Chapter 13

Traumatic Brain Injury Rehabilitation: An Overview

Wafa Al Yazeedi, Loganathan Venkatachalam, Somaya Al Molawi and Fatma Al Kuwari

Additional information is available at the end of the chapter

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1. Introduction

Traumatic brain injury (TBI) is a leading cause of seizure, disorders, disability and death worldwide; regrettably, facilities for rehabilitation remain insufficient. One million Americans are treated and released from hospital emergency departments because of TBI [1]. The range of severity of TBI is broad, from concussion through to persistent vegetative states and categories are mild, moderate and severe (Box 1). In the European Union, brain injury accounts for one million hospital admissions per year. Many published studies support the notion that males are far more likely to incur a TBI than females. The highest rate of injury occurs between the ages of 15-24 years. Persons under the age of five or over the age of 75 are also at higher risk. Brain injury can cause many physical, cognitive and behavioural/emotional impairments, as well as common lifestyle consequences that may be either temporary or permanent (Box No 2). Brain injury may also result in seizure disorders. Brain injury is a public health concern that demands ongoing epidemiological study, increased efforts in the prevention of injuries occurring and research to advance medical options and therapeutic interventions.

Box No 1

Injury severity category	Initial Glasgow Coma Scale	Duration of post-traumatic amnesia
Mild	12-15	Less than 24 hours
Moderate	9-11	1-7 days
Severe	3-8	1-4 weeks

Box No 2
Consequences of traumatic brain injury

Neurological impairment (motor, sensory and autonomic)
- Motor function impairment – coordination, balance, walking, hand function, speech
- Sensory loss – taste, touch, hearing, vision, smell
- Sleep disturbance – insomnia, fatigue
- Medical complications – spasticity, post-traumatic epilepsy, hydrocephalus, heterotopic ossification
- Sexual dysfunction

Cognitive impairment
- Memory impairment, difficulty with new learning, attention and concentration; reduced speed and flexibility of thought processing; impaired problem-solving skills
- Problems in planning, organizing, and making decisions
- Language problems – dysphasia, problems finding words and impaired reading and writing skills
- Impaired judgment and safety awareness

Personality and behavioural changes
- Impaired social and coping skills, reduced self-esteem
- Altered emotional control; poor frustration tolerance and anger management; denial, and self-centeredness
- Reduced insight, disinhibition, impulsivity
- Psychiatric disorders – anxiety, depression, post-traumatic stress disorder, psychosis
- Apathy, a motivational state

Common lifestyle consequences
- Unemployment and financial hardship
- Inadequate academic achievement
- Lack of transportation alternatives
- Inadequate recreational opportunities
- Difficulties in maintaining interpersonal relationships, marital breakdown
- Loss of pre-injury roles; loss of independence

2. Body

The recovery process following TBI is a slow process that might take months or years, rather than weeks. Six months following an injury yields a clearer picture of what effect the injury has had, but waiting roughly a year after the accident before making any important decisions regarding the future is considered advisable. Physical recovery will take approximately a year, but psychological recovery might take considerably longer. Factors that may affect the rate of a person's recovery include injury type, severity, location of the individual's brain injury, age (younger patients tend to have better outcomes), pre-injury health, pre-injury personality, intelligence and lifestyle, social support from family and friends and other factors like alcohol or drug abuse. Depending on the individual's physical abilities and potential, a rehabilitation programme will be initiated accordingly.

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The effectiveness of a comprehensive multidisciplinary rehabilitation team (Box No.3) is increased when compared to natural recovery following brain injury. The importance of recognizing the vegetative state and its management is emphasized. Finally, the important, but often neglected area of employment rehabilitation is covered. We plan to explain the rehabilitation process starting from the day of the accident with the aim of recovering from the posttraumatic brain injury sequlae and achieving reintegration into the community.

Box No 3 Rehabilitation team

- Patient and patient's family
- Rehabilitation medicine physician
- Rehabilitation nurse
- Allied health professionals: physiotherapist, occupational therapist, speech pathologist, social worker and orthotics
- Neuropsychologist, clinical psychologist
- Vocational rehabilitation services and counsellors
- Other medical specialties: neurosurgery, orthopaedic surgery and urologist

The iterative process of consultation yielded consensus definitions for each component of the rehabilitation service pathway for head-injured adults (Table 1). This chapter describes not only brain injury due to road traffic accident or fall from a great height but also brain injury in war victims. Modern rehabilitation practices are based around the concepts of impairment, disability and handicap, as outlined by the World Health Organization (WHO) in 1980. Recently, however, the WHO has redefined these concepts.

The modern terminology that will be introduced in the near future still encompasses the term 'impairment', but now replaces 'disability' with 'activity' and 'handicap' with 'participation'. This is not simply a sign of political correctness, but serves to emphasize the positive aspects of disability rather than its negative connotations. The rehabilitation approaches consist of three basic types; 1) reducing the disability; 2) acquiring new skills and their application for reducing the impact of disability; 3) alteration of the environment in physical and social contexts, so that existing disability will carry as little participation as possible. For example, a young male individual had a traumatic brain injury and recovery with residual hemiplegia with spasticity and urinary incontinence. A specific programme tailored to this individual's needs was offered during brain injury rehabilitation management process. (Box No. 4).

Title and description	Sites	Description of rehabilitation input
Minor HI: education – medically stable, requiring 24-48 hrs. observation prior to community rehabilitation, with low probability of acute neurological deterioration	Acute A&E observation ward	Assessment and observation – education, emotional and social support. Planned discharge home or moves to code 30 at 48 h
Supportive rehab – medically unstable, requiring neurosurgical or clinical care	Acute hospital	Identifying and addressing early rehab goals before medically stable and transfer of care to rehab team.
Supportive rehab – medically unstable, not requiring neurosurgical or critical care	Acute hospital	Identifying and addressing early rehab goals before medically stable and transfer of care to rehab team.
Rapid access rehab – medically stable, not (necessarily) able to actively participate due to amnesia, confusion, rejection, low response or awareness	Acute hospital	Needs inpatient care due to physical dependency and requires continuous clinical assessment to facilitate optimal timing for rehab input and detect clinical deterioration. Immediate early rehab delivered and judgment made on timing/ appropriateness of referral to next rehab sector.
Active participation inpatient rehab – medically stable, able to actively participate with and benefit from therapy	Acute or community hospital	Needs inpatient care due to physical dependency, or need for specialist therapy equipment, safe environment, supervision or intensity of therapy, which cannot be provided in community
Behavioural rehab – medically stable, but with prolonged confusion, amnesia or behavioural difficulties, requiring specialist behavioural management, intensive supervision and secure environment	Specialist inpatient unit	Specialist behavioural management, including high staff/patient ratio to ensure intensive supervision and secure environment; access to neuropsychology and neuropsychiatry.
Slow-stream rehab – medically stable, but with low awareness or response persisting beyond, e.g., three weeks after sedation; withdrawn and medically stable. Able to benefit from medical and physical therapy to prevent complications and support recovery	Community hospital or specialist inpatient unit	Assessment/active rehabilitation phase, which needs to be distinguished from long-term care, although planning of care an increasingly important aim after, e.g., six months. Patients may go to active participation unit if sufficient improvement occurs.

Title and description	Sites	Description of rehabilitation input
Community rehab – medically stable, able to actively participate with and benefit from, therapy. Will include spectrum of initial severity of injury with a small minority derived from code 05 category.	Domiciliary or day hospital	Interdisciplinary coordinated management therapy aimed at community reintegration/inclusion by enhancing independence and assisting return to work/education. In collaboration with social services, voluntary and statutory services. Includes treatment of patients in residential care or with live-in carers.
Intensive cognitive rehab – medically stable, independently mobile, primarily cognitive impairments likely to benefit from intensive neuropsychological therapy.	Domiciliary or day hospital	Aiming to return to work, studies or independent community life.
Specialist vocational rehab – medically stable, living in community, aiming to enter/ return to employment.	Domiciliary or residential	Aiming for return to work, where this is influenced by physical or cognitive problems, or needs residential placement.
Maintenance – medically stable but permanently disabled.	Domiciliary, residential or nursing home, respite unit	Prevent deterioration of physical, emotional and behavioural conditions, and long-term management of seating, pressure, spasticity, etc.
Social, patient and carer support – carer support for initial injury, patient support when able to communicate.	All sites	Developing social skills, stamina, confidence, attention and leisure pursuits, sorting out benefits, day supervision and respite care. Specific attention paid to: community involvement and integration (further education, etc.); personal social development; structured daytime activity; family support and outreach.
HI = head injury; rehab = rehabilitation; A&E = accident and emergency		

Table 1. Classification of head injury recovery and actual/potential rehabilitation services (adult).

Box No 4 Specific programme offered during brain injury rehabilitation

Post-traumatic amnesia assessment
Management of post-traumatic agitation
Neuropharmacological management
Cognitive rehabilitation therapy
Coma emergence and rehabilitation of minimally responsive states
Spasticity management including motor point/nerve blocks and Botulinum toxin therapy
Casting, splinting, orthotics, contracture management
Pain management services for cervicogenic headaches, trigger point injections
Balance and vestibular assessment and rehabilitation
Cognitive and behavioural assessment and remediation
Comprehensive dysphagia and speech therapy services
Assistive technology using augmentative and alternative communication
Rehabilitation nursing education
Intrathecal Baclofen pump therapy
Brain injury discharge advice and family education
Social support: discharge planning, caregiver training

Brain injury rehabilitation occurs in the following settings:

- **Inpatient rehabilitation:** This involves intensive specialist rehabilitation for people who are not yet ready to return home after discharge from hospital. Neurological rehabilitation centres provide an ideal setting for further treatment, where a structured rehabilitation programme is in place throughout the day.
- **Outpatient rehabilitation:** Some people may be well enough to return home and receive further treatment as an outpatient, either at a local hospital or at a separate rehabilitation centre.
- **Community rehabilitation:** Following an inpatient rehabilitation stay, some people may be transferred to a residential transitional living unit. Here people can develop their independent living skills so that they may be able to live in a place of their own. Others will go straight back to their homes, with a community rehabilitation team or outreach team helping them to make further progress; this may involve therapists working with the person in their home or community environment [2].

The main basic approach to treatment in the above example was to reduce disability through appropriate medication with which to control spasticity and for applying new skills of physiotherapy and occupational therapy to improve the individual's functional activity of gait training. This was done through means of ambulation in an indoor environment, with physical aid and wheelchair aid for long distances and, by using an adaptive device to facilitate feeding and other self-care activities. Additionally, adapted fittings to bathrooms and kitchens can be installed. Liaising with the injured individual's employer and having a dialogue for initiating his return to work in a part-time capacity or having downtime between working hours to

reduce fatigue can also be instigated. The involvement of his family is also important to make them more accepting of his condition and for effecting the necessary adjustments to their own lifestyles.

The basic nature of rehabilitation is to work with the disabled person and family in partnership. The interdisciplinary rehabilitation team should provide accurate information and advice, explain the prognosis and natural history and work with the individual to establish realistic goals within an appropriate social environment. Whatever approaches implemented, setting a realistic goal is key to a good quality rehabilitation programme. For example, the long-term goal of independent walking requires a number of short stages to be implemented, such as sitting, balance training without support, standing balance without support, walking in parallel bar, walking with a person's assistance, walking with aids and lastly independent walking.

The rehabilitation team and disabled person should know what the goal is and when this goal has been achieved. Thus, valid and reliable outcome measures are very important for supporting the rehabilitation process. The most common measures used in the UK is the Barthel Index, but functional independence measures are also very common worldwide. Physiotherapy and occupational therapy using a 10-meter walking test for improvement of walking and a nine hole pick peg test for improvement of hand function, respectively, are also used. There are many other tools for measuring variable functional independence measure (FIM) cognitive and motor functions, the Glasgow coma scale (GCS), Rancho Los Amigos levels of cognitive functioning scale (RLA), disability rating scale and the Coma Recovery Scale-(Revised). It is important to highlight that the use of valid and reliable outcome measures is important in order to observe goals, assess progress and adjust the rehabilitation programme. The author has published articles related to the above-mentioned variables influencing and predicting functional outcomes after TBI [3].

For example, in her study [3], she pointed out that there was positive correlation of functional independence measure on discharge (FIMd) and RLA (Figure1). The researcher postulated GCS as a predictor of functional outcome and showed in her result positive correlation of GCS and FIM cognitive. Rehabilitation should begin as early as possible (even at the level of acute care) (Figure 3) [4]. It is common for individuals to ultimately be transferred to a rehabilitation unit when avoidable complications are already present. Unfortunately, muscle contractures, pressure sores and unnecessary aggressive behaviour are atypical during stay in rehabilitation unit . If the rehabilitation team can be involved in the early stage of acute care setting, perhaps even on the intensive care unit, it is more likely that such complications can be avoided. Studies provide evidence that undertaking rehabilitation within the first days of evolution improved cognition, perception and motor recovery of brain-damaged patients, and led to shorter lengths of stay (LOS) in rehabilitation units [5,6,8].

An early intervention rehabilitation team (EIRT) has been initiated by the author at the level of trauma or surgical intensive care units in Hamad General Hospital (HGH), Qatar. A rehabilitation programme focusing on cognitive stimulation and prevention of musculoskeletal complications of contractures has been offered. Pressure ulcers and aggressive behaviour has been limited by providing appropriate orthoses, frequent positioning, psychotropic

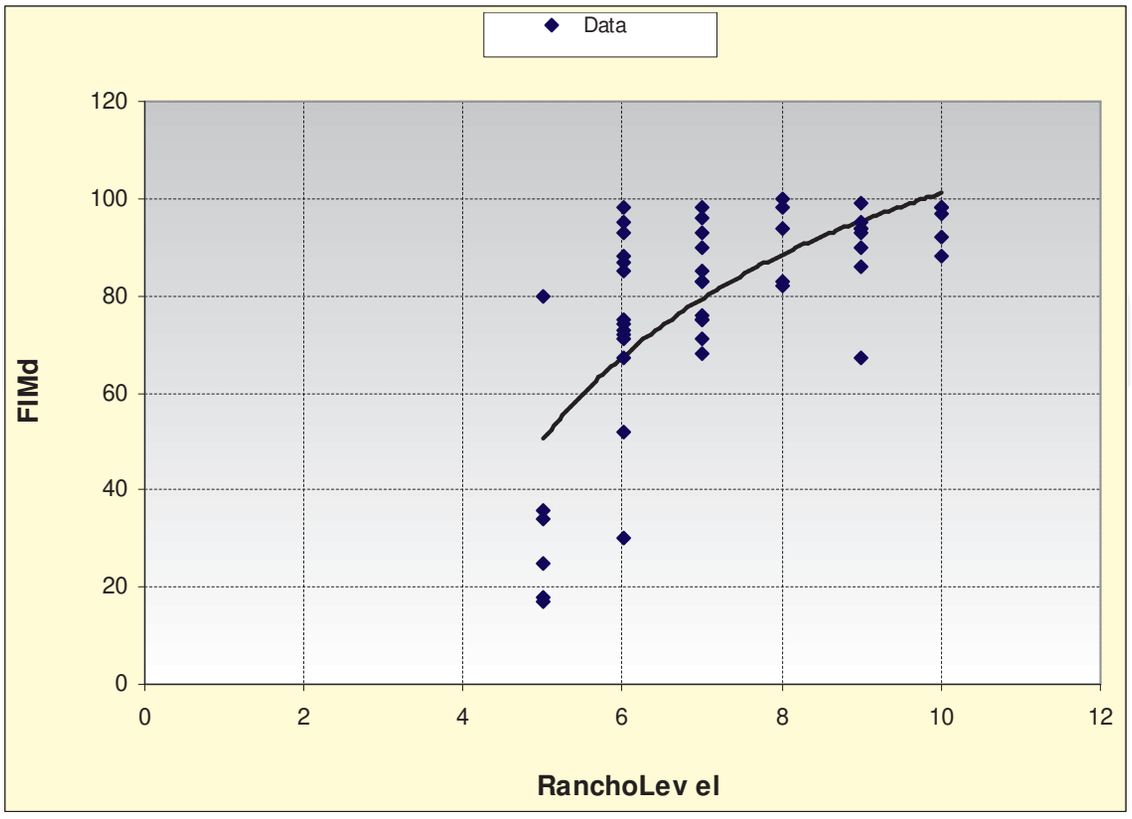

Figure 1. Correlation of FIM d and Rancho

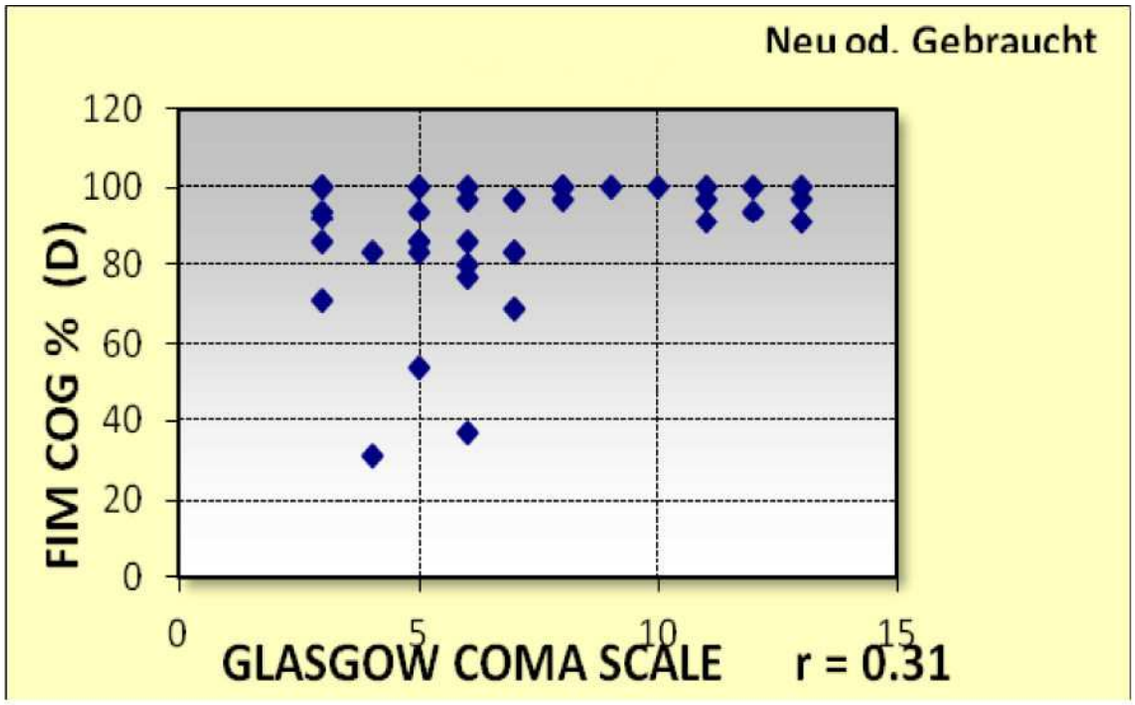

Figure 2. Correlation of FIIM cog D and GCS

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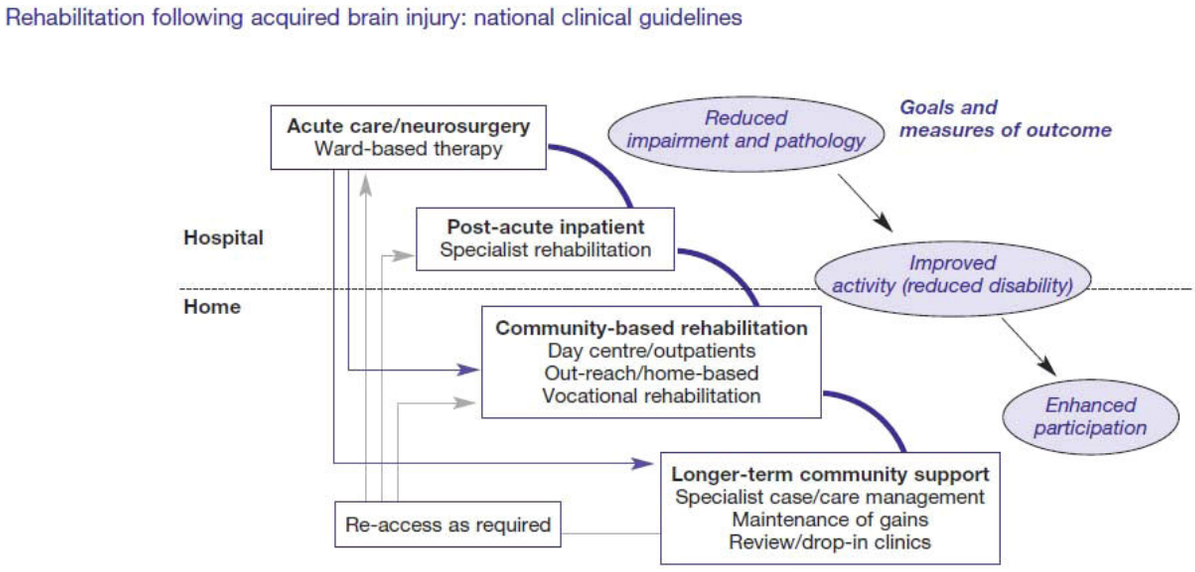

Figure 3. Rehabilitation following brain injury

medication or psychiatric consultation, while transfer to rehabilitation units as early as possible have resulted in shorter LOS in acute care units in HGH and have shown improvement in physical and mental impediments. This chapter will classify and promptly summarize the rehabilitation process of the slow stream rehabilitation programme, the active participation programme and long-term rehabilitation programme, the community based rehabilitation programme and returning to the community or work.

Most rehabilitation units will admit individuals a week or so after injury once they are medically stable. Generally, individuals have an average stay of about three months. However, longer-term rehabilitation is important if short-term gains are not to be lost. Outpatient rehabilitation should continue at least until physical recovery has plateaued. Recovery of cognitive and intellectual problems can take longer than physical problems and it is often such psychological difficulties that cause most handicaps and distress to the injured individual's family. This problem must be compensated by establishing a long-term facility that must be allowed to give the injured individual rehabilitation and medical service for at least one year. Following on, another important step in the rehabilitation setting is that the rehabilitation team will need to clearly establish links with social services as well as other relevant professionals, such as employment rehabilitation experts.

The rehabilitation team recommends developing close links with the established community rehabilitation centre (CRC) in the state or province, with CRC in turn having links with the regional rehabilitation unit or rehabilitation hospital. Most post-acute rehabilitation is conducted in the hospital setting or at the regional rehabilitation unit, before individuals are discharged back into the community. At this point, the community team becomes involved and is able to deliver ongoing physical and psychological rehabilitation through a multidisci-

plinary team, based in a peripheral hospital, as well as being able to deliver services within the home. The author is working on establishing CRC in Qatar under the national strategy of rehabilitation.

When addressing the efficacy of head injury rehabilitation, there are many problems to be overcome. Randomized and blind study is almost impossible to achieve, as there are very few people who have not received some form of rehabilitation after acute injury. Rehabilitation is obviously a multi-faceted and multi-professional process without clear-cut definitions. M.P. Barnes reported rehabilitation after head injury to be a long-term process with much impairment taking two years or more to achieve full recovery [5]. Thus, long-term follow-up and data collection is important for ideal study. More studies revealed that the standard outcome measures help to improve cognitive and motor functional level. However, no studies have been found that that tracks the continuum of rehabilitation from intensive care to final community re-integration. Though the literature in this area is confusing and hard to come by, some studies are nonetheless worth considering and can begin to provide good evidence for the value of head injury rehabilitation.

McKay and colleagues [6] compared matched groups of severe head injury individuals who did or did not receive formal rehabilitation during their acute trauma centre admission. All TBI rehabilitation individuals received physical, occupational or speech therapy, whereas in the non-rehabilitation group, only a very small minority did. In the rehabilitation group, therapy was also initiated quickly, whereas in the other group, therapy started about three weeks after the acute episode. Overall coma length, rehabilitation stay and cognitive functioning showed a significant benefit in the rehabilitation group. An interesting study by Blackerby [7] demonstrated that an increase in intensity of rehabilitation for five to eight hours a day produced a reduction in the average length of stay.

An important study by Cope and Hall [8] compared 34 head injured people who had either been referred 'early' or 'late' to a comprehensive inpatient rehabilitation programme. The early group had significant reduction in length of stay both in the acute care unit and in the rehabilitation unit. Many studies indicate better functional outcomes following a formal rehabilitation programme. For example, Aronow [9] produced one of the very few case controlled studies, where patients from an inpatient head injury programme were matched with similar patients in a neuro-trauma programme who received no formal rehabilitation. On the outcome scale used (not widely published in terms of validity and reliability), the rehabilitation group had a significantly better outcome than the non-rehabilitation group. Some published studies are supportive of the view that comprehensive TBI rehabilitation programmes produce benefits over and above standard care and spontaneous recovery.

Barnes [5] indicated in his study that early intervention by a specialist head injury service significantly reduced social morbidity and severity of post-concussion symptoms at six months. On referral to this study and her own experience, the author introduced an Early Intervention Rehabilitation Team at the level of intensive care and acute care units in Hamad General Hospital, Qatar, which resulted in reducing the length of stay in acute settings and preventing complications. It is clear that much work still needs to be done in this field. Nonetheless, valuable studies strongly support a comprehensive TBI rehabilitation pro-

gramme, which produced worthwhile benefits over and above standard care and spontaneous recovery. The rehabilitation team of rehabilitation unit's focus is on a comprehensive assessment for TBI-related neurological and functional impairments and the development of an individualized specific programme based on functional goals and serial monitoring of outcomes (Box No. 4).

What follows will describe the process of a specialized rehabilitation programme for specific rehabilitation problems after traumatic brain injury. Physical disability is divided into three types – mild, moderate and severe. The severe type of disability consists of the following factors of muscle contracture: spasticity, heterotopic ossification and communication problems; these will be discussed in detail.

Severe physical disability. This occurred after severe head injury; relatively few people have had severe physical disability in the long-term. The longer-term problems of traumatic brain injury tend to include cognitive, intellectual, behavioural and emotional difficulties rather than physical problems. This has been confirmed by a number of studies [10, 11]. Spasticity can be particularly problematic after TBI and if not treated persistently, can often lead to muscle contracture and a functionally useless limb. Passive stretching in the acute phase is important, as may be the use of orthoses or even serial splinting and casts in order to prevent such contracture. Whilst there are a number of modern oral anti-spastic agents *(*e.g., Baclofen, Dantrium and Tizandine), troublesome spasticity tends to be focal and thus better treated by a local modality. Botulinum toxin has recently been introduced as a potent muscle relaxant and a number of studies have now demonstrated efficacy in the management of spasticity [12, 13]. Fortunately, the effects of Botolinium toxin wore off after three months and did not impair long-term recovery, which used to be the case in other focal techniques such as phenol and alcohol nerve blocks.

Heterotopic ossification. Neurogenic heterotopic ossification (HO) is characterized by the formation of bone in soft tissues following traumatic injury to the central nervous system, especially around large joints (CNS). The hip is the most commonly involved joint, but elbow and knee is also common in both spinal cord injury and traumatic brain injury (Figure 4]. HO was first described in 1883 by Reidel and in 1918, Dejerne and Ceillier reported that HO frequently occurred among soldiers who had experienced spinal cord trauma as combatants in World War I [14]. The development of HO is extra-articular and occurs outside the joint capsule. Bone forms in the connective tissue between the muscle planes and not within the muscle itself. The new bone can be contiguous with the skeleton but generally does not involve the periosteum. Mature HO shows cancellous bone and mature lamellar bone blood vessels and bone marrow with a minor amount of haematopoiesis.

Alkaline phosphatase has been recommended as a useful screening tool for HO [15]. Alkaline phosphatase levels become abnormal approximately two weeks after injury. In the typical case of HO, the alkaline phosphatase levels reached approximately 3.5 times the normal value 10 weeks after the inciting trauma, before returning to normal at approximately 18 weeks. The literature suggests reasonably good results for primary and secondary prevention with Non-Steroidal Anti Inflammatory Drugs, bisphosphonates and radiation. Surgical excision and joint release can provide improvements for many patients, but have varied results and often depend

Lateral radiograph demonstrate the anterior and posterior ossification.

Anteroposterior radiograph of the left knee in a traumatic brain injury. Mature heterotopic ossification surrounds the medial femoral condyle, with a solid Peripheral cortex (arrows).

Figure 4. X Ray of heterotrophic ossification

on the degree of CNS injury. The role of physical therapy in patients with HO is somewhat controversial. There are those who believe that aggressive ROM may lead to increase bone formation. Most, however, agree that physical therapy preserves movement, leading to better function and prevention of ankylosis. Physiotherapy typically involves active and passive ROM, gentle terminal stretching and resisted ROM exercise [16].

Nutrition is a particular problem. The reasons are two-fold – an increased catabolic rate immediately after brain trauma compounded by the common occurrence of swallowing difficulties. If maintenance of good nutritional status is difficult, a judgment that should preferably be made only after adequate dietary advice, then nasogastric feeding can be used in the very short-term. However, if adequate nutrition cannot be maintained within a few days following iTBI, then a fine bore percutaneous endoscopic gastrostomy (PEG) tube should be inserted. This is a relatively simple and straightforward procedure with few complications. If nutrition is not maintained, it can have serious consequences for wound healing and an increased risk of pressure sores.

Pressure sores remained, unfortunately; they are rather common and are nearly always avoidable. Rigid adherence to regular turning regimens, as well as the use of appropriate pressure relieving mattresses and appropriate lifting and handling techniques should help to

limit the occurrence of pressure sores. However, risks could be increased by poor nutrition as well as by other factors such as urinary or faecal incontinence. Regrettably, once sores are present, they can be extremely time consuming in terms of healing and often require surgical intervention to excise the ulcer, bony prominence or affected bone and to resurface the defect by skin grafting or other techniques such as a myocutaneous flap [17].

Urinary continence can also be problematic after head injury. Whilst in the short-term, indwelling catheterization can be used, in the long-term this is a most undesirable solution. Urodynamic study regarding the exact nature of the underlying detrusor and/or sphincter problem, combined with appropriate pharmacology, often relieves the situation. However, if impairment of bladder emptying remains, the technique of clean and intermittent self-catheterization can be invaluable - performed either by the patient or sometimes by an appropriate carer [18].

Communication problems can be troublesome after brain injury. Thus, an assessment by a speech therapist is important and various speech and language interventions can obviously be of benefit, particularly for dysarthria and dysphagia. However, those with very severe disablement are often unable to communicate orally and need to revert to an appropriate communication aid. These can vary from simple pointing boards to more complex pre-programmed artificial voice communicators. There are a number of Communication Aid centres who have particular expertise in this field and in the forms of assistive technology, which is becoming increasingly important in reducing disability and participation in those with severe physical problems.

Medical rehabilitation Problems. Urinary tract infections, pulmonary complications and derangement in electrolytes and liver function are common in 60% to 70% of acute TBI cases and may prolong acute hospital stay. Seizures may be reported in 20% of those with a severe TBI. Common neuroendocrine disorders include growth hormone deficiency, syndrome of inappropriate secretion of antidiuretic hormone, diabetes insipidus, secondary amenorrhoea, galactorrhoea and gynaecomastia. The common hormonal insufficiencies were found to be from the pituitary (hypothalamus) region. (Figure 5).In hypo pituitarism, the anterior pituitary insufficiency had higher incidence [19] rather than the posterior. There is an increasing amount of evidence that suggest that post TBI hormonal deficiency syndrome affects many people who have sustained TBI and mild TBI, and research is now beginning to show that replacement of deficient hormones can lead to significant improvements.

To evaluate patients, a full hormonal assessment via a spot or 24-hour urine should be performed to test for hormones and their metabolites (serum testing). It is also important to test for neuroendocrine markers. This can be done with either spot or 24-hour urine testing. It is important to use a laboratory with neurotransmitter capability. To treat hormonal insufficiencies after TBI, early hormonal supplementation should be considered to minimize the physical and psychological sequelae. Hormonal assessments can be done at three-month intervals from the date of injury, or more frequently, based on treatment [20].

Cranial nerve injury in TBI. TBI-complicated cranial nerve injury is subject to a high incidence rate, a high mortality rate and a high disability rate. One study explained that the extent of

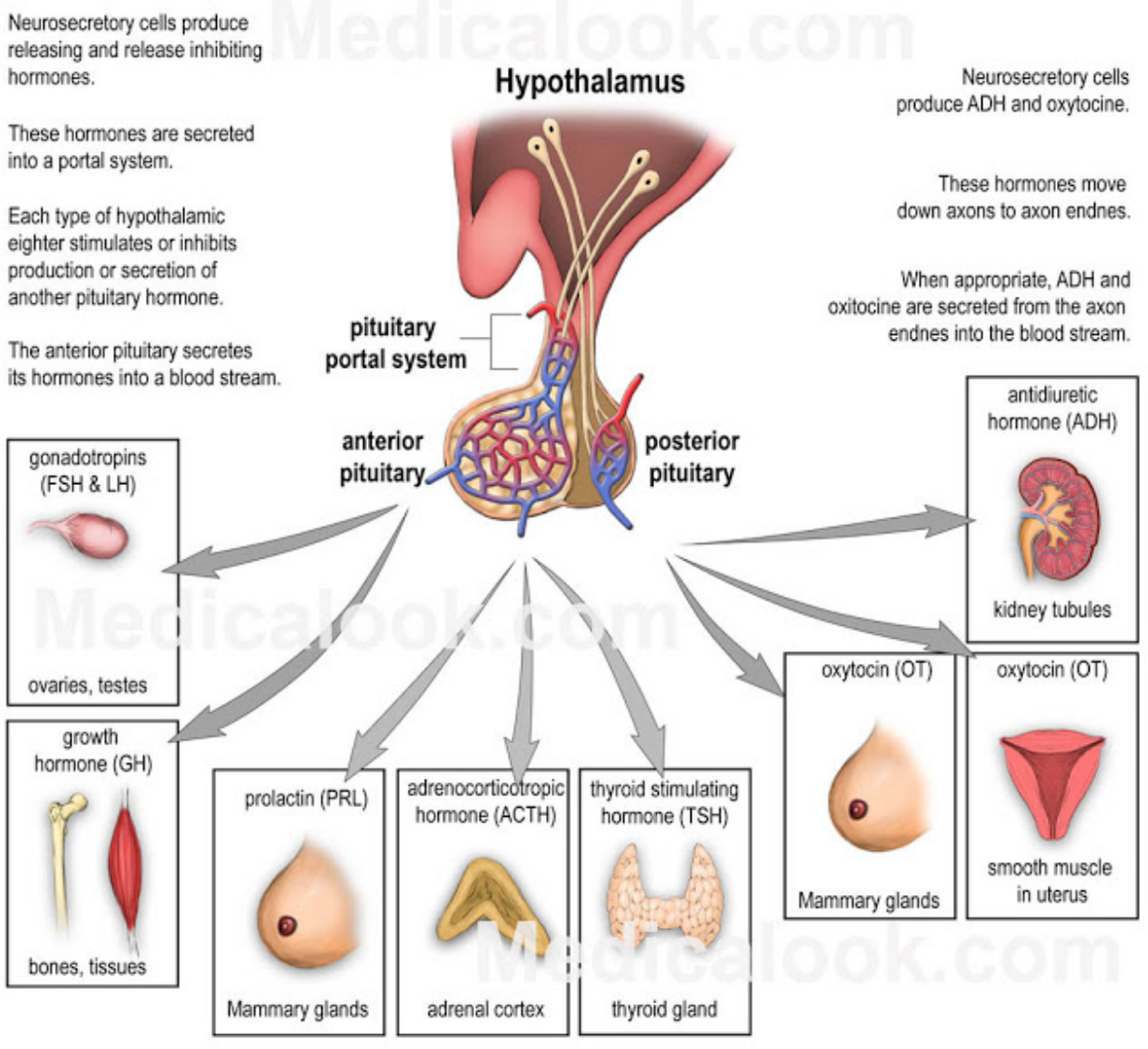

Figure 5. Pituitary hormone15

nerve injury varied and involved the olfactory nerve (66 cases), optic nerve (78 cases), oculomotor nerve (56 cases), trochlear nerve (eight cases), trigeminal nerve (four cases), abducent nerve (12 cases), facial nerve (48 cases), acoustic nerve [10 cases), glossopharyngeal nerve (eight cases), vagus nerve (six cases), accessory nerve (10 cases) and hypoglossal nerve (six cases) [21].

Environmental control equipment provides a means of controlling simple electrical equipment around the house such as the ability to turn the television, lights and other equipment on and off, and the ability to answer the telephone, open the door and adjust the bed. Such independence can be very important to an individual who is otherwise entirely dependent on a third party. The application of relatively simple technology can sometimes make a dramatic difference to level of independence. For example, a number of devices are available that enable a severely disabled person to drive a motor vehicle. These can vary from simple hand controls

(switches) to more complex joystick steering with voice controlled accessory equipment (Figure 6]. Overall, those with severe physical disabilities need the support of a rehabilitation expert, which in turn will have access to the necessary wide range of multidisciplinary expertise, facilities and equipment.

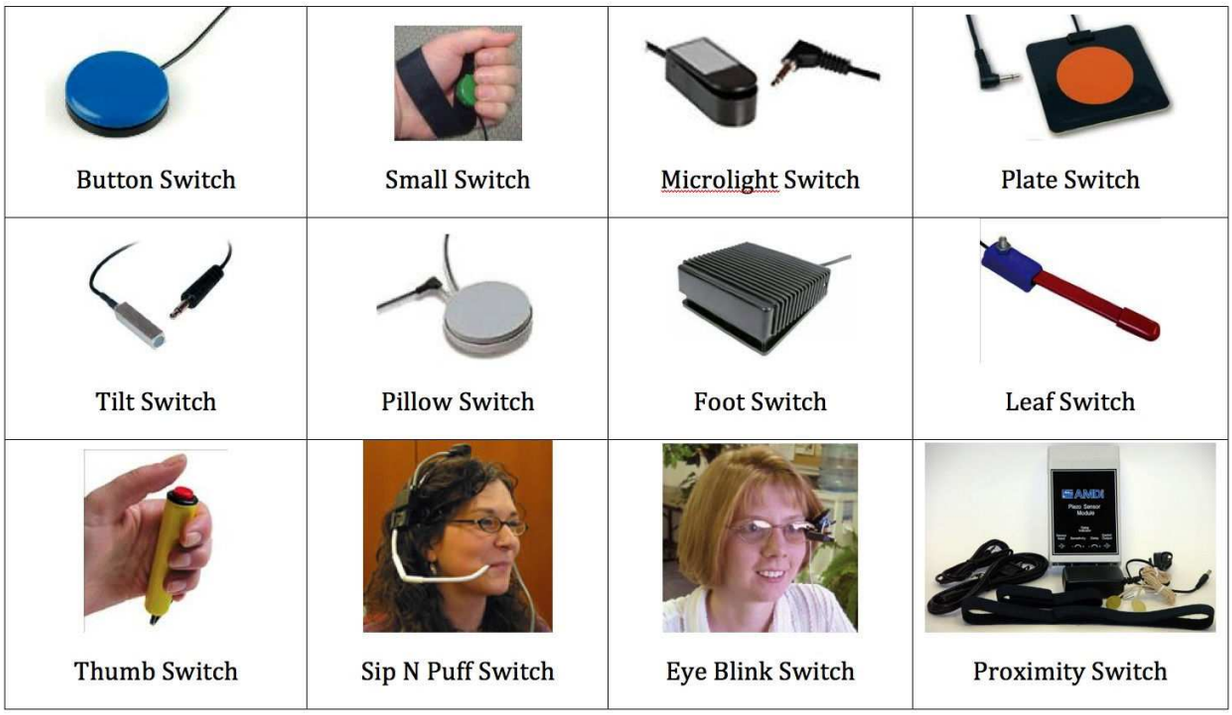

Figure 6. Adaptive devises

Following head injury, a variety of important cognitive impairments can be observed. The commonest are those associated with attention deficits, problems with concentration, memory and perception, information processing speed and problem solving. Normal recovery of neuropsychological difficulties can take place over a prolonged period of time and certainly up to two years post-injury. Obviously, this can be a complex set of impairments and consequent disabilities need to be assessed by a clinical neuropsychologist. It is somewhat controversial whether neuropsychological intervention can actually promote recovery, but there is little doubt that coping strategies can be designed that will effectively reduce disability. There have been very few randomized trials in this field and such trials are likely inappropriate when one is dealing with so many variables. The use of well-designed single case studies is a methodology that is probably best pursued in this area. Most work has been conducted in the field of memory disorders [21].

Rehabilitation can be divided into those techniques involving internal strategies and those dependent on external resources. Internal strategies, for example, can involve the use of various mnemonic techniques such as the use of imagery, methods to organize information in particular sequences (e.g., the PQRST technique), as well as other techniques that involve the use of acronyms, rhymes and systematic queuing. An alternative or even coexistent strategy

is to devise interventions for reducing the handicapping effects of amnesic problems. Some may appear simple and obvious, such as planned use of a personal organizer with electronic alarm systems, colour codes around the house or a rigid use of lists, memos and diaries.

However, there is no doubt that such techniques, whilst not influencing memory impairment, can certainly reduce the effects of such impairment and have positive benefits in terms of disability and handicap [22]. Similar approaches have been taken to the remediation of problem solving deficits, attention deficits and perceptual problems [23]

Fortunately, very few individuals remain in prolonged coma or prolonged vegetative state following brain injury. One study [24] found that 0.6% of all brain-injured individuals admitted to a neurosurgical unit remained in prolonged coma (of more than two weeks' duration). Care certainly needs to be taken in the early diagnosis of coma and/or vegetative state, as later recovery has been well documented. A comparison of clinical features associated with vegetative state and minimally conscious state is shown in Table 2. Andrews [25] recently found a very high incidence of misdiagnosis in the so called persistent vegetative state. In view of the level of misdiagnosis, referral to a specialist centre is desirable. Quality of life should be maximized and unnecessary complications avoided, particularly contractures, pressure sores and malnutrition. Prolonged reassessment is necessary in order to detect when some form of cognitive recovery is taking place.

Condition	Consciousness	Sleep /wake	Motor Function	Auditory Function	Visual Fixation	Communication	Emotion
Coma	None	Absent	Reflex and postural responses only	None	None	None	None
Vegetative State	None	Present	Postures or withdraws from noxious stimuli Occasional non purposeful movement	Startle Brief orienting to sound	Startle Brief visual Fixation	None	None Reflexive crying or smiling
Minimally Conscious State	Partial	Present	Localizes noxious stimuli Reaches for objects Holds or touches objects in a manner that accommodate size and shape Automatic movements (e.g., scratching)	Localizes sound location Inconsistent command following	Sustained visual fixation Sustained inconsistent but intelligible verbalization or gesture	Contingent vocalization Inconsistent but intelligible verbalization or gesture	Contingent smiling or crying

Table 2. Comparison of clinical features associated with vegetative state and minimally conscious state

Regrettably, there are a number of case studies that illustrate instances of cognitive recovery when attendants, staff and relatives believed the individual to have still been in a vegetative state. This stage is critical and requires patience and more recovery time. The rehabilitation team should dedicate their specialized skills and techniques to get away from their conditions. The rehabilitation team can apply the appropriate evidence-based pharmacological and non-pharmacological methods. For example, to recover from awareness medication like amantadine, sensory modality assessment and rehabilitation technique (SMART) and coma recovery programme–revised (CRS-R) can be utilized. The rehabilitation team might consider that the involvement of a psychologist or specialized neuropsychology is preferable to the involvement of a psychiatrist.

Many TBI patients are required to undergo appropriate counselling and psychotherapy. Many people with TBI develop behavioural problems in the short-term, particularly whilst emerging from a coma or during the phase of posttraumatic amnesia. A few individuals develop persistent and severe behavioural problems and can be a source of extreme disruption on the acute or rehabilitation ward, and certainly a source of major difficulty for the family. Eames and colleagues [26] stated that the application of behavioural management techniques could be effective in ameliorating difficult behaviour and in improving functional independence levels, as well as improving compliance with physical therapy even years after injury. Staff at a rehabilitation unit should have a degree of expertise in the management of behavioural problems; nevertheless, those with severe and persistent difficulties should be referred to appropriate psychiatric or specialized behavioural units.

The use of drug therapy in the management of such behaviours is best avoided, but in practise, this is unavoidable. Certainly, the use of sedative anxiolytics or psychotropic medication is generally unhelpful and may even worsen behaviour. Occasionally such intervention is essential, because of the proximity of vulnerable people of TBI or because of extreme pressure on staff time and resources. There is very little good quality literature on this subject; however, some studies have indicated an improvement in aggression and episodic dyscontrol by use of serotoninergic anti-depressant Trazodone [27] or the anti-convulsant Carbamazepine [28]. Other authors advocate the use of lithium or beta-blockade with Metoprolol [29]. If TBI patients became severely agitated, some advocate the use of Buspirone, which is chemically distinct from other anxiolytics.

For negative behaviours, some improvement is occasionally noticed following the use of dopamine agonists. A few authors continue to use stimulants such as Dexamethetamine or methyl phenidate, but such medication should be used with caution and only by those with some experience in the field. Other behavioural problems can be less troublesome but nonetheless give rise to marital stress, social isolation and often unemployment. Such problems can include egocentricity, poor judgment, lack of initiation, reduced achievement drive, lethargy, disinterest, lack of depth of feeling, irritability, aggressiveness, reduced tact and increase or decrease in sexual interest. Alongside these problems, both in the patient and the carer, can be the presence of associated mood disorders, particularly depressive illness and anxiety [30]. It is essential for the multidisciplinary team to recognize such problems and treat them appropriately.

There is no evidence that depressive illness responds less well in the context of acquired brain injury than in the context of endogenous depression. Thus, standard approaches, either psychological or pharmacological, should be used as aggressively as needed. Even if some of these problems are not remediable, they should be recognized and explained to the injured individual's family and colleagues. The immediate family will often benefit from counselling and supportive psychotherapy. Nowadays, before initiating pharmacotherapy or psychotherapy, patients should be screened to rule out any history of constipation, retention urine, infection, fracture and musculoskeletal illness. Levy et al. [31] stated that numerous studies have examined the use of medications in the treatment of agitation of post-TBI patients, but that there is limited evidence to help guide the clinician. Thus, the prescription of pharmacotherapy must be closely monitored and a multidisciplinary approach combining both pharmacological and non-pharmacological interventions may be necessary.

In the US, a number of studies have shown the efficacy of an employment support scheme. In such schemes, a trained rehabilitator accompanies the individual back to work and further rehabilitation will take place in the workplace, allowing an opportunity for specific goal orientated re-entry as well as an opportunity for education of the employer and work colleagues. It is regrettable that many rehabilitation facilities feel their job to be completed after the patient has been discharged back home, perhaps having received a follow up after the passing of a few months.

The best long-term outcome in those of working age is to return to their pre-accident employment situation. In many countries, little attention is paid to employment rehabilitation. Such rehabilitation rarely take place at all, or if it does, is the responsibility of a completely separate government department that likely lacks the necessary expertise for the management of those with brain injury problems. Following TBI recovery, rushing back to work too quickly is not advisable. If this happens, symptoms that were on the mend might flare up once more. A period of retraining may be required and adaptations to the workplace may be needed.

If an individual can return to work it will serve as a boost to their self-esteem and independence, particularly from a financial point of view. Such re-employment will clearly be of overall benefit to the state in terms of reduced benefits and may even enable the carer to return to employment as well. Wehman and colleagues [32] have clearly demonstrated the effectiveness of the supported employment programme. In his study forty-one [41] head injured people were included in the initial study;Only 36% of referred clients had achieved any competitive postinjury employment, compared with 91% of the same group who were competitively employed before injury. A job retention rate of 71% was reported, with most jobs in warehouse, clerical, and service-related occupations. This group presented a mean period of seven years from injury and thus the chances of spontaneous recovery were minimal.

The improved integration of employment professionals with health and social service professionals must be a priority in the future. At present, simulator-based education programmes have a strong scientific basis. Virtual reality driving simulation rehabilitation training (Figures 7 and 8) has shown promising results with respect to retraining driving performance and behaviour among military personnel recovering from TBI [33]. This is a new development in advanced driving solutions for disabled individuals after TBI or stroke and spinal cord injury, employing a fully immersive car driving simulator ideally suited for driver assessment and rehabilitation application.

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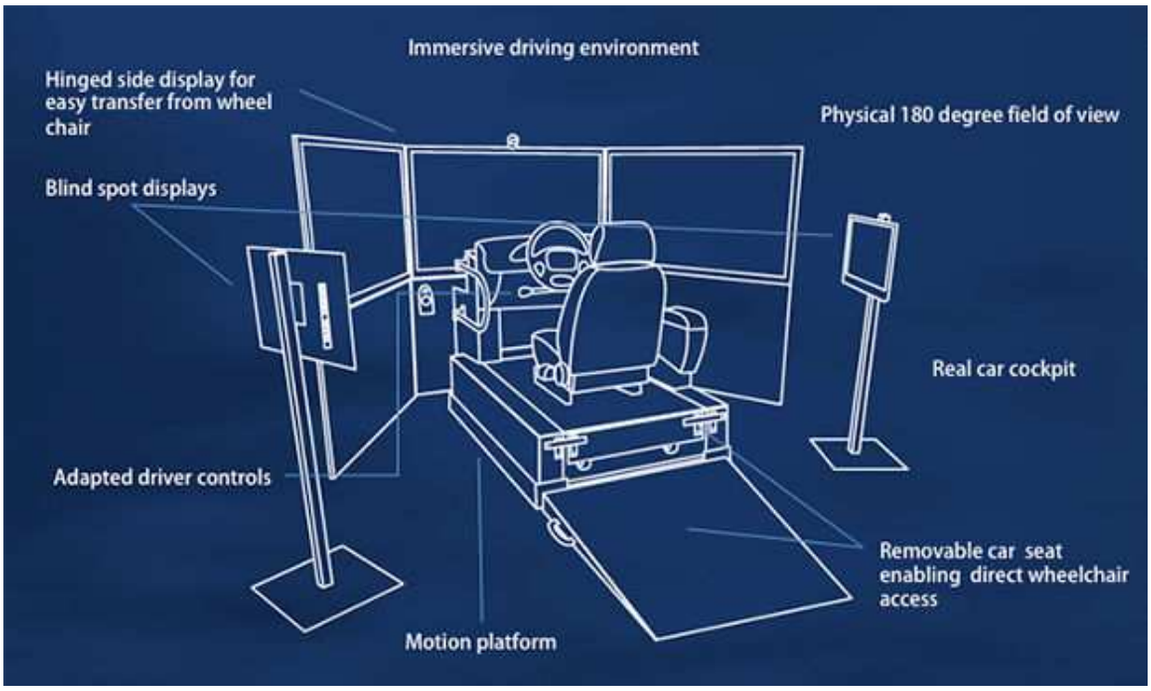

Figure 7. Virtual reality driving simulation rehabilitation training

Figure 8. Virtual reality driving simulation rehabilitation training

3. Conclusion

TBI is a diverse disorder of major public health significance. Rehabilitation services, matched to the needs of people with TBI, as well as community-based nonmedical services are required to optimize outcomes over the course of recovery. Both the person with TBI and their social support networks should have access to rehabilitation services through the entire course of recovery, which will continue for many years after the injury. The services required will change as the person's needs change over time. Survivors of severe TBI face the challenge of resuming a meaningful life for themselves and their families. However, severe TBI is not curable and medical and rehabilitation management may not ultimately be able to provide the improvement desired by the patient and his/her family.

In summary, TBI rehabilitation is a recognized subspecialty of neurorehabilitation and there is increasing awareness of its important role in early management for all severities of injury. While evidence for its effectiveness and specific interventions is limited, emerging therapies need to be subjected to rigorous research. The families of TBI survivors, particularly the severely injured, young TBI patients and those in a vegetative state accept most of the social and societal burdens of long-term care. It is crucial to bear in mind that prevention of TBI is vital, as there remains no cure for the sequelae of either moderate or severe TBI.

Author details

Wafa Al Yazeedi, Loganathan Venkatachalam, Somaya Al Molawi and Fatma Al Kuwari

Department of Physical Medicine & Rehabilitation, Hamad Medical Corporation, Doha, Qatar

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