sections of the FIM+FAM.***

Study Snapshot

Powell J, Heslin J, Greenwood R. Community based rehabilitation after severe traumatic brain injury: A randomized controlled trial. *Journal of Neurology, Neurosurgery and Psychiatry* 2002;72(2):193-202.

- 92 individuals who had sustained a moderate to severe TBI participated in an outreach treatment program.
- Participants were randomly assigned to either the experimental or information groups
- 35% of the experimental group improved their scores on the BI and BICRO compared to 20% of the information group ($p<0.05$).
- When looking at the FIM and FAM scores significant changes were noted when measuring their level of personal care ($p<0.06$) and cognition ($p<0.09$) for the Outreach group compared to the information group.

In a retrospective cohort study by **Wood et al.** [93] data related to dependency, social activity, and care support were collected on seventy-six subjects who received community-based social and behavioural rehabilitation. They found that ***rehabilitation of at least six months led to greater independence, higher social activity levels, and less need for care support.***

In the RCT conducted by **Webb and Glueckauf** [94] the effects of direct patient involvement in neurorehabilitation goal setting was evaluated. Sixteen subjects were randomly assigned to one of two groups: high involvement (HI) in goal setting or low involvement (LI) in goal setting. The main difference between the two groups was that subjects in the HI group were encouraged to be directly involved in their goal setting, while subjects in the LI group were not. ***At post-test, as compared to pre-test, both groups made significant improvements in obtaining their goals. However, only subjects in the HI group maintained the improvements at a two-month follow-up.***

Study Snapshot

Webb PM and Glueckauf RL. The effects of direct involvement in goal setting on rehabilitation outcome for persons with traumatic brain injuries. *Rehabilitation Psychology* 1994;39(3):179-188.

- 16 participants randomly assigned to have high involvement (HI) in their neurorehabilitation goal setting or low involvement (LI) in their neurorehabilitation goal setting.
- Both groups made significant improvements in obtaining their goals from pre to post testing ($F(1,14) = 64.69$, $p<0.001$).
- However, only participants who had high involvement in their neurorehabilitation goal setting maintained the improvements at a 2-month follow-up.

Two studies examined the effects of a comprehensive day treatment program (CDTP). While the former looked at its effects on impaired self-awareness (ISA) and distress, the latter evaluated its impact on societal participation. Using nonparametric analyses, **Malec and Moessner** [95] discovered that after participation in the CDTP patients experienced reduced ISA and distress. With regards to societal participation, **Malec** [96] found that at one year after participation in the program 72% were living independently, 39% were working independently, 10% were in transitional placements, and 18% were involved in supported or volunteer work.

Ownsworth et al. [97] compared performed a randomized trial to compare individual, group, and combined interventions for goal attainment and psychosocial functioning. Each group showed improvements in different areas. The individual intervention component contributed to gains in performance in goal-specific areas. ***The combined intervention was associated with maintained gains in satisfaction and performance, while the group and individual interventions were more likely to result in gains in behavioural competency and psychological well being.***

Q13. What is the impact of community based rehabilitation program for patients with a diagnosis of TBI and substance abuse

Answer

1. There is Level 4 evidence that patients with a dual-diagnosis of TBI and substance abuse who participate in a community-based treatment program generally do not become chemical-free. This is due to both an inability to keep them in the program for the six-month period desired and the failure of clients to follow recommendations for additional rehabilitation of psychiatric treatment at discharge.

Discussion

Blackerby and Baumgarten [98] conducted a series of single subject intervention studies on seven persons with TBI and substance abuse problems. In this study, the intervention was a dual diagnosis treatment program known as RELATE (Rebound Lifestyle Adjustment Team) that took place within a community-based Alcoholics Anonymous or Narcotics Anonymous group. Complete abstinence from chemical substances was the program's ultimate goal. The authors discovered that both of the clients who followed recommendations for additional rehabilitation or psychiatric treatment at discharge from the program remained drug-free. On the other hand, only one of the five clients who did not follow recommendations remained drug-free at follow-up, while three continued their chemical dependency and one's follow-up status was unknown. The authors concluded that this program was relatively unsuccessful due to an inability to keep clients in the program for the six-month period desired and the clients' failure to follow discharge treatment recommendations.

Two studies examined the outcomes of those who had previously participated in rehabilitation [99;100]. In the **Olver et al.** [100] study, patients reported no mobility issues, improved communication skills and completed basic daily activities independently; however two-thirds reported still having some cognitive issues. Many reported feelings of anger, irritability, and aggression. Of the 103 who completed the surveys, only 34 were employed and 12 were in school, suggesting that ongoing support is needed. Findings reported by **Klonoff et al.** [99] indicate that approximately one third were in long term relationships and of those who had returned to work, the majority were younger and of higher education. The income of participants decreased significantly post injury with fewer patients returning to full or part-time work.

Summary

Continuity of rehabilitation strategy includes a community-based program following inpatient rehabilitation that is tailored to individuals' needs in order to maximize their recovery. It is generally accepted as neither safe nor prudent to allow patients to be discharged from a rehabilitation setting without adequate follow through on the issues that they continue to face in the course of their recovery. Given that most patients will continue to make gains for two or more years, it is reasonable to ensure that they continue to receive therapeutic intervention for this period of time. When looking at patients years post injury, although gains were made there was still a need for continued support. However, the evidence to support or refute remains insufficient.

3.5 Vocational Rehabilitation

Returning to work following ABI is probably the most challenging task that a patient will face in the course of their recovery. The work environment often produces stresses on their physical body, cognitive challenges, and emotional strain. However, given the financial burden of not being able to work for most individuals, it is a very important aspect of full reintegration into society and return to independent living. The research on assisting patients in their goal of returning to work is explored in the following section.

Q14. What is the evidence that vocational rehabilitation is of benefit in acquired brain injured individuals?

Answer

There is Level 4 evidence that:

1. Vocational rehabilitation results in greater total taxpayer benefits than either total program operational costs or government costs.
2. After vocational rehabilitation the majority of subjects have fair or good adjusted outcome, while more than half become gainfully employed or full-time students.
3. Individuals with the most significant cognitive impairments benefit the most from vocational rehabilitation services.
4. Individuals with severe head injury do benefit from supported employment services.

Discussion

There were three studies that dealt with the intervention of vocational rehabilitation. Amongst these, there was a cost-benefit analysis, a single group intervention and an outcome study.

In the cost-benefit analysis by **Abrams et al.** [101] an individualized work reentry program was evaluated. Of the 142 persons with TBI who participated in the program, 65% obtained employment during the first year of entering the program and 75% obtained employment during the entire observation period. This resulted in a 2:1 ratio of total taxpayer benefit to total program operational cost and a 4:1 ratio of total taxpayer benefit to state cost.

Klonoff et al. [102] looked at the adjusted outcome of sixty-four subjects who participated in the Adult Day Hospital for Neurological Rehabilitation Work/School Re-entry program. Adjusted outcome was defined as discharge productivity level modified by staff ratings of functional impairment severity at program admission. At discharge, 89.5% of the subjects displayed fair or good adjusted outcome and 10.5% of them displayed poor adjusted outcome. With regards to being gainfully employed or full-time students at discharge, 62.5% were, while 15.6% returned to the same level of work or school as pre-injury.

Johnstone et al. [103] examined the relationship between receiving services from the Missouri Division of Vocational Rehabilitation and neuropsychological variables and vocational outcomes. They separated 110 patients into the following three groups: successfully employed, services interrupted, and no services provided. The results from Johnstone et al. [103] suggest that even individuals with significant cognitive deficits can benefit from vocational rehabilitation services, and individuals should not therefore be deemed ineligible for such services based solely on neuropsychological test scores. Johnstone et al. [103] also point out that individuals with less severe cognitive deficits may have successfully obtained employment on their own and did

not require the assistance of vocational rehabilitation services. Thus, the subjects of their sample were for the most part individuals with significant cognitive deficits who needed the vocational rehabilitation services to successfully return to work.

Wehman et al. [104] looked at the success of 20 individuals who had been referred for supported employment. Several others were initially referred but due to their age at injury they were not included in the final analysis. Employment specialists provided participants in the program with on the job support. Of the 20 that were included, at total of 24 placements were made of which 50% of participants remained in their first placement. Overall there were no significant differences in the number of jobs held by the group or in the numbers of hours the individuals worked across the 3 phases of employment (pre-injury work, post-injury work, supported employment). Differences were noted in the hourly wages (with significant differences noted between the pre and post injury wages) and employment ratios (number of hours worked per week) with the post-injury employment ratio being significantly different from the pre and supported employment ratios. Overall Wehman et al.[104] found that supported employment did help improve the vocational capacity of severely head injured individuals.

Summary

There is good reason to believe that vocational programs are useful in assisting patients with moderate to severe brain injury with their vocational goals. In doing so, the benefits to the individual financially and in terms of their self-esteem are great. In addition, there is an obvious savings to the taxpayer to have programs designed towards assisting patients with returning to work.

3.6 Supported Employment

Once a patient with brain injury has returned to competitive employment they are at a high risk for failure because of the lingering effects of their brain injury.

Q15. What evidence is there for the benefit of supported employment following ABI?

Answer

1. There is Level 3 evidence, from one case-control study and Level 4 evidence from one case series that supported employment improves the level of competitive employment outcomes particularly for ABI survivors who are older, have more education, have no prior work experience or who have suffered more severe injuries.

Discussion

Gamble and Moore [105] seventy-eight patients with TBI received supported employment (treatment group), while 995 patients with TBI did not receive supported employment (control group) during vocational rehabilitation. Supported employment consisted of on-the-job training and support for as long as the client needed. Closure status (competitive employment versus not working), occupational placements, weekly earnings, and hours worked each week were used as some of the main outcome measures. Overall, the authors found supported

employment significantly improved the level of competitive employment as 67.9% of those who received supported employment versus 47% of those who did not receive supported employment were competitively employed at the time of closure ($p < 0.003$). Both groups were equally employed in miscellaneous occupations at closure (43.4% of the treatment group versus 42.3% of the control group). The authors found that ***the provision of supported employment services contributed to competitive employment outcomes, particularly for clients with 12 or more years of education, clients over 35 years of age, male clients, clients without prior work experience, and clients with severe TBI.***

Study Snapshot

Gamble D and Moore GL. Supported employment: Disparities in vocational rehabilitation outcomes, expenditures and service time for person with traumatic brain injury. *Journal of Vocational Rehabilitation*. 2003;47-57.

- 78 individuals with TBI who received supported employment (treatment group) were compared to 995 patients with TBI who did not receive supported employment (control group) during vocational rehabilitation.
- The control group had significantly higher earnings per week than treatment group and the control group worked substantially more hours per week than treatment group.

Wehman et al. [106] found that 41 of the 53 patients enrolled in the program were placed in competitive employment. They also noted that the average number of hours worked per week for the group was 31.2 hours. Wehman et al. [106] also found that most of the patients had reached a point of stability and independence on the job within 20 weeks of working. Even though there were successes (although no statistically significant findings were reported) with this program, they did note that their findings did provide reason for cautious optimism.

Summary

The evidence favoring the utilization of supported employment programs in order to maximize the earning potential of these individuals is limited. There is a clear need for more data in this area to delineate the most appropriate strategies to facilitate job retention, maximizing earnings, and achieve vocational success.

3.7 Support Groups

Living in the community following brain injury can often result in isolation and depression in individuals who no longer possess the capacity to seek help via appropriate means. Support groups are frequently organized in the community in order to diminish these feelings of isolation and provide assistance through group discussion forums.

Q16. What evidence is there that support groups are of benefit for ABI patients?

Answer

1. Based on the finding from three non-experimental studies, there is Level 4 evidence that support groups generate positive results such as improving feelings of hopelessness, coping with depression and improving psychosocial functioning.

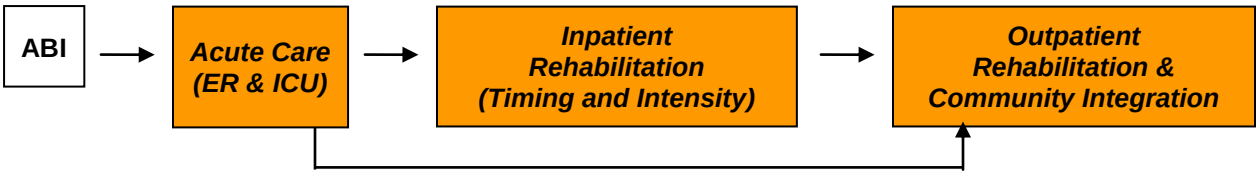
Discussion

Three studies focused on the efficacy of support groups. While **Armengol** [107] specifically examined a support group for Hispanic TBI survivors, **Hibbard et al.** [108] evaluated a community-based support program for individuals with TBI and their family members and **Ownsworth et al.** [109] evaluated a sixteen week group support program for twenty-one patients with ABI. In all three cases, ***significant results were found regarding improving feelings of hopelessness and being vocationally active in the first study, improving quality of life and coping with depression in the second study, and improving psychosocial functioning in the final study.***

Summary

There is limited data to suggest that support groups are an appropriate means of providing a structure for individuals with brain injury to diminish feelings of isolation and depression. They appear to be an excellent vehicle for dissemination of information regarding living in the community with an ABI and provide direction to other resources if warranted. There is a need for further evaluation of these groups in order to define the most effective design of these programs.

3.8 Complete Care Pathways



The ultimate goal in any rehabilitation stream is to provide seamless care from the onset of injury to the ultimate recovery. As this chapter has demonstrated, the continuum of ABI care involves acute interventions with a transition to some combination of rehabilitation therapies. This section aims to identify studies which have compared pathways of care combining several rehabilitation strategies.

Discussion

These studies re-affirm many of the concerns already noted in this chapter. Brain injury displays significant heterogeneity and direct comparison of complete systems is difficult. All three papers identify similar foci for model of care design. Continuity and accessibility of services is crucial to allow a patient the greatest opportunities for rehabilitation while a multidisciplinary approach to rehabilitation with communication between stages is ideal. Also, regional differences in resource

availability need to be taken into consideration along with patient demographics so that the correct pathway decisions can be made.

Unfortunately, no matter what health care system is assessed, budgetary concerns play a role in the accessibility of care. As a result, difficult decisions need to be made regarding resource allocation. Mellick et al. [110] list those being female, older, severely injured and not a member of a minority group as less likely to receive rehabilitation. While this is clearly the product of larger social issues, these facts need to be addressed when decisions regarding ABI care systems are being made. In a similar fashion, Khan et al. [3] provide encouraging news regarding decreases in LOS and fiscal savings brought on by an integrated ABI system in Canada. The author points out that care needs to be taken to ensure that savings do not arise from sacrifices in quality of care but rather from the improvement of systematic inefficiencies. Finally, Harradine et al. [111] note that co-ordination of regional facilities resulted in an equal availability of resources despite geographic challenges in New South Wales, Australia.

Reference List

(1) National Institute of Health. Rehabilitation of persons with traumatic brain injury. NIH consensus statement. United States Department of Health and Human Services.Public Health Service.National Institutes of Health (41 p) . 1998. Bethesda, MA, NIH.
Ref Type: Report

(2) Saatman KE, Duhaime AC, Bullock R, Maas AI, Valadka A, Manley GT. Classification of traumatic brain injury for targeted therapies. *J Neurotrauma* 2008;25:719-738.

(3) Khan S, Khan A, Feyz M. Decreased Length of stay, cost savings and descriptive findings of enhanced patient care resulting from and integrated traumatic brain injury programme. *Brain Inj* 2002;16:537-554.

(4) Zygun DA, Laupland KB, Hader WJ et al. Severe traumatic brain injury in a large Canadian health region. *Can J Neurol Sci* 2005;32:87-92.

(5) Teasdale GM, Braakman R, Cohadon F et al. The European Brain Injury Consortium. Nemo solus satis sapit: nobody knows enough alone. *Acta Neurochir (Wien)* 1997;139:797-803.

(6) IBIA. International Brain Injury Association. *Brain Inj* [serial online] 2008; Available from: HDI Publishers. Accessed July 12, 2008.

(7) Carney NA, Ghajar J. Guidelines for the management of severe traumatic brain injury. Introduction. *J Neurotrauma* 2007;24 Suppl 1:S1-S2.

(8) Citerio G, Stocchetti N, Cormio M, Beretta L, Galli D, Pesenti A. Application of guidelines for severe head trauma: data from an Italian database. *Eur J Emerg Med* 2003;10:68-72.

(9) Matta B, Menon D. Severe head injury in the United Kingdom and Ireland: a survey of practice and implications for management. *Crit Care Med* 1996;24:1743-1748.

(10) Espinosa-Aguilar A, Reyes-Morales H, Huerta-Posada CE et al. Design and validation of a critical pathway for hospital management of patients with severe traumatic brain injury. *J Trauma* 2008;64:1327-1341.

(11) Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: a global perspective. *NeuroRehabilitation* 2007;22:341-353.

(12) Cope DN, Mayer NH, Cervelli L. Development of systems of care for persons with traumatic brain injury. *J Head Trauma Rehabil* 2005;20:128-142.

(13) BIAA. Brain Injury Association of America. *Brain Injury Association of America* [serial online] 2008; Accessed July 12, 2008.

(14) NASHIA. National Association of State Head Injury Administrators. *National Association of State Head Injury Administrators* [serial online] 2008; Accessed July 12, 2008.

(15) CDC. Centers for Disease Control. *Centers for Disease Control* [serial online] 2008; Accessed July 12, 2008.

(16) TBINDSC. The Traumatic Brain Injury Model Systems of Care. *National Data and Statistical Center* [serial online] 2008; Accessed July 12, 2008.

(17) Cullen N. Canadian healthcare perspective in traumatic brain injury rehabilitation. *J Head Trauma Rehabil* 2007;22:214-220.

(18) BIAC. Brain Injury Association of Canada. *Brain Injury Association of Canada* [serial online] 2008; Accessed July 12, 2008.

(19) AC. Accreditation Canada. *Accreditation Canada* [serial online] 2008; Accessed July 12, 20080.

(20) Canadian Institute for Health Information. The Burden of Neurological Diseases, Disorders and Injuries in Canada. 2008.
Ref Type: Serial (Book,Monograph)

(21) EBIC. European Brain Injury Society. *European Brain Injury Society* [serial online] 2008; Accessed July 12, 2008.

(22) Maas AI, Dearden M, Teasdale GM et al. EBIC-guidelines for management of severe head injury in adults. European Brain Injury Consortium. *Acta Neurochir (Wien)* 1997;139:286-294.

(23) EBC. European Brain Council. *European Brain Council* [serial online] 2008; Accessed July 12, 2008.

(24) Zasler ND, Katz DI, Zafonte RD. *Brain Injury Medicine*. New York, New york: Demos Medical Publishing, 2007.

(25) Gabriel EJ, Ghajar J, Jagoda A, Pons PT, Scalea T, Walters BC. Guidelines for prehospital management of traumatic brain injury. *J Neurotrauma* 2002;19:111-174.

(26) Bulger EM, Nathens AB, Rivara FP, MacKenzie E, Sabath DR, Jurkovich GJ. National variability in out-of-hospital treatment after traumatic injury. *Ann Emerg Med* 2007;49:293-301.

(27) Baethmann A, Chapuis D, Wirth A. System analysis of patient management during the pre- and early clinical phase in severe head injury. *Acta Neurochir Suppl* 1999;73:93-97.

(28) Harrington DT, Connolly M, Biffl WL, Majercik SD, Cioffi WG. Transfer times to definitive care facilities are too long: a consequence of an immature trauma system. *Ann Surg* 2005;241:961-966.

(29) MacKenzie EJ, Rivara FP, Jurkovich GJ et al. The National Study on Costs and Outcomes of Trauma. *J Trauma* 2007;63:S54-S67.

(30) Faul M, Wald MM, Rutland-Brown W, Sullivent EE, Sattin RW. Using a cost-benefit analysis to estimate outcomes of a clinical treatment guideline: testing theBrain Trauma Foundation guidelines for the treatment of severe traumatic brain injury. *J Trauma* 2007;63:1271-1278.

(31) Chan L, Doctor J, Temkin N et al. Discharge disposition from acute care after traumatic brain injury: the effect of insurance type. *Arch Phys Med Rehabil* 2001;82:1151-1154.

(32) Kim E, Bijlani M. A pilot study of quetiapine treatment of aggression due to traumatic brain injury. *J Neuropsychiatry Clin Neurosci* 2006;18:547-549.

(33) Bulger EM, Nathens AB, Rivara FP, Moore M, MacKenzie EJ, Jurkovich GJ. Management of severe head injury: institutional variations in care and effect on outcome. *Crit Care Med* 2002;30:1870-1876.

(34) Fakhry SM, Trask AL, Waller MA, Watts DD. Management of brain-injured patients by an evidence-based medicine protocol improves outcomes and decreases hospital charges. *J Trauma* 2004;56:492-499.

(35) Palmer S, Bader MK, Qureshi A et al. The impact on outcomes in a community hospital setting of using the AANS traumatic brain injury guidelines. Americans Associations for Neurologic Surgeons. *J Trauma* 2001;50:657-664.

(36) Jones PA, Chambers IR, Minns RA, Lo TY, Myles LM, Steers AJ. Are head injury guidelines changing the outcome of head injured children? A regional investigation. *Acta Neurochir Suppl* 2008;102:81-84.

(37) Mains C, Scarborough K, Bar-Or R et al. Staff commitment to trauma care improves mortality and length of stay at a level I trauma center. *J Trauma* 2009;66:1315-1320.

(38) Dubose JJ, Browder T, Inaba K, Teixeira PG, Chan LS, Demetriades D. Effect of trauma center designation on outcome in patients with severe traumatic brain injury. *Arch Surg* 2008;143:1213-1217.

(39) Harris OA, Bruce CA, Reid M et al. Examination of the management of traumatic brain injury in the developing and developed world: focus on resource utilization, protocols, and practices that alter outcome. *J Neurosurg* 2008;109:433-438.

(40) Hawkins ML, Lewis FD, Medeiros RS. Impact of length of stay on functional outcomes of TBI patients. *Am Surg* 2005;71:920-929.

(41) McGarry LJ, Thompson D, Millham FH et al. Outcomes and costs of acute treatment of traumatic brain injury. *J Trauma* 2002;53:1152-1159.

(42) Myburgh JA, Cooper DJ, Finfer SR et al. Epidemiology and 12-month outcomes from traumatic brain injury in Australia and New Zealand. *J Trauma* 2008;64:854-862.

(43) Shigemori M, Tokutomi T. Result of nationwide survey of the management of severe head injury in Japan. *Neurol Res* 2002;24:41-44.

(44) Rusnak M, Janciak I, Majdan M, Wilbacher I, Mauritz W. Severe traumatic brain injury in Austria I: introduction to the study. *Wien Klin Wochenschr* 2007;119:23-28.

(45) Hesdorffer DC, Ghajar J. Marked improvement in adherence to traumatic brain injury guidelines in United States trauma centers. *J Trauma* 2007;63:841-847.

(46) Goodacre S. Hospital admissions with head injury following publication of NICE guidance. *Emerg Med J* 2008;25:556-557.

(47) Heskestad B, Baardsen R, Helseth E, Ingebrigtsen T. Guideline compliance in management of minimal, mild, and moderate head injury: high frequency of noncompliance among individual physicians despite strong guideline support from clinical leaders. *J Trauma* 2008;65:1309-1313.

(48) Palchak MJ, Holmes JF, Kuppermann N. Clinician judgment versus a decision rule for identifying children at risk of traumatic brain injury on computed tomography after blunt head trauma. *Pediatr Emerg Care* 2009;25:61-65.

(49) Esselman PC, Dikmen SS, Bell K, Temkin NR. Access to inpatient rehabilitation after violence-related traumatic brain injury. *Arch Phys Med Rehabil* 2004;85:1445-1449.

(50) Kim H, Colantonio A, Deber R, Vernich L. Discharge destination from acute care after traumatic brain injury. *Can J Neurol Sci* 2006;33:48-52.

(51) Foster M, Fleming J, Tilse C, Rosenman L. Referral to post-acute care following traumatic brain injury (TBI) in the Australian context. *Brain Inj* 2000;14:1035-1045.

(52) Foster M, Tilse C. Referral to rehabilitation following traumatic brain injury: a model for understanding inequities in access. *Soc Sci Med* 2003;56:2201-2210.

(53) Colantonio A, Ratcliff G, Chase S, Kelsey S, Escobar M, Vernich L. Long-term outcomes after moderate to severe traumatic brain injury. *Disabil Rehabil* 2004;26:253-261.

(54) Cullen N. Canadian healthcare perspective in traumatic brain injury rehabilitation. *J Head Trauma Rehabil* 2007;22:214-220.

(55) Cifu DX, Kreutzer JS, Kolakowsky-Hayner SA, Marwitz JH, Englander J. The relationship between therapy intensity and rehabilitative outcomes after traumatic brain injury: a multicenter analysis. *Arch Phys Med Rehabil* 2003;84:1441-1448.

(56) Mazaux JM, Richer E. Rehabilitation after traumatic brain injury in adults. *Disabil Rehabil* 1998;20:435-447.

(57) Evans RW. Postacute neurorehabilitation: roles and responsibilities within a national information system. *Arch Phys Med Rehabil* 1997;78:S17-S25.

(58) Sahgal V, Heinemann A. Recovery of function during inpatient rehabilitation for moderate traumatic brain injury. *Scand J Rehabil Med* 1989;21:71-79.

(59) Gray DS, Burnham RS. Preliminary outcome analysis of a long-term rehabilitation program for severe acquired brain injury. *Arch Phys Med Rehabil* 2000;81:1447-1456.

(60) Whitlock JA, Jr., Hamilton BB. Functional outcome after rehabilitation for severe traumatic brain injury. *Arch Phys Med Rehabil* 1995;76:1103-1112.

(61) Whitlock JA, Jr. Functional outcome of low-level traumatically brain-injured admitted to an acute rehabilitation programme. *Brain Inj* 1992;6:447-459.

(62) Tuel SM, Presty SK, Meythaler JM, Heinemann AW, Katz RT. Functional improvement in severe head injury after readmission for rehabilitation. *Brain Inj* 1992;6:363-372.

(63) Zhu XL, Poon WS, Chan CC, Chan SS. Does intensive rehabilitation improve the functional outcome of patients with traumatic brain injury (TBI)? A randomized controlled trial. *Brain Inj* 2007;21:681-690.

(64) Shiel A, Burn JP, Henry D et al. The effects of increased rehabilitation therapy after brain injury: results of a prospective controlled trial. *Clin Rehabil* 2001;15:501-514.

(65) Zhu XL, Poon WS, Chan CH, Chan SH. Does intensive rehabilitation improve the functional outcome of patients with traumatic brain injury? Interim result of a randomized controlled trial. *Br J Neurosurg* 2001;15:464-473.

(66) Blackerby WF. Intensity of rehabilitation and length of stay. *Brain Inj* 1990;4:167-173.

(67) Spivack G, Spettell CM, Ellis DW, Ross SE. Effects of intensity of treatment and length of stay on rehabilitation outcomes. *Brain Inj* 1992;6:419-434.

(68) Semlyen JK, Summers SJ, Barnes MP. Traumatic brain injury: efficacy of multidisciplinary rehabilitation. *Arch Phys Med Rehabil* 1998;79:678-683.

(69) Cicerone KD, Mott T, Azulay J, Friel JC. Community integration and satisfaction with functioning after intensive cognitive rehabilitation for traumatic brain injury. *Arch Phys Med Rehabil* 2004;85:943-950.

(70) Sandhaug M, Andelic N, Vatne A, Seiler S, Mygland A. Functional level during sub-acute rehabilitation after traumatic brain injury: course and predictors of outcome. *Brain Inj* 2010;24:740-747.

(71) Wagner AK, Fabio T, Zafonte RD, Goldberg G, Marion DW, Peitzman AB. Physical medicine and rehabilitation consultation: relationships with acute functional outcome, length of stay, and discharge planning after traumatic brain injury. *Am J Phys Med Rehabil* 2003;82:526-536.

(72) Edwards MJ, McNeil JE, Greenwood RJ. Process and outcome during early inpatient rehabilitation after brain injury. *Disabil Rehabil* 2003;25:405-410.

(73) Mackay LE, Bernstein BA, Chapman PE, Morgan AS, Milazzo LS. Early intervention in severe head injury: long-term benefits of a formalized program. *Arch Phys Med Rehabil* 1992;73:635-641.

(74) High WM, Jr., Roebuck-Spencer T, Sander AM, Struchen MA, Sherer M. Early versus later admission to postacute rehabilitation: impact on functional outcome after traumatic brain injury. *Arch Phys Med Rehabil* 2006;87:334-342.

(75) Cope DN, Hall K. Head injury rehabilitation: benefit of early intervention. *Arch Phys Med Rehabil* 1982;63:433-437.

(76) Aronow HV. Rehabilitation effectiveness with severe brain injury: Translating research into policy. *J Head Trauma Rehabil* 1987;2:24-36.

(77) Tepas JJ, III, Leaphart CL, Pieper P et al. The effect of delay in rehabilitation on outcome of severe traumatic brain injury. *J Pediatr Surg* 2009;44:368-372.

(78) Kunik CL, Flowers L, Kazanjian T. Time to rehabilitation admission and associated outcomes for patients with traumatic brain injury. *Arch Phys Med Rehabil* 2006;87:1590-1596.

(79) O'Dell MW, Barr K, Spanier D, Warnick RE. Functional outcome of inpatient rehabilitation in persons with brain tumors. *Arch Phys Med Rehabil* 1998;79:1530-1534.

(80) Cifu DX, Kreutzer JS, Marwitz JH, Rosenthal M, Englander J, High W. Functional outcomes of older adults with traumatic brain injury: a prospective, multicenter analysis. *Arch Phys Med Rehabil* 1996;77:883-888.

(81) Braverman SE, Spector J, Warden DL et al. A multidisciplinary TBI inpatient rehabilitation programme for active duty service members as part of a randomized clinical trial. *Brain Inj* 1999;13:405-415.

(82) McLaughlin AM, Peters S. Evaluation of an innovative cost-effective programme for brain injury patients: response to a need for flexible treatment planning. *Brain Inj* 1993;7:71-75.

(83) Sample PL, Langlois JA. Linking people with traumatic brain injury to services: successes and challenges in Colorado. *J Head Trauma Rehabil* 2005;20:270-278.

(84) Leith KH, Phillips L, Sample PL. Exploring the service needs and experiences of persons with TBI and their families: the South Carolina experience. *Brain Inj* 2004;18:1191-1208.

(85) Powell J, Heslin J, Greenwood R. Community based rehabilitation after severe traumatic brain injury: a randomised controlled trial. *J Neurol Neurosurg Psychiatry* 2002;72:193-202.

(86) Ponsford J, Harrington H, Olver J, Roper M. Evaluation of a community-based model of rehabilitation following traumatic brain injury. *Neuropsychol Rehabil* 2006;16:315-328.

(87) Rapport LJ, Bryer RC, Hanks RA. Driving and community integration after traumatic brain injury. *Arch Phys Med Rehabil* 2008;89:922-930.

(88) Willer B, Button J, Rempel R. Residential and home-based postacute rehabilitation of individuals with traumatic brain injury: a case control study. *Arch Phys Med Rehabil* 1999;80:399-406.

(89) Cusick CP, Gerhart KA, Mellick D, Breese P, Towle V, Whiteneck GG. Evaluation of the home and community-based services brain injury Medicaid Waiver Programme in Colorado. *Brain Inj* 2003;17:931-945.

(90) Braunling-Mcmorrow D, Dollinger SJ, Gould M, Neumann T, Heiligenthal R. Outcomes of post-acute rehabilitation for persons with brain injury. *Brain Inj* 2010;24:928-938.

(91) Braunling-Mcmorrow D, Lloyd K, Fralish K. Teaching social skills to head injured adults. *Journla of Rehabilitation* 1986;52:39-44.

(92) Malec JF, Degiorgio L. Characteristics of successful and unsuccessful completers of 3 postacute brain injury rehabilitation pathways. *Arch Phys Med Rehabil* 2002;83:1759-1764.

(93) Wood RL, McCrea JD, Wood LM, Merriman RN. Clinical and cost effectiveness of post-acute neurobehavioural rehabilitation. *Brain Inj* 1999;13:69-88.

(94) Webb PM, Glueckauf RL. The effects of direct involvement in goal setting on rehabilitation outcome for person with traumatic brain injuries. *Rehabilitation Psychology* 1994;39:179-188.

(95) Malec JF, Moessner AM. Self-awareness, distress, and postacute rehabilitation outcome. *Rehabilitation Psychology* 2000;45:227-241.

(96) Malec JF. Impact of comprehensive day treatment on societal participation for persons with acquired brain injury. *Arch Phys Med Rehabil* 2001;82:885-895.

(97) Ownsworth T, Fleming J, Shum D, Kuipers P, Strong J. Comparison of individual, group and combined intervention formats in a randomized controlled trial for facilitating goal attainment and improving psychosocial function following acquired brain injury. *J Rehabil Med* 2008;40:81-88.

(98) Blackerby WF, Baumgarten A. A model treatment program for the head-injured substace abuser: preliminary findings. *J Head Trauma Rehabil* 1990;5:47-59.

(99) Klonoff PS, Watt LM, Dawson LK, Henderson SW, Gehrels JA, Wethe JV. Psychosocial outcomes 1-7 years after comprehensive milieu-oriented neurorehabilitation: the role of pre-injury status. *Brain Inj* 2006;20:601-612.

(100) Olver JH, Ponsford JL, Curran CA. Outcome following traumatic brain injury: a comparison between 2 and 5 years after injury. *Brain Inj* 1996;10:841-848.

(101) Abrams D, Barker LT, Haffey W, Nelson H. The economics of return to work for survivors of traumatic brain injury: vocational services are worth the investment. *J Head Trauma Rehabil* 1993;8:59-76.

(102) Klonoff PS, Lamb DG, Henderson SW, Shepherd J. Outcome assessment after milieu-oriented rehabilitation: new considerations. *Arch Phys Med Rehabil* 1998;79:684-690.

(103) Johnstone B, Schopp LH, Harper J, Koscuilek J. Neuropsychological impairments, vocational outcomes, and financial costs for individuals with traumatic brain injury receiving state vocational rehabilitation services. *J Head Trauma Rehabil* 1999;14:220-232.

(104) Wehman P, West M, Fry R et al. Effect of supported employment on the vocational outcomes of persons with traumatic brain injury. *J Appl Behav Anal* 1989;22:395-405.

(105) Gamble D, Moore CL. Supported employment: disparities in vocational rehabilitation outcomes, expenditures and service time for persons with traumatic brain injury. *Journal of Vocational Rehabilitation* 2003;2003:47-57.

(106) Wehman PH, Kreutzer JS, West MD et al. Return to work for persons with traumatic brain injury: a supported employment approach. *Arch Phys Med Rehabil* 1990;71:1047-1052.

(107) Armengol CG. A multimodal support group with Hispanic traumatic brain injury survivors. *J Head Trauma Rehabil* 1999;14:233-246.

(108) Hibbard MR, Cantor J, Charatz H et al. Peer support in the community: initial findings of a mentoring program for individuals with traumatic brain injury and their families. *J Head Trauma Rehabil* 2002;17:112-131.

(109) Ownsworth TL, McFarland K, Young RM. Self-awareness and psychosocial functioning following acquired brain injury: an evaluation of a group support programme. *Neuropsychological Rehabilitation* 2000;10:465-484.

(110) Mellick D, Gerhart KA, Whiteneck GG. Understanding outcomes based on the post-acute hospitalization pathways followed by persons with traumatic brain injury. *Brain Inj* 2003;17:55-71.

(111) Harradine PG, Winstanley JB, Tate R, Cameron ID, Baguley IJ, Harris RD. Severe traumatic brain injury in New South Wales: comparable outcomes for rural and urban residents. *Med J Aust* 2004;181:130-134.