Commentary

Rehabilitation for Traumatic Brain Injury in Children and Adolescents

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Abstract

Children and adolescents who have sustained a traumatic brain injury (TBI) may be left with multiple deficits and impairments that can impact adversely their abilities to return to pre-morbid functioning in the home, school and community. Early rehabilitation has been shown to improve functional outcome; the rehabilitation programme itself has to be based on real-world demands and experiences. Rehabilitation has to be continued beyond the post-acute stage in order to promote neuronal re-organisation, monitor the child's development as well as identify and manage new issues that may appear with growth, development and maturation. The availability of relevant research data and findings for children is much less than those for adults. It is not always appropriate to apply data for adults to the younger persons due to important differences in the 2 groups and these are discussed in more detail in the article. Multiple factors have been found to affect recovery and functional outcome. Apart from age and developmental stage at injury, other variables can be grouped as injury-related, patient-related and treatment-related factors. The goals and components of the rehabilitation process are examined for the various stages of recovery and the last section of the article describes the paediatric rehabilitation scene in Singapore.

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Introduction

Traumatic injury to the brain (TBI) can lead to multiple medical, cognitive and functional issues, both in the acute care setting as well as over the much longer term. Much knowledge has been gained from relevant research in this area for adults, and the goals, guidelines and outcome for the practice of brain injury rehabilitation in the adult population is well-established. This is not so for younger persons. Meticulously performed research in children and adolescents with acquired brain injury is still relatively scarce. Oftentimes, data obtained from work done in adults is extrapolated to the younger age groups. However, they may not always be applicable due to several important differences between children and adults,[1] as will be explained in the following sections of the article.

Epidemiology and Pathophysiology of TBI

In the United States, trauma accounts for over 50% of paediatric deaths and the majority of cases involve brain injury.[2] The estimated incidence in children is approximately 185 per 100,000 per year: 235 for boys and 132 for girls.[3] There are 2 peak periods of incidence: early childhood (age below 5 years) and mid- to late adolescence.[2] The leading causes of paediatric brain injury are transportation-related (39%), falls (28%), sports and recreational activities (17%) and assault (7%).[3] In early childhood, child abuse (or non-accidental trauma) is a major cause of severe brain injury and accounts for up to two-thirds of cases in those 4 years of age and below.[2] In general, 7% to 20% of child abuse victims sustain severe head injuries.[4] With age, the frequency of injuries due to motor vehicle accidents increases: 30% in children up to 4 years, to a high as 60% in adolescents. Young children are more likely to be involved as pedestrians or bicyclists. In contrast, adolescents are prone to be injured as passengers in road traffic accidents, similar to adults.[2]

There is no brain injury register in Singapore. The emergency department of the largest paediatric hospital in Singapore handles about 3000 cases of TBI a year (unpublished data). Of these, 60% are over the age of 2

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years and the remaining 40% less than 2 years. The emergency department admits about 30% of the patients seeking medical attention, that is, about 900 children are admitted to the hospital a year, comprising those with moderate and severe head injuries, and all infants (up to 1 year of age) who have sustained TBI. The majority of cases are due to falls.

The pathophysiology and outcome of head trauma differ significantly between children and adults.[4] Severe brain injury occurs less frequently in children than adults. Mortality is lower for children, even after stratification by severity of head injury. After severe head injury, children present with diffuse brain injury and cerebral swelling with resultant intracranial hypertension (up to 44%) more commonly than adults.[2] Children are at higher risk of diffuse axonal injury caused by rotational acceleration and deceleration because of their relatively higher head to body ratio, weak neck muscles, and lack of nerve myelination. In cases of child abuse, anoxia and hypotension are often causes of secondary injury, possibly associated with a delay in seeking medical attention. Focal injuries, such as subdural, extradural and intracerebral haematomas are less frequent in children (15% to 20%) compared to adults (30% to 40%) and are associated with lower mortality.[2] Immediate post-traumatic seizures occur much more frequently in children and are more common in younger than older children.[4]

In general, the costs of brain injury are enormous. Medical expenses can be very high and additional costs include those of long-term disabilities, reduced employability and increased carer burden. Not only are children and adolescents more likely than adults to survive following TBI, they are also likely to survive for a longer time.[5] The costs in terms of individual suffering, family burden and financial burden to society are greater for those who have more years to live.

Factors Affecting the Outcome of Paediatric TBI

Children are not little adults.[6] Their nervous systems at the time of injury are still not fully mature. They are still in the process of developing and acquiring new skills. Following injury, children must not only meet the challenges of recovery but also ongoing challenges of development and maturation.[7] The impact of TBI on a child's ability to achieve developmental milestones has been found to be a critical factor in determining long-term outcome.[6,8]

A common misconception regarding neuroplasticity assumes that the child possesses a greater capacity for neuronal reorganisation post-injury and therefore, the younger the child, the better the outcome. However, this assumption is now considered seriously flawed.[9] There is increasing evidence that children may be more vulnerable to the adverse consequences of TBI than adults. Apart from injury severity, pre- and co-morbid factors, the age and developmental stage at injury have great influences on subsequent recovery.[10] Greater mortality and disability are noted in the very young (infants/toddlers) compared to school-going children or adolescents. Functional recovery has also been observed to be related to age; the older the child, the greater the recovery from TBI.[11] In addition, age at injury has a profound influence on the types of skills affected, severity of impairments as well as rate and recovery from deficits in language, memory, attention, and executive and academic skills. Studies have demonstrated that children injured in infancy and childhood (less than 5 years) recover minimally with greater impairments in intellectual skills several years after injury relative to the intellectual abilities of children injured during their school-going years (6 to 16 years).[12,13]

Children who have sustained a severe TBI can suffer a wide spectrum of neuropsychological deficits. In the acute rehabilitation setting, deficits may be noted in arousal and alertness, orientation, attention, intellectual functioning, memory, expressive and receptive language, motor skills, visuoperceptual and visuospatial abilities, construction skills, executive and self-regulatory skills, and academic skills.[14] The severity of the deficits and the resulting disabilities and handicaps are not necessarily proportional to the severity of injury.[15] Factors that can impact functional outcome can be broadly categorised into the following 3 groups:[1]

1. Injury-related factors:

Type and severity of injury

Pattern and extent of primary injuries e.g., focal contusion, diffuse axonal injury

Presence and severity of secondary injuries e.g., cerebral oedema, hypotension/hypoxia, seizures

Severity of clinical parameters e.g., depth of coma, duration of post-traumatic amnesia

2. Patient-related factors:

Age at injury

Pre-morbid issues e.g., childhood medical problems, psychological/psychiatric disorders

Developmental achievements at time of injury

Educational achievement, including the presence of any intellectual or learning disorder

Family/psychosocial characteristics:

- Parent-child relationship
- Support network
- Financial resources
- Socioeconomic status
- Educational resources

3. Treatment-related factors:

Time to rescue
Time to trauma care and type of care given
Medical complications
Presence and severity of other peripheral injuries
Nutrition
Pharmacological treatment
Time to rehabilitation
Type, intensity and duration of rehabilitation

The contribution of each of these factors to the long-term outcome of children with TBI differs at different stages of the recovery continuum.[16]

The Importance of Paediatric Rehabilitation

Rehabilitation provides the necessary experiences for stimulating neuronal plasticity. It employs an interdisciplinary approach involving the rehabilitation physician, paediatrician, physiotherapists, occupational therapists, speech-language therapist, psychologist, rehabilitation nurses and the social worker. The team provides individually tailored training, allowing children to re-experience life and face life's challenges again. The nature of paediatric rehabilitation is to stimulate the child through real-world demands via the provision of an "enriched environment".[17] Research evidence suggests that the incorporation of real-world experiences in the rehabilitation programme is essential to effect the neuronal re-organisation necessary for recovery of function.

The greatest benefit from rehabilitation is seen in patients who received rehabilitation early after onset of injury.[18] Such patients were found to have reduced levels of impairment, disability and secondary complications, and better long-term functional outcome.

The Process of Paediatric Rehabilitation

The first step in the rehabilitation process is to determine whether referral to a dedicated neurorehabilition team is necessary and to decide on the need for inpatient rehabilitation. Factors to consider include the severity of injury, the child's general health status, the child's level of arousal and ability to participate in therapy, the child's mobility status, the need for involvement of multiple disciplines, the family social situation and the family's choice of discharge placement.[19] The specific goals for any one child depends on the child's status at the time of admission, the rate and extent of recovery whilst receiving rehabilitation, the family's response to the child following injury and the family's involvement in the rehabilitation process.[1] The primary goals in acute rehabilitation focus on the child's capacity to perform age-appropriate self-care and daily living activities, as well as to begin the process of community re-entry.

During the initial period, therapies are generally designed to prevent the complications of reduced mobility (such as contractures and pressure sores), reduce the negative effects of sensory deprivation, improve awareness of the surrounding environment and ongoing daily events, stabilise the sleep-wake cycle, prompt and shape automatic behaviours (such as feeding), and promote active participation in familiar daily activities.[1] As the attention span of injured children may be short during this phase, especially for those with post-traumatic amnesia, it is important to time the sessions properly; to have short, focused therapies with regular therapists in a quiet environment and to avoid over-stimulation. Family members should be actively involved in the rehabilitation process from this early stage. Due to the critical and constant role of parents and family in the everyday lives of children, the family's role in the rehabilitation process cannot be over-emphasised. Educating them about the nature and severity of their child's injury, the rehabilitation goals and the likely short- and long-term needs of the child will increase their understanding, motivation and participation in the programme. Early solicitation and involvement of the family has been found to reduce long-term dependence on hospital-based systems and subsequently reduce the cost of caring for the children.[20]

Once the child has progressed through the initial stage of acute rehabilitation, the child is generally capable, to some extent, of participating in their daily care. The focus of acute rehabilitation then shifts to establishing a structured daily routine to minimise confusion, agitation and the negative effects of memory deficits on daily functioning; controlled and systematic treatments directed at improving basic cognitive processes (attention, concentration, information processing speed); re-establishing well-learned and knowledge-based skills; compensatory strategies for minimising residual deficits such as those in short-term memory, judgement, problem-solving and social skills, and emotional and behavioural regulation. It is usually at this stage that the child is enrolled in a hospital-based school education system, where available. As with the initial phase, family involvement is essential for successful outcome. Family training can assist in the follow through of treatment recommendations, in treatment compliance, maintenance of treatment effects, and in the generalisation of treatment effects beyond the hospital setting.[21]

Post-acute Rehabilitation

After discharge from the acute rehabilitation hospital, participation in an outpatient rehabilitation programme is important to promote continuing neuronal re-organisation, to further optimise physical and functional recovery, assist in the child's transition to school and support the family's coping abilities. Due to ongoing development and matura-

tion, deficits following paediatric trauma will not always be immediately evident and may only emerge in the course of development, when skills subserved by damaged tissue fail to evolve or when healthy tissue is unable to fully evolve due to previous re-organisation.[1] Further complicating the picture are findings that different skills have different vulnerabilities to injury, with well-established skills appearing less vulnerable than developing skills.[10,22] The overall effect of early TBI is a reduced rate of new skill acquisition, a complication that has life-long implications for the paediatric survivor.[8,23,24]

The long-term outcome following paediatric TBI is not only dependent on injury, treatment and recovery factors. Additional factors such as pre-injury level of functioning, developmental variation, educational opportunities, socioeconomic status and family demographics also impact outcome.[6,7,14] Continuing rehabilitation can modulate these factors to maximise long-term outcome. For example, family dysfunction can be reduced and functional outcome improved by evaluation of family functioning and needs, and intervening at appropriate stages, or referring families to community resources.[25] Quality of life for patient and caregivers can be improved by educating and establishing long-term community resources for patients and families.[26-28] Financial burdens on families can be reduced by training multiple caregivers for lifelong care demands.[21] In short, rehabilitation needs to be continued long after the period of inpatient stay for optimal recovery and functioning of the injured child and family.

The Development of Paediatric Rehabilitation in Singapore

Rehabilitation medicine as a specialty is well-recognised in Singapore and all the rehabilitation physicians registered with the Singapore Medical Council have been trained in adult medicine. The 2 authors of this article, one a rehabilitation physician with an interest in children and the other, a paediatric neurologist with an interest in rehabilitation, have collaborated to set up a paediatric neurorehabilitation service in the largest paediatric hospital in Singapore. This Brain Injury Rehabilitation Programme is targeted at children with acquired brain injury, and interdisciplinary care is provided by a team comprising physiotherapists and occupational therapists, speech and language therapists, play therapists, a psychologist and a social worker. Assessment and therapies are started in the acute care setting as soon as the head-injured child is deemed medically and surgically fit. Family education and support, and carer training form integral components of the rehabilitation process. A primary school teacher is available on-site to provide hospital-based school education to children between the ages of 7 and 12. Discharge planning is done to ensure a seamless transition to the home environment and to further rehabilitation in an outpatient setting. A one-stop multidisciplinary neurorehabilitation clinic is conducted once in 2 months to review the progress of the child, monitor for any new developmental or behavioural issues and to set further rehabilitation goals. Decisions on appropriate school placement are made, with all available information, by the doctors, therapists, psychologist and social worker in conjunction with the child's family. The team liaises with the school principal and teachers regarding any special needs and the best ways to meet these needs. The hospital is currently looking into the feasibility of providing domiciliary rehabilitation to selected children who are unable to return to hospital for regular therapies.

Conclusion

TBI in children can lead to multiple impairments and disabilities. There are major differences between the aetiologies, underlying pathophysiology and needs of injured children compared with adults. A critical issue is that children are subject to ongoing development and maturation – they are not small adults. Paediatric rehabilitation is the setting that provides the necessary experiences for stimulating neuronal re-organisation following TBI. It provides an enriched, stimulating environment tailored to the needs of the child and based on real-world experiences. The involvement and training of family members is vital for successful long-term outcome as they are best equipped to ensure treatment compliance, maintenance of treatment gains and the generalisation of treatment effects beyond medical settings.

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