The Hong Kong Society of Child Neurology and Developmental Paediatrics
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SPECIAL ISSUE ON ACQUIRED BRAIN INJURY

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The Hong Kong Society of Child Neurology and Developmental Paediatrics

EDITOR'S NOTES for the October 2015 Issue

Acquired Brain Injury

Dr. Chok Wan CHAN

The current issue of Brainchild is devoted to "Acquired Brain Injury". It is capably convened by Dr. Stephanie Liu of the Child Assessment Service of Department of Health based on international and local data. She is to be commended for her effort in gathering so many powerful papers on the subject, namely, *Management of Paediatric Acquired Brain Injury* (Dr Dawson FONG), *Neurorehabilitation of Children after Traumatic Brain Injury* (Professor Joe Watt), *Children Surviving Traumatic Brain Injury – The Experience in Child Assessment Service* (Dr. Stephenie KY Liu & Acquired Cognitive Impairment Team, Child Assessment Service, Department of Health, Hong Kong), *Children and Adolescents with Traumatic Brain Injury: Collaborative Team Approach in School Reintegration Program* (Donna Yau Kam, Chan, Occupational Therapist, Child Assessment Service, Department of Health, Hong Kong), *Assessment and Rehabilitation of Speech and Language Impairment in Children and Adolescents with Traumatic Brain Injury* (Gillian Tang, Speech therapist), *Physical Assessment in Children and Adolescents with Traumatic Brain Injury* (Teresa Pui Shan Wong, Physiotherapist, The Hong Kong Brain Injury Association for the Young (HKBIAY)). The authors are all top experts in their own fields and together they have created a good local collection of excellent papers on this important topic on child health. I am sure you will find the content useful for your professional activities.

The Hong Kong Society of Child Neurology and Developmental Paediatrics is indeed very proud to witness the advancement of the subspecialties of Child Neurology (CN) and Development Behavour Paediatrics (DBP) under the capable leadership of Board Chairpersons Dr. Tim Liu and Dr. Catherine Lam respectively. They together with all the First Fellows in CN and DP have significantly moved our flag forward that we are now having our own Board to look after our own professional affairs including accreditation, training, examination, continuous professional development and quality practice of our subspecialties. This is a great breakthrough! However sustainable effort and professional solidarity are both mandatory to upkeep our mission going so that CN and DBP can continue to flourish in the child health arena in Hong Kong.

One potential threat to further development of our subspecialties is the establishment of the Children's Hospital to be opened in 2018. With the cancellation of the Government's original promise of establishing the Centre of Excellence on Neuroscience (CEN) next door to the Children's Hospital, all child neurology faculties planned for children in CEN now becomes fictitious and hanging in the air. The change of the Hospital from a Bureau Hospital to the present Hospital Authority Hospital poses great impact to DBP because in the original planning, Department of Health, being part of the Health and Food Bureau, was proactively engaged in the planning of child assessment service for the hospital. Now we really do not know where, how and what such services well exist in the new setting. Everything is in the dark and there is no clue of such to the child healthcare professionals whatsoever! HKCNDP, being the professional body for these subspecialties is obliged to fight for the rights of CN and DP not only for the good of subspecialties but also as advocate for our children in the community, we should endeavour to voice out our concerns, approach HA for more details regarding our subspecialties and approach the Bureau for final confirmation of their promises. These are all imminent issues and we should work jointly to achieve our targets as what we have been doing over the past for our subspecialties. We need our joint effort to move the task forward. *United we stand and separate we fall!*

Finally we would like to convey our deepest appreciation for the good work of all responsible professionals and key players in contribution to the realization of our mission for the Centre of Excellence for Paediatrics (Children's Hospital of Hong Kong). We look forward to the grand opening in 2018 of quality tertiary service care, training of both undergraduates and post-graduates in child health and high-level research for Hong Kong academics in child health. *I wish you all reading pleasure and best of health!*

Dr. CHAN Chok Wan

Editor-in-Chief, *The Brainchild*
President, The HK Society of Child Neurology & Developmental Paediatrics
28th October 2015.

Management of Paediatric Acquired Brain Injury

Dawson FONG

Specialist in Neurosurgery

There are myriads of causes to brain injury. As the most important organ of the body, the brain demands a constant, high supply of energy and oxygen for it to function normally. Any incident that hinders its blood supply and metabolism could result in injury. Examples include trauma, stroke, epilepsy, neoplasm and infection, just to name a few. Yet conventionally, traumatic brain injury (TBI) is the classic example whereby the organ is hurt not only from the primary physical trauma but a subsequent cascade of secondary events every one of which adds and compounds to the ultimate damage. Mastering the management of traumatic brain injury is indeed the Holy Grail for clinicians in this field.

Peculiarities of Local Paediatric Traumatic Brain Injury

In Hong Kong, people live in crowded environment. In an ordinary household, double bunk is commonplace. Furniture and utensils are stacked up on top of each other. Infants and children, while having fun in their home sweet home, are subject to domestic injuries – either they themselves falling down from height or objects falling down on them. Local studies at Tuen Mun Hospital in the 90's revealed that home is really not that safe, at least for children. For children under 12 sustaining head injuries, 41 % were below the age of 1. Seventy percent of the incidents happened at home and close to 80% from a fall from a height of less than 2 m. The fact that these children were usually not alone while these injuries occurred leads us to conclude that the quality of care of our young children has much to be desired. On this issue, crowded living condition is not the only culprit but other social and economic factors are implicated.

For decades, parents find it necessary for both to work to make ends meet leaving their young kids to foreign domestic helpers who have indeed become 'pillars' of our thousands of families. But there were exceptions! Estranged parents or partners from increasing number of marital disharmony confronted with babies and infants in tantrum would snap. These are the people who would commit *child abuse* or better known as *Non-accidental injuries (NAI)*. The number is on the rise especially in the more impoverished areas. This trend is not unique to Hong Kong but to all major metropolis – something that all clinicians who handle injuries in children should note.

Primary and Secondary Injuries

Primary injury refers to the trauma sustained to the central nervous system right at the time of impact. Not only is it irrevocable, it also triggers off a cascade of events due to the surge of catecholamine, a period of apnea and in turn secondary hypoxemia and hypercarbia. Anoxic injury is believed to take place within minutes even without brain cell disruption. At a macroscopic level, contusion and haematoma from the primary injury would in turn compress on the surrounding brain tissue inducing anoxic damage and swelling would ensue completing a vicious cycle. All these are termed secondary injuries neurosurgeons are trying their best to avoid and contain.

Acute Management

All the principles for Acute Trauma Life Support hold in the acute management of brain injury. Airway remaining patent, breathing regular and good circulation are of paramount importance. Hypoxia and hypotension are potent aggravating factors to secondary injury and should be avoided at all cost. First-aiders have to be vigilant to any spinal injury and unless totally ruled out, appropriate immobilisation is advisable.

A brief examination is important to identify the exact sites of trauma to the head and body and from that one would have an idea of how the injury was sustained. The mechanism of injury allows clinicians to estimate the lateralisation of coup and possible contracoup injuries. Glasgow Coma Scale (GCS) is useful not only to classify the severity of brain injury, for progress monitoring and for prognostication purpose.

Once arriving at the Accident and Emergency Department (AED), admission would be considered for those with history of loss of consciousness that usually signifies significant injury. For young children, this part of the history is not easy to ascertain and for the benefit of doubt, local policy is that these children would be admitted under neurosurgery for observation for at least 24 hours.

Severe injuries with multiple traumas require the attention of Trauma Team consisting of general and orthopedics surgeons and intensivists. If emergency surgery is indicated, the patient would have to be moved to the operation theatre directly once stabilised and the theatre staffs are ready. Or else, these patients would be transferred to the Intensive Care Unit (ICU) for monitoring and joint management.

Neuroimaging

With the advent of computed tomography, it has become the mainstay of acute trauma assessment. Patients with significant head injury will have CT at the AED. Any acute intracranial blood, bony fracture or depression would be readily revealed. If a CT was done very soon after the trauma, say within an hour or two, it is always advisable to repeat another one in 6 to 8 hours in order to pick up any delay changes such as bleeding within a contusion.

Magnetic resonance imaging is of limited use in acute trauma because of its insensitivity to acute blood. Only in selected cases that MR is of special use, such as diffuse axon injury.

Monitoring

For minor head injuries – with GCS between 15 and 12 – clinical monitoring usually suffices. Any deterioration in GCS should be respected and CT is needed for progress. For moderate to severe injuries – with GCS below 12 – ventilatory support is sometimes indicated. Sedation renders clinical monitoring not possible. Intracranial pressure (ICP) monitor is then necessary, either via an intraventricular catheter or a parenchymal sensor. The former may be technically more demanding because of the cerebral edema on the outset but it gives an additional advantage of allowing continuous cerebral spinal fluid (CSF) drainage and an effective control of intracranial hypertension.

While ICP is maintained, a good perfusion to the brain is of equal importance.

Cerebral Perfusion Pressure (CPP) =
Mean Arterial Pressure (MAP) – Intracranial Pressure (ICP)

Since CPP is our ultimate concern, it is obvious from this formula that a 'good' ICP is meaningful only when it is coupled to a good perfusion.

Medical Management

It is not within the scope of this article to discuss every aspect of intensive care for paediatric TBI except to highlight a few accepted guidelines and the level of evidence.1

Cerebral Perfusion Pressure

Level III

- A minimum CPP of 40 mm Hg

Level III

- Age-specific thresholds 40–50 mm Hg
- Infants at the lower and adolescents at the upper end of this range

Hyperosmolar therapy

Level II

- Hypertonic saline between 6.5 and 10ml/kg

Level III

- Hypertonic saline continuous infusion
- 3% saline range between 0.1 and 1.0 mL/kg of body weight per hour on a sliding scale
- Minimum dose to maintain ICP <20 mmHg
- Serum osmolarity maintained below 360 mOsm/L

Temperature Control at moderate hypothermia (32–33°C)

Level II

- beginning early after severe TBI for only 24 hrs duration
- beginning within 8 hrs after severe TBI for up to 48 hrs duration to reduce intracranial hypertension
- rewarming at a rate of >0.5°C per hour

Level III

- beginning early after severe TBI for 48 hrs duration

<u>*Hyperventilation*</u>
Level III
- Avoidance of prophylactic severe hyperventilation to a $PaCO_2$ <30 mmHg in the initial 48 hrs after injury
- If hyperventilation is used in refractory intracranial hypertension, advance neuromonitoring for evaluation of cerebral ischemia

<u>*Corticosteroid*</u>
Level II
Not recommended to improve outcome nor to reduce ICP

<u>*Drugs to control ICP*</u>
Level III
- Thiopental
- Etomidate

<u>*Others*</u>
Level II
Immune modulating diet NOT recommended to improve outcome
Level III
- Prophylactic treatment with phenytoin to reduce the incidence of early posttraumatic seizures in severe TBI

Common Clinical Examples

Cephalhaematoma/subgaleal haematoma

Quite often seen in young children or in newborns as a complication of instrumentation at delivery. Generally, the only concern is the extravasation of blood and anemia that ensues. Surgical intervention is not indicated in most cases. (Fig. 1)

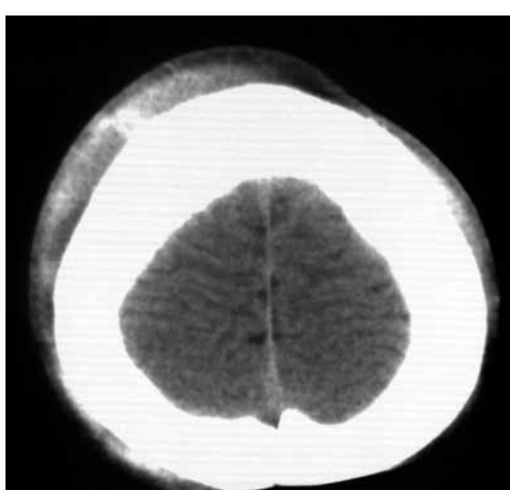

Figure 1 Cephalhaematoma - Blood clot located in the subgaleal layer of the scalp.

Depressed fracture skull

Peculiar to the soft nature of skull bone in infants, an injury to the head might not fracture and displace the fragments but only indent it, compressing the dura and the brain within. Elevation of the skull is indicated especially when the depression is more than the full thickness of the skull. (Fig. 2 and 3)

Figure 2 Depressed fracture skull

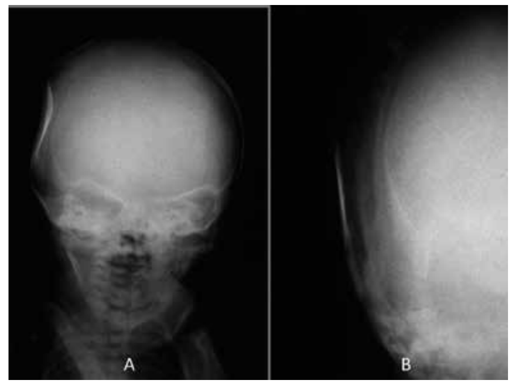

Figure 3 Skull X-ray A. before and B. after elevation of the depression.

Growing fracture

Asymptomatic skull fracture generally does not require intervention. Yet for some of these cases, the fracture line persists after a few months. Not only does it not heal, it gets wider and more extensive.

In fact it is more appropriately called leptomeningeal cyst. The sharp edges of the fracture actually punctured the dura during the injury and CSF leaked out and with the fluid system developing along the fracture, healing could not take place. Prior to the era of CT, this could not be visualised.

By the time the fracture is seen widen on X-ray, the cyst may have already undermined and grew way beyond the original fracture line and to correct it takes a lot more effort. Skull bone around the fracture have to be removed extensively in order to expose fully the dural tear and have it repaired in a watertight fashion before the skull defect be repaired, preferably with autologous split bone graft. (Fig. 4)

Figure 4 Leptomeningeal cyst A. fracture line on the outer table of the skull.
B,C. dissection in stages to define the cyst and D. the final repair prior to closing.

Thus it would be important to repeat skull x-ray after a few months to confirm complete healing. Otherwise, a CT/MR is warranted to further investigate.

Epidural haematoma

When the impact is strong enough to fracture the full thickness of the skull, bleeding from the diploe or typically the middle meningeal artery or vein results in epidural haematoma. (Fig. 5) Early diagnosis is very simple these days with CT scan at the AED and it deserves a shift response. Surgical evacuation is the mainstay of treatment. This applies particularly to epidural haematoma in the posterior fossa. Only occasionally, thin epidural that is asymptomatic could be managed conservatively.

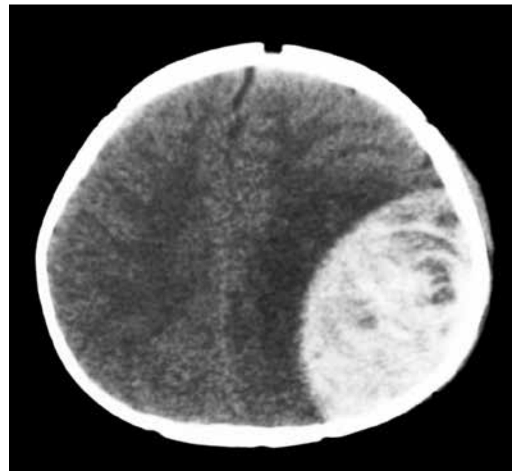

Figure 5 Epidural haematoma in a 5 month-old girl

Contusion and Intracranial haematoma

Haematoma and even contusion act as space-occupying lesion and elevate ICP. If ICP becomes too high, not well controlled with medical means, these have to be removed.

When contusion or edema is too extensive, the overlying skull bone is better removed, stored and to be replaced a few months afterward.

One thing to note for young children, infants in particular is that while craniectomy is done, the child and the brain still grow and the original skull flap might soon be insufficient to cover the defect. Therefore decompressive craniectomy should be taken with discretion for this group of patients.

Subdural collection and subarachnoid Haemorrhage

Unlike the geriatric population in which there is always a degree of cerebral atrophy, the fullness of young brains makes these uncommon solo entities in accidental trauma of children. Once this was diagnosed in a child, one thinks of or needs to exclude by all means the possibility of NAI. (Fig. 6) Generally, conservative management is preferred unless the mass effect gets out of hand.

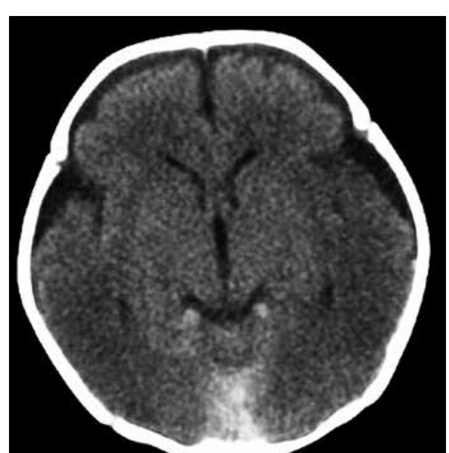

Figure 6 Subdural effusion with subarachnoid haemorrhage in a baby with NAI

Diffuse Axonal Injury

Whenever the clinical state is too poor to be explained by the CT findings, diffuse axonal injury (DAI) is suspected and MR is a better modality to confirm. (Fig. 7) Lesions are usually noted in the lobar white matter, corpus callosum and dorsolateral upper brainstem. Since these lesions are not space occupying, apart from continuous ICP monitoring, there is little role of surgical intervention. Patient is expected to take a long time for any significant improvement and rehabilitation has to commence once the acute problems are under control to avoid complication of protracted immobilisation.

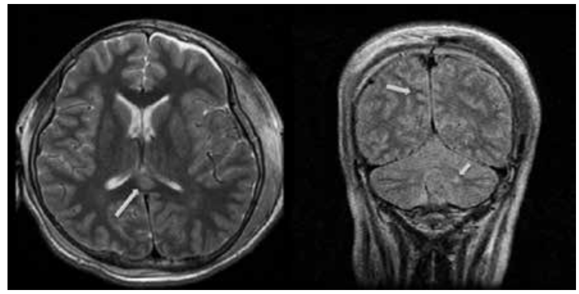

Figure 7 Multiple lesions (blue arrows) in the lobar white matter, cerebellum and corpus callosum in a patient with DAI

Neurorehabilitation

Rehabilitation takes time and neurorehabilitation takes even longer. The latter involves cooperation of a maimed brain and mind and might not even begin a few months after the trauma. Although we believe in neuroplasticity especially for young children, it demands tremendous patience from therapists, family members and caretakers. Yet prevention of deterioration and further complication is the key and it has to start in the ICU.

In severe TBI, patients are comatose and intubated. Physiotherapy to the chest and limbs is needed from the very beginning. To avoid postural deformity of immobility, splints to the ankles are very helpful. Passive mobilisation by therapists or with cycling device on bed like the 'Motomed' is very useful to keep lower limbs moving even in the ICU setting. As patients gradually awake, speech therapist would be looking at swallowing and occupational therapist the fine motor activities.

Through gradual transition, management is shifted from neurosurgeons to rehabilitation specialists. Close collaboration among medical, nursing, allied health professionals, family members and caretakers of patients and patients themselves is the only way to deliver the best possible outcome.

Conclusion

The brain is the most complex organ of the human body. Once an injury is acquired, the healing process is equally complex and recovery is all the more difficult. The importance of prevention cannot be overstated. Management of brain injury involves a team approach by various specialists from the acute phase to the months or even years of neurorehabilitation that follows.

Reference

1 Guidelines for the Acute Medical Management of Severe Traumatic Brain Injury in Infants, Children, and Adolescents-Second Edition *Pediatr Crit Care Med 2012 pp: S1-82.*

Neurorehabilitation of Children after Traumatic Brain Injury

Professor Joe Watt

Clinical Professor, Department of Paediatrics and Department of Physical Medicine and Rehabilitation, University of Alberta, Canada.

Traumatic brain injury (TBI) is a leading cause of death and disability in the pediatric age group. Causes of injury vary with child developmental age, with more inflicted injuries in infants, fall-related injuries among toddlers, sports–related injuries among middle-school-aged children and motor vehicle accidents in older children.[1]

Population estimates of head injury range from 219-345 per 100,000 per year. A recent Ontario study found male annual prevalence of 231 per 100,000 and female 123.2 per 100,000 for children 0-14. 6% of all initial admissions result in discharge to rehabilitation facility, a minimal estimate of morbidity.[2] A retrospective study from Australia of 1115 cases identified reviewed 89.1% were mild (Glasgow Coma Scale (GCS)13-15, no evidence of mass lesion on CT or MRI and no neurological deficits), 7.9% were moderate (lowest GCS 9-12, and/or mass lesion on CT/MRI) and 3.0% were severe (lowest GCS 3-8 and/or mass lesion on CT/MRI).[3] 35% of those with severe brain injury die and another 65% are left severely disabled, of which the majority suffer cognitive and behavioral disability and only the minority being severely physically disabled.[4,5,6]

It is difficult to estimate incidence of mild head injury for children as many go unreported. Systematic reviews of the prevalence of cognitive and academic sequelae following mild brain injury are contradictory. It is unclear whether or not cognitive deficits persist in children and adolescents following mild head injury.[7,8] What was once considered a "mild' TBI may lead to learning difficulties and behavioral problems in the short term and occasionally long term disability, including neuropsychiatric disorders.[9]

Rehabilitation is the process aimed at enabling people with disabilities to reach and maintain optimal physical, sensory, intellectual, psychological and social function,[10] according to the framework of the International Classification of Functioning, Disability, and Health.[11] Rehabilitation of children with acquired injury requires a family centered, multidisciplinary, and life-span program starting from the first days when the patient is still in intensive care unit. The goals are to provide brain resuscitation and function preservation, prevent medical and surgical complications and to support the family.[12]

In children with moderate to severe TBI, the nature and intensity of pediatric neurorehabilitation interventions may be influenced by the stage of recovery as well as health resources.[13] Monitoring recovery and progress of treatment is crucial in rehabilitation. A crude tool often used by adult rehabilitation specialists is the Ranchos Los Amigos Level of

Cognitive Function. This is not standardized in children and will only serve as a guideline to plan intervention at various Levels.

RANCHO LOS AMIGOS
NATIONAL REHABILITATION CENTER

THE RANCHO LEVELS OF COGNITIVE FUNCTIONING

LEVEL OF COGNITIVE FUNCTIONING	A PERSON AT THIS LEVEL WILL OR MAY:	WHAT FAMILY & FRIENDS CAN DO
COGNITIVE LEVEL I No Response	♦ be unresponsive to sounds, sights, touch or movement.	♦ Keep the room calm and quiet. ♦ Keep comments and questions short and simple. ♦ Explain what is about to be done using a "calm" tone of voice.
COGNITIVE LEVEL II Generalized Response	♦ begin to respond to sounds, sights, touch or movement ♦ respond slowly, inconsistently, or after a delay ♦ respond in the same way to what they hear, see or feel. Responses may include chewing, sweating, breathing faster, moaning, moving, and increasing blood pressure.	♦ Same approach as for Level I.
COGNITIVE LEVEL III Localized Response	♦ be awake on and off during the day ♦ make more movements than before; react more specifically to what they see, hear, or feel. For example, they may turn towards a sound, withdraw from pain, and attempt to watch a person move around the room ♦ react slowly and inconsistently ♦ begin to recognize family and friends ♦ follow some simple directions such as "look at me" or "squeeze my hand" ♦ begin to respond inconsistently to simple questions with "yes" and "no" head nods ♦ respond more consistently to familiar people.	♦ Limit the number of visitors to 2-3 people at a time. ♦ Allow the person extra time to respond, but don't expect responses to be correct. ♦ Give the person rest periods. ♦ Tell the person who you are, where they are, why they are in the hospital, and what day it is. ♦ Bring in favorite belongings and pictures of family members. ♦ Engage the person in familiar activities, such as listening to their favorite music, talking about their family and friends, reading out loud to the person, watching TV, combing their hair, putting on lotion, etc.
COGNITIVE LEVEL IV Confused, Agitated	♦ be very confused and frightened ♦ not understand what they feel or what is happening around them	♦ Allow the person as much movement as is safe. ♦ Allow the person to choose activities, and follow their lead, within safety limits. Do not force the person to do tasks or activities.

LEVEL OF COGNITIVE FUNCTIONING	A PERSON AT THIS LEVEL WILL OR MAY:	WHAT FAMILY & FRIENDS CAN DO
COGNITIVE LEVEL V Confused, Inappropriate, Nonagitated *(Continued)*		♦ Bring in family pictures and personal items from home. ♦ Reminisce about familiar and fun past activities.
COGNITIVE LEVEL VI Confused, Appropriate	♦ be somewhat confused because of memory and thinking problems. Will remember main points from a conversation, but forget and confuse the details. For example, they may remember they had visitors in the morning, but forget what they talked about ♦ follow a schedule with some help, but become confused by changes in the routine ♦ know the month and year, unless there is a severe memory problem ♦ pay attention for about 30 minutes, but have trouble concentrating when it is noisy or when the activity involves many steps. For example, at an intersection, they may not be able to step off the curb, watch for cars, watch the traffic light, walk, and talk at the same time ♦ brush their teeth, get dressed, feed themselves etc., with help; know when they need to use the bathroom ♦ do or say things too fast, without thinking about potential consequences ♦ know that they are hospitalized because of an injury, but will not understand all of the problems they are having ♦ be more aware of physical problems than thinking problems. They often associate their problems with being in the hospital and think they'll be fine at home.	♦ Repeat things. Discuss things that have happened during the day to help the person improve their ability to recall what they have been doing and learning. ♦ Encourage the person to repeat information that they need or want to remember. ♦ Provide cues to help the person start and continue activities. ♦ Encourage the person to use familiar visual and written information to help the person with their memory (e.g. calendar). ♦ Encourage the person to participate in all therapies. They will not fully understand the extent of their problems and the benefits of therapy. ♦ Encourage the person to write down something about what they have done each day.
COGNITIVE LEVEL VII Automatic, Appropriate	♦ follow a set schedule ♦ be able to do routine self care without help, if physically able. For example, they can dress or feed themselves independently ♦ have problems in new situations and may become frustrated or act without thinking first ♦ have problems planning, starting, and following through with activities	**Approach for Levels VII and VIII are the same:** ♦ Treat the person as an adult while still providing guidance and assistance in decision making. Their opinions should be respected and their feelings should be validated.

During the acute phase of recovery, excellent intensive care includes ICP monitoring, frequent positioning, alternating mattresses, central lines management, appropriate nutrition, respiratory therapy, head cooling, avoidance of hyperthermia and corneal ulcerations. There should be daily check-lists for medical complications including seizure disorder, syndrome of inappropriate antidiuretic hormone, peptic stress ulcers, hypercalcemia, seizures, hyperglycemia and hypoglycemia, deep vein thrombosis, atelectasis and pneumonia, urinary tract infections, constipation, critical illness neuropathy and myopathy, problems with nasogastric or gastrostomy feeding, complications of endotracheal tube and tracheotomy and superinfections.

There should be high index of suspicion of surgical complications, including spinal cord injuries, chronic subdural collections, hydrocephalus, growing skull fractures, cerebral edema and meningitis. Musculoskeletal complications include spasticity, contractures, pressure ulcers, heterotopic ossification and fracture. If spasticity is emerging, management of focal spasticity with botulinum toxin should be initiated immediately, even before the child leaves intensive care unit. Antispasticity medications such as Baclofen and /or Dantrolene Sodium can be initiated. Feeding avenue should be established early and splinting/casting before contractures sets in.[14]

Once the child is able to exit intensive care to a general unit, active rehabilitation will start with coma management, feeding evaluation, management of agitation/confusion and inappropriate behavior. Mobilization and establishment of communication becomes the main goals. Rehabilitation often targets sensory and motor stimulation. When coma is prolonged and arousal severely impaired, medications for improving responsiveness such as Amantidine, Zolpidem and Methyphenidate may be worth a trial.[15,16] Education of the patient and the family regarding brain injury will become ongoing. The patient is seen as suitable for intensive neurorehabilitation once medically stable, at or better than Level III on the Ranchos Los Amigo cognitive functioning. Some patients may benefit from transfer to a rehabilitation facility at this time.

During the subacute phase of rehabilitation, the focus may center on the promotion of recovery, compensation for impairment, the ongoing of acquisition of developmental skills and the adjustment of the family for disability. Multidisciplinary neurorehabilitation is often done early and intensively at inpatient or out patient rehabilitation facilities to take advantage of neuroplasticity and to influence recovery.

Physical rehabilitation techniques include constraint-induced movement therapy, bimanual training, strength training, treadmill training, virtual reality training, transcranial magnetic stimulations, motor imagery, mirror therapy, music therapy, and robotic therapy are some of the newer interventions besides conventional self-care and gait re-training. Adjunctive therapies include use of Botulinum toxin A intramuscular injections for spasticity management, orthotics and serial casting/splinting.[13]

Cognitive rehabilitation aims to promote ongoing cognitive competencies. The focus of intervention may include vision and visuospatial functioning, memory, executive functioning, cognitive-linguistic functioning, problem solving and awareness. Interventions may involve function-specific training and cognition exercises, or the use of aids and instruments to compensate for impaired function.[17]

Behavioral problems after traumatic brain injury is very prevalent. This may include attention deficit, aggression and conduct disorders, depression, anxiety, personality change.[18] Neuropsychiatric disorders is known to occur in 54-63% of children after severe and 10-21% after moderate to mild TBI, and they are related to specific brain lesions. They can include obsession, obsessive compulsive disorder, mania and hypomania besides the ones listed above.[9,19] Treatment can be very challenging because of pre-injury psychiatric disorders of the child and of his /her parents, which may have pre-disposed them to TBI. Neuropharmacology plays an important adjunctive role in the neurorehabilitation.[15,16] Goal setting with the child and family is a core component of multidisciplinary intervention, and includes education and support of the family and child regarding changed abilities and planning for the future needs.

In the chronic stage, in fact, for the rest of the child's life-span, reintegration into the child's family, school and community to maximal participation is the focus. It may require adaptation of the environment, supporting transitions in critical ages of development and education, provision of home and school therapy and periodic reviews and surveillance.[13] The current state of rehabilitation is variable across different quality-of-care indicators addressing neurobehavioral and psychosocial needs and community reintegration of the patient and the family.[20]

Rehabilitation healthcare professionals are often asked about the prognosis of traumatic brain injury. The early Glasgow Coma Scale has a linear relationship with predicting death but not as accurate in predicting morbidity. The motor component and pupil reactivity were of highest value. Intracranial and cerebral perfusion pressure predicts unfavorable outcomes (death or severe disability.) Diffuse axonal injury arising from trauma involving shearing or rotational mechanical forces tends to have poorer long term outcome. Time to follow commands was the best indication of injury severity variable as predictor of WeeFIM scores in children with moderate to severe TBI.[21] The duration of post-traumatic amnesia is helpful for predicting outcome, but is difficult to assess in intensive care settings, especially in younger children and those sedated for various reasons. In general, complications of hypoxic–ischemic insults, cardiac arrest, near drowning resulting in coma, meningitis, damage to white matter, and status epilepticus carry worse prognosis.[22] Advanced neuro-monitoring and imaging may be helpful to predict prognosis early.[23] Biomarkers have been explored for the past 15 years and may hold some promise to improve prognostication in the future.[24] Until such time, repeated neurocognitive assessments by pediatric brain injury multidisciplinary rehabilitation team, using standardized outcome measures, are the most accurate gold standards.[25] One example is executive functioning and verbal memory added to injury severity can predict behavioral and cognitive educational outcomes.[26]

Emerging evidence on the long-term functional disabilities after pediatric traumatic brain injury may be affected by pre-injury functioning, intellectual ability and family factors as well as access to interventions.[27] This supports the need to organize early and provide long term rehabilitation and follow-up, as the consequence may not be fully apparent until years after this devastating catastrophe. Prevention of traumatic brain injury in children is crucial in this common public health problem. Much more research of the cognitive, behavioral, psychiatric and social consequence of early TBI is warranted.[28]

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Children Surviving Traumatic Brain Injury – The Experience in Child Assessment Service

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Introduction

Traumatic Brain Injury (TBI) is one of the leading causes of mortality and morbidity in children and adolescence in the world. In Hong Kong, the local epidemiological data was very limited. The incidence of TBI was reported to be 1.7/ 1000 population in 2002 by Fong et al.[1] In United States in 2010, 2.5 million cases of TBI occurred. The rate of emergency department visit due to TBI was 7.15/ 1000 population and the mortality rate was 0.17/ 1000. The leading causes of TBI are fall, unintentional blunt trauma and motor vehicle crashes.[2] In Europe in 2006, the incidence rate of TBI was reported to be 2.35/ 1000 population and the mortality rate was 0.15 /1000.[3] In a recent longitudinal study in Taiwan, < 30 % of TBI patients could gain favorable outcomes at 3 years post injury (i.e. return to work with no disabling neurological or psychological deficits) and > 50% still could not recover well after 6 years.[4] TBI can cause a variety of impairments which include cognitive deficits such as memory impairments and executive dysfunctions, neurobehavioral disturbance such as disinhibition syndrome and mood problem, language impairment, motor and sensory impairment. Persistence of these impairments results in ongoing school failure in children, disruption of social and family relationship, and future unemployment in adulthood. Hence, better understanding of the long-term functional outcome of these patients is of great clinical significance.

In the Child Assessment Service (CAS) of Department of Health, the Acquired Cognitive Impairment (ACI) Team was set up in 2003. Clinical protocol in assessment and management of patients with TBI was then established. It involves assessment of these patients by a multidisciplinary team, use of standardized assessment procedures and tools, and standard follow-up workflow. Assessment and follow up points are set at the acute phase of injury (Time 1: post traumatic amnesia 6 weeks to 6 months), recovery phase (Time 2: post first assessment 1 year), chronic phase (Time 3: post second assessment 2 years), and transition points between schools and work. Interim support by therapists and clinical psychologist is provided; and appropriate referral and rehabilitation service is prescribed. Most important of all, school conference with the student support team will be held for selected patients to facilitate their school reintegration after discharge from the hospital.

In this study, we report the epidemiological and longitudinal outcome data for patients with TBI who have been referred to our service in the past ten years (2003 Oct – 2014 July). It aims to summarize our clinical experience and report the neurological, neuropsychological and other functional outcome of these patients, to define their course of recovery on various functional domains and to evaluate the clinical predictive factors for their long term functional outcomes.

Method

Participants

This study retrospectively reviewed the medical charts of patients who were referred to our service for assessment after TBI in the past ten years. The diagnosis of TBI and referrals were made by major neurosurgical teams in Hong Kong. Patients with premorbid neurodegenerative disease, psychiatric disorder, significant cognitive impairment or developmental delay were excluded. Patients with TBI due to shaken baby syndrome were also excluded due to their different and distinct clinical profile. From October 2003 to July 2014, a total of 30 patients with TBI were recruited to the present study (n=30).

Data collection

Three types of clinical data in patients' record were collected. Firstly, demographic variables including sex, age at injury and premorbid conditions were recorded. Secondly, the injury-related variables such as mode of injury, severity of injury as indicated by the Glasgow Coma Scale (GCS) on admission to hospital, the presence of intracranial lesions and cranial nerve injury were recorded. Finally, functional outcomes including neurological, neuropsychological, language, fine motor and gross motor function assessed by various disciplines were recorded.

Data analysis

Both Parametric test and Non-parametric test (Friedman test) were used to evaluate the improvement of functional outcomes with time. Statistical significance was defined as a probability value < 0.05. Commercially available software (SPSS) was employed.

Results

Demographic data:

A total of 30 patients were recruited during the ten years period. Male to Female ratio was 4:1. Age at injury ranged from 1 year 5 months to 14 years 1 month old. 50% of patients were injured at age 6 – 12, 30 % injured between age 13 – 15, and 20 % injured before age 6. Two of them have premorbid history of ADHD, and one has history of epilepsy. Other patients were reported to have good past health before the injury. For school aged children who could be assessed by formal tests (n=24), 10 patients came back for assessment for three times, 6 patients were assessed for twice (5 lost follow up after second assessment and one is pending for third assessment) and 8 patients were assessed for once only (all lost follow up after first assessment). The rest are school aged children who cannot be assessed by formal test (n=2) and preschool children (n=4).

Injury related data:

Mode of injury: 74 % of patients were road traffic accident (70% were pedestrians, 4 % were passengers of vehicles), 20 % were fall and 6 % were bicycle related accident.

Severity of injury: 68 % of patients suffered from severe head injury (GCS 3-8 on admission to hospital), 29 % suffered from moderate head injury (GCS 9 – 12), 3 % suffered from mild head injury (GCS 13 – 15).

Intracranial lesion: 67 % of patients have diffuse brain injury on admission (subdural haemorrhage, Subarachnoid haemorrhage, intraventricular haemorrhage, cerebral oedema, diffuse axonal injury, etc.), 23 % have focal brain injury (focal epidural haemorrhage/ brain contusion), and 10 % have normal MRI brain founding.

Functional outcome:

<u>Neurological and motor outcome:</u>

For gross motor function, during assessment at time 1 (T1), 33 % (10/30) of patients suffered from neurological deficit, 54 % (16/30) suffered from gross motor problem with no hard neurological sign and 13 % (4/30) have normal gross motor function.

Among the 10 patients with neurological deficit, 8 patients have hemiparesis, 1 patient has triplegia and 1 patient has quadriplegia. On subsequent follow up, 4 patients with hemiparesis resolved with residual gross motor problem, whereas 6 patients were found to have persistent neurological deficit (6/30 =20 %)

Among the 16 patients with gross motor problem, the most impaired aspect in standardized gross motor function test (Bruininks Oseretsky Test of Motor Proficiency) were running speed/ agility and balance (-1 to -3 SD). Eight patients were followed up. Three patients were assessed for twice. The other five patients were assessed for 3 times and their results were shown in Figure 1. Their mean performance score improved in all aspects on follow up, but their balance was still mostly impaired (mean score -1 SD). Two patients showed improvement to normal gross motor function on follow up.

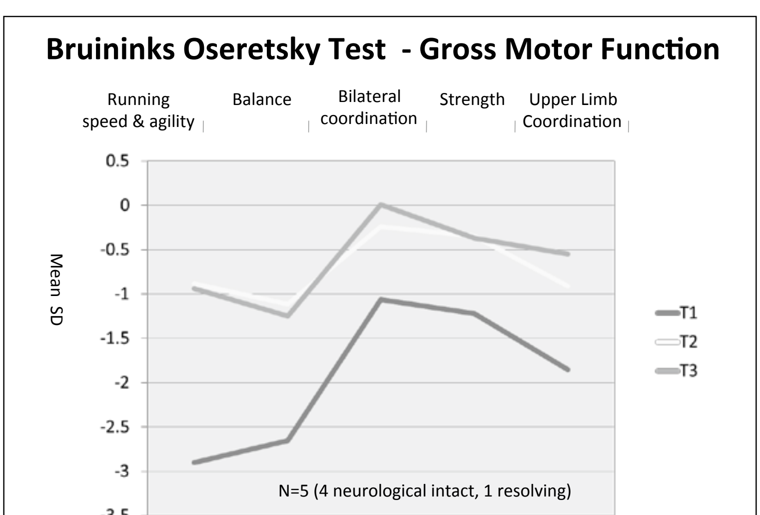

Figure 1. Gross motor function

For fine motor function, assessment at T1 showed that 33% (10/30) of patients suffered from neurological deficit, 37 % (11/30) suffered from fine motor problem without hard neurological signs, and 30 % (9/30) have normal fine motor function. Ten patients were assessed for 3 times and four patients were assessed for twice (Figure 2). The most impaired aspect in standardized fine motor function test (Bruininks Oseretsky Test of Motor Proficiency) was dexterity and response speed. On subsequent follow up, there was significant improvement in dexterity and visual motor skill (Friedman test, $p< 0.05$), but not in response speed. Persistent impairment in their manual dexterity (mean score -1 to -1.5 SD) was noted. Handwriting speed was also severely impaired at T1 but significantly improved at T2 (Friedman test, $p < 0.05$). However persistent impairment was still noted at T3 (mean score -1.5 SD).

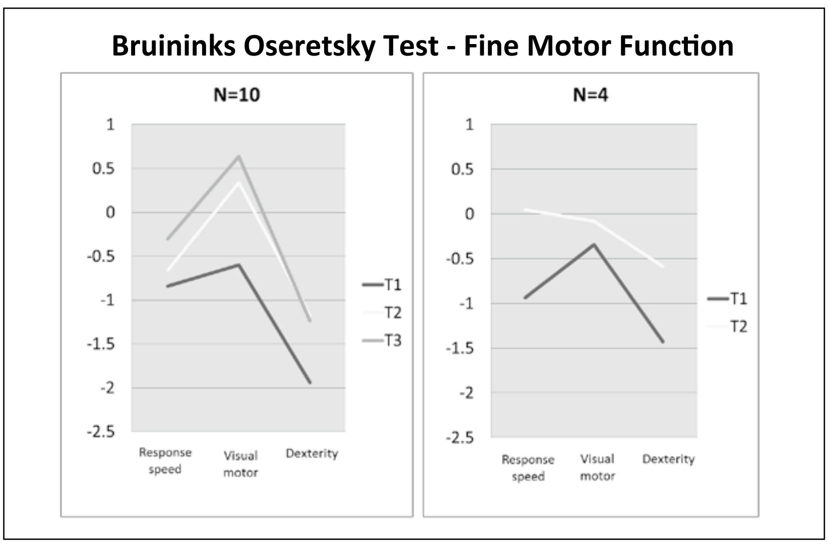

Figure 2. Fine motor function

Visual perceptual function:

Test of Visual Perceptual Skills (TVPS) was used to evaluate the visual perceptual function of these patients. During assessment at T1 in 16 patients, the visual memory (VM) was mostly impaired (Figure 3). It was assessed in 10 patients for 3 times and 6 patients for twice. There was significant improvement in mean score in all aspects on subsequent follow up (Friedman test, $p < 0.05$), but visual memory was still mostly impaired (mean score – 0.5 SD). The result indicated that these children have difficulty in handling complex visual information at the early post injury period, but showed recovery with time.

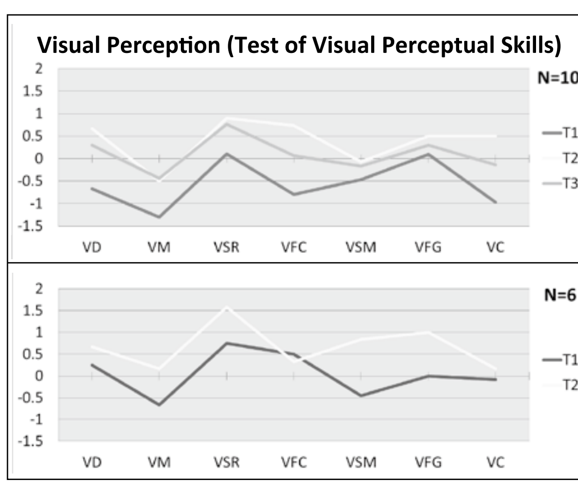

Figure 3. Visual perceptual skills

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2
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1
5

Functional memory skill

Rivermead Behavioral Memory Test (RBMT) and Contextual Memory Test (CMT) were used to identify children's functional memory skill and strategies in daily life. Ten patients were assessed by RBMT for 3 times and five patients for twice. Their mean scores improved on follow up though not statistical significant. Their mean score in CMT showed persistent impairment across T1 to T3 in both immediate and delay recall (Figure 4). They possessed limited strategy to aid their daily memory function (e.g. association, grouping, location, rehearsal and visual strategy), which result in persistent functional impairment in this aspect.

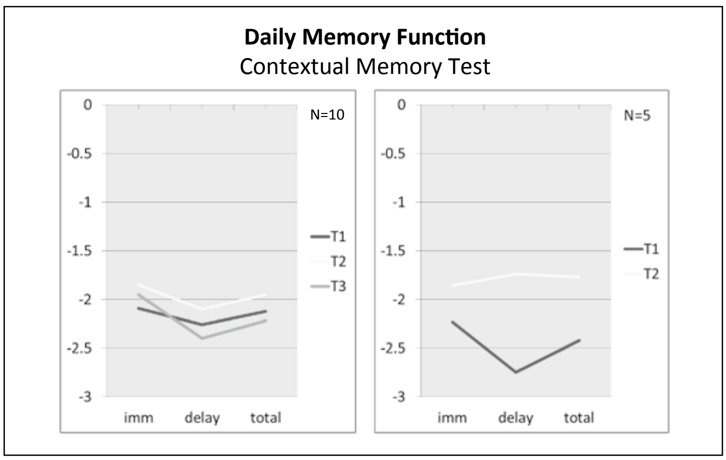

Figure 4. Daily memory function

Neurocognitive function

Intellectual function

The HK Wechsler Intelligence Scale for Children (HK-WISC) was used to assess intellectual functioning in school age children. The test provides three separate IQ scores: a Verbal IQ which measures verbal intellectual function, a Performance IQ which measures non-verbal intellectual function, and a Full Scale IQ. During assessment at T1, 34 % (10/30) of patients showed average intelligence, 20 % (6/30) have low average intelligence, 20 % (6/30) have limited intelligence and 14 % (4/30) have mild / moderate grade intellectual disability. Four patients were preschool children and they were found to have developmental delay on assessment by Griffith Mental Development Scales (Figure 5).

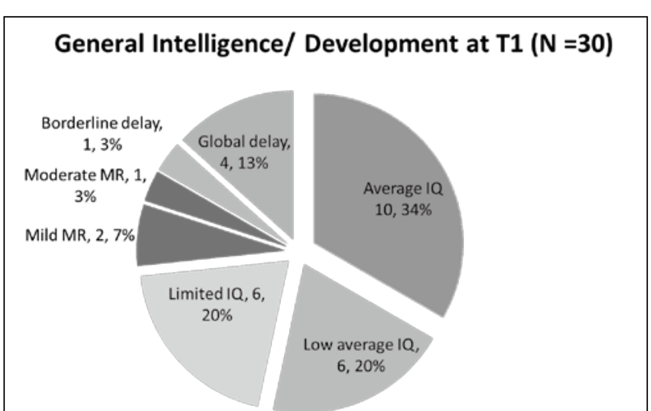

Figure 5. Neurocognitive outcome

The intelligence of eight patients was reassessed at T2 and T3. There was notable gain in their Performance IQ from T1 to T3 (mean score increase from 82.85 to 96.29), whereas their Verbal IQ remained similar across time (Figure 6). This is in line with the world literature that Performance IQ of patients with TBI improved with time due to gradual improvement of their processing speed.

The Hong Kong Wechsler Intelligence Scale for Children

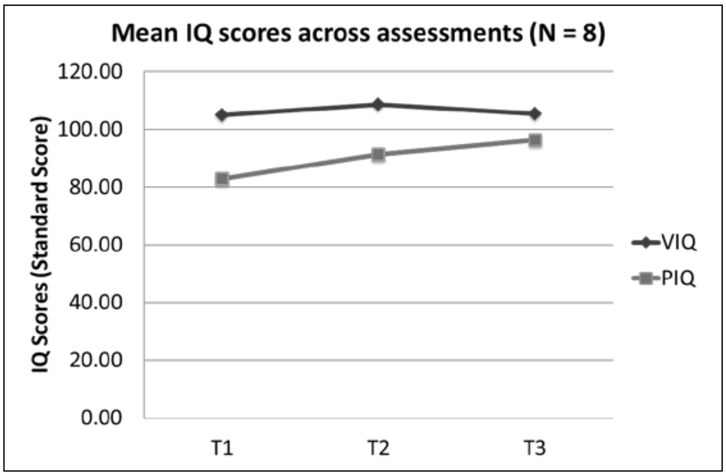

Figure 6. Intellectual functioning

Verbal memory

The HK List Learning Test 2nd Edition (HKLLT) was used to evaluate the patient's verbal learning and memory. For verbal short retention (10 minute delay recall), assessment at T1 showed a z-score of -1 to - 3 SD below mean in 11 out of 13 patients assessed, and the result was similar on reassessment at T2. For verbal retrieval (30 min delayed recall), assessment at T1 showed a z-score of -1 to -3 SD below mean in 10 out of 12 patients assessed, and the result was again similar on reassessment in T2. Only 8 patients were assessed at T3 and 7 of them have persistent memory problem. This signifies that verbal memory problem persisted with time in our patients.

Visual memory

Visual memory was assessed by the Rey Complex Figure Test and Recognition Trial (RCFT). The test requires the patient to copy a complex figure on paper, immediate and delayed recall by drawing it and recognize its pieces on delayed recall. Although some improvement in mean T score was noted with time, persistent impairment (T-score < 40) was noted in the immediate, delayed recall and recognition tests which signify persistent impairment in visual memory in majority of our patients.

Processing speed

Processing speed (visuo-motor) was assessed by a paper-pencil coding subtest in the HK-WISC test, which assessed the ability to learn new visual material associatively, and to reproduce with speed and accuracy. Fifteen patients were assessed for twice and eight patients were assessed for 3 times. Although their mean standard score improved from 5.4 to 7.75 from T1 to T3, it did not reach statistical significance and the score was still at deficient level at T3 (defined by standard score =< 7). This trend of improvement of processing speed with time is consistent with the world literature that processing speed of patients with TBI improves with time. However there was still persistent impairment when compared to the general population.

Attention and other neuropsychiatric problem

Attention problem was assessed clinically, supplemented by information from questionnaires to parents and teachers, and a computerized test on the children's sustained visual attention (Conners' Continuous Performance Test-II - CPT-II). During assessment at T1, 40 % (12/30) of patients were found to have attention problem +/- hyperactivity. Among them, one patient also has comorbid Oppositional Defiant Disorder and another has mood problem with psychotic symptoms. All patients were referred to the school student support team for behavioral and learning support, and 17 % (5/30) of patients warranted referral to Child and Adolescent Mental Health Service for further treatment.

Language and Speech Function

Language skills were assessed by formal assessment tools including Reynell Developmental Language Scales (RDLS Chinese version 1987) for preschool children and the HK Cantonese Oral Language Scales (HKCOLAS 2006) for school age children. Informal clinical tests were done for school age children before the publication of HKCOLAS and for children age > 12.

During assessment at T1, 46 % (14/30) patients have moderate language impairment or worse, 27 % (8/30) have mild impairment and 27 % (8/30) have normal language ability. Speech disorder/ dysarthria were noted in 20 % (6/30) of patients. During reassessment in T2 (n=14), 5 patients showed improvement (3 patients improved from moderate impairment to mild impairment, 2 patients improved from mild/ moderate impairment to normal), 5 patients showed persistent impairment in the same level, and 4 patients continued to be normal. Eight patients have been assessed by the HKCOLAS test for 3 times (Figure 7). It showed that these patients were most impaired in their Narrative Test (test on story retelling skill) followed by Lexical-Semantic Relations Test (test

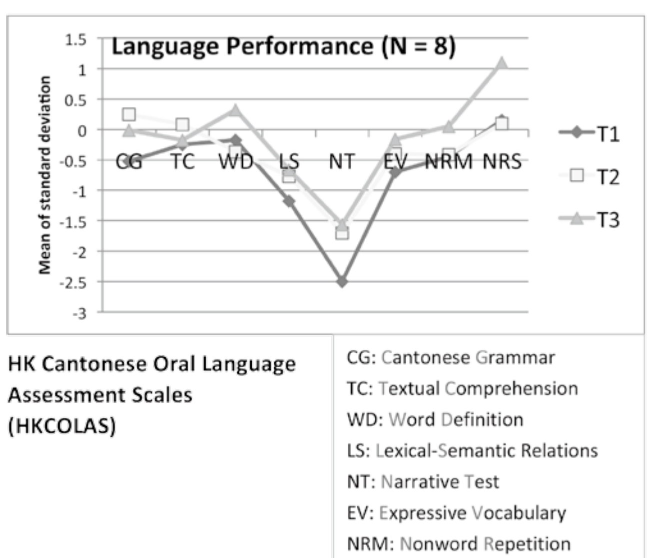

Figure 7. Language performance

on the knowledge between a word and its meaning). On subsequent assessment at T2 and T3, their mean scores improved in all aspects but narrative skill was persistently impaired. For speech disorder, majority of the patients remained in the same level on follow up (10 remained normal and 4 remained dysarthria), but two patients improved from dysarthria to normal.

Discussion

In this review, half of our patients suffered from head injury during the age of 6-12 years with male predominance of 4:1, which is compatible with overseas report of male predominance. Majority of our patients suffered from road traffic accident and less with fall, which are also the two most common causes of TBI. Around 90% of our patients suffered from moderate to severe head injury and majority of them suffered from diffuse brain injury. This shows that only patients with moderate to severe head injury were referred to our service for assessment and follow up, while the outcome of patients with mild brain injury is largely unknown.

In this review, we found that majority of our patients showed good neurological outcome. Only 20 % of them have persistent neurological deficit, but more than half have persistent gross and fine motor problem. Their running speed, agility and balance were mostly affected, which showed improvement with time. Their fine motor function improved significantly with time, but dexterity and handwriting speed were persistently impaired. Their visual perceptual function also showed good recovery. This is compatible with some overseas reports on the good motor recovery of these patients,[5] but they may have persistent deficit in balance and gait speed.[6] Their persistent deficit in strength, agility and coordination also affect their participation in sports and other physical activities.[7] The motor weakness in patients with TBI is characterized by a low incidence, decreased severity, long recovery time, and good motor outcome when comparing with cognitive or behavior problems following TBI.[8]

On the other hand, the neurocognitive function of our patients recovered less well when compared to their motor function. General intelligence was not a good representation of their overall neurocognitive function, although improvement in Performance IQ was noted as a result of improvement of their processing speed with time. Their persistent impairment in verbal and visual memory, and daily memory function caused the biggest impairment in their neurocognitive ability and daily function. Attention problem was common and occurred in 40 % of our patients. Majority of them required further behavioral and educational support in school.

The clinical outcome in this review echoed with the world literature on clinical outcome of patients with TBI. In a meta-analysis of literature on neurocognitive outcomes after pediatric TBI,[9] significant impairment in intellectual function, executive skills (including processing speed, attention, fluency, inhibition and problem solving skills), and verbal and visual memory were found in patients with moderate to severe TBI. During chronic phase, substantial recovery in intellectual functioning (PIQ > VIQ), small to moderate recovery in processing speed, working memory and visual perceptual function were observed. Children with moderate TBI showed modest recovery in intellectual functioning and attention but failed to catch up with their peers, whereas children with severe TBI fell farther behind their peers over time. This may be due to injury consequences together with lack of adequate learning opportunities, medical treatment and rehabilitation (the "double hazard" injury model).

Language impairment occurred in 73 % (22/30) of our patients which improved with time, but narrative ability was persistently impaired in some patients. Speech disorder also developed in 20 % (6/30) of patients due to oral muscle weakness and incoordination. Communication deficits are common among patients with TBI. They may have difficulty in understanding or producing speech correctly (aphasia), slurred speech consequent to weak muscles (dysarthria) and/or difficulty in programming oral muscles for speech production (apraxia). They may have problem in understanding both written and spoken language. Social communication, such as turn taking in conversation and topic maintenance, is difficult in some patients.[10] Impairment in discourse processing are commonly found in patients with TBI[11,12] Discourse processing includes event reporting, storytelling and conducting conversation, which is assessed by the narrative test in HKCOLAS. It is mostly impaired because a lot of cognitive and linguistic skills are involved, and they are mostly impaired in this group of patients.

Researchers have identified several factors that can predict outcome following TBI.[13] Injury related factors which predict poor outcome include severe diffuse brain injury, posttraumatic amnesia more than 2 weeks, secondary brain injury due to raised intracranial pressure, hypoxia/ ischemia, fever and seizure. Demographic predictors of poor outcome include young age at injury, presence of cognitive disability and behavioral problem prior to injury, lower socioeconomic status and poor family functioning. Post injury predictors of good outcome include individualized rehabilitation interventions that are embedded in naturalistic environment of the child; using basic antecedent management strategies and external structured support to improve cognitive, behavioral and executive function; and training in metacognitive, behavioral and direct instruction strategies to improve memory and executive function. Integrated and multidisciplinary assessment and coordination of care improves parents' understanding, functional outcome and overall quality of life. Specific neuropsychological deficits (executive function, attention, memory) and poor school performance post injury are related to poor long term social functioning, quality of life and employment problem.[14] Poor family functioning also predicts family stress and child behavioral problems.

Due to the small number of patients reviewed in this study, the fact that majority of them suffered from moderate to severe TBI and short follow up time, no correlation can be found between their severity of TBI and long term clinical outcome. Moreover, our measurements only include domains that could be quantified by standardized test results. Hence, methods that can systematically capture child's academic and daily function, emotional and behavioral function, and quality of life will be highly valuable in our future assessment and follow up protocol.

Conclusion

This study reports the epidemiology and clinical outcome of our patients with moderate to severe TBI. Majority of our patients have satisfactory neurological outcome, but most of them have persistent deficits in neurocognitive, psychological, motor and language function. These deficits affect their academic, social and daily function, and long term quality of life. A multidisciplinary team assessment and coordinated care, and individualized rehabilitation intervention are necessary to improve the long term outcome of this group of patients.

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Children and Adolescents with Traumatic Brain Injury: Collaborative Team Approach in School Reintegration Program

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Abstract

Children and adolescents sustain moderate and severe traumatic brain injuries (TBI) have unique challenges after discharging from hospital back to their home, school and community. There is usually a communication gap between hospital and school setting in traditional medical model. Under the International Classification of Functioning, Disability and Health (ICF model) in 2001, rehabilitation plan of these patients should emphasize on their participation and involvement in different life situations.[1] Therefore, the Acquired Cognitive Impairment Team in our service has established a comprehensive School Reintegration Program for students with moderate to severe traumatic brain injury. It plays an important role in enhancing successful participation these students in school and community.

Introduction

Patients who sustain moderate to severe traumatic brain injuries (TBI) present unique challenges to rehabilitation and school professionals. TBI occurs when an external force causes either transient or permanent impairment in the brain's ability to regulate physical, cognitive, emotional, or behavioral functioning.[2] For each patient, the nature of impairment is affected by many factors, such as the mechanisms of injury, the brain area affected, and the severity of injury. In addition, the patient's pre injury characteristics, such as age, developmental level, academic achievement, and behavioral adjustment interact with the brain injury itself to determine the patient's initial presentation and long term outcome.[3] Traditionally, children and adolescents with TBI are discharged from hospital once they are medically stable, and return to home and school when appropriate. However, there is frequently a communication breakdown between hospital, families and school. Regardless of the etiology, severity level, or progress made in acute care, these patients and their families have limited experience in taking care of their new selves and planning for their rehabilitation. The school professionals also lack understanding of the patient's problem and have limited experience in teaching students with brain injury. As a consequence, many of these patients lack motivation to go back to school, not able to catch up with their schoolwork and fail to finish their schooling.

In view of these problems, the Acquired Cognitive Impairment team in our service has established a comprehensive School Reintegration Program for these patients using a multidisciplinary approach. There are four phases in this program, including a preparation phase, going back to school phase, on-going monitoring phase and transition phase.

Because of the broad range and complexity of impairments of these patients, a multi-disciplinary team approached is necessary. In our service, our team includes Paediatrician, Health nurse, Clinical Psychologist, Occupational Therapist, Physiotherapist, Speech Therapist, Optometrist, Audiologist and Social worker. When we receive a referral from hospital team, our nurse will arrange an appointment to see the parents to obtain preliminary information on the medical problem and current function of the patient. A case coordinator will then arrange a comprehensive team assessment for the patient based on he/her needs.

Preparation Phase: before discharge from hospital to home

Since the medical problem and functional impairment in each patient is unique, there is no standard approach to assessment and rehabilitation. However, useful guidelines do exist. Assessment should be individualized and aims to enhance the medical, physical and mental recovery of the patient. It gives us information on the baseline function of the patients, including sensory, motor, cognitive, language, behavioral and family functioning. It can also help us to document the improvement in function and identify the types of intervention that are useful at home and in school. We should also assess the environmental, social and motivational factors that influence patients' functioning.[4] Last, but not the least, the assessment results contribute to the development of Individualized Education Program (IEP) for the patients at the time of discharge.[5,6]

After assessment by our team, we will conduct a team conference aiming to gather and integrate all assessment findings and formulate a school reintegration plan for the patients. We will also find out their strength and weakness which can help to predict their school functioning. A multi- disciplinary conference with the patients and their families will be held to discuss the patients' strength, weakness and potential recovery trend. Based on the above information, the team will recommend a suitable school placement for the patients and come into consensus with them and their families. They may be recommended to go back to their original school with/ without special support services, or go to a special school that suits their needs. During disclosure, the team should be very careful and be prepared to address any acceptance problem, especially for those who need to change to special school.

Going back to School Phase

In this phase, the case manager will organize a multi-disciplinary school conference including key members of our team, the school team, Educational psychologist from the school or Education Bureau, the patients and their parents. Prior consent from the parents and their patients on disclosure of the patients' condition should be sorted. The school conference aims at (1) Disclosure of current function of patients, (2) Teaching the teachers, (3) Discussion on school accommodations, (4) Educating their peers, (5) Preparing the patients to return to school. The details are elaborated as follow.

(1) Disclosure of current function of patients

The first crucial domain to disclose and explain to the school personnel is the medical and health conditions of the patients. The medical problems associated with TBI are numerous.[4] Immediately following brain injury, these patients require immediate, intensive medical care to prevent complications. After they are medically stable, they will receive different professional interventions, including nursing care, occupational therapy, physiotherapy and speech therapy. Upon discharge from hospital, they still have numerous residual medical problems including seizure, irritability, fatigue, headaches, respiratory problems, hormonal changes, and bowel or bladder incontinence.[7]

The second crucial domain is about the cognitive function of the patients. These patients are at risk of persistent impairment in cognition, which is broadly defined as all mental processes and systems involved in acquiring and using knowledge.[6,8] Under this definition, cognition comprises three areas: (a) basic psychological process (i.e., orientation, attention, perception, language, memory, and abstract reasoning), (b) component systems (i.e., working memory, long term memory or knowledge base, response modalities and executive function of initiating, planning and organizing); and (c) integration of these abilities to produce a functional performance that is age appropriate and efficient.[4] Deficits in these areas of cognition frequently occur in patients with moderate to severe TBI.[9,10,11] Problems most frequently reported are attention, memory, speed of processing, reasoning and problem solving, and executive function.

The third domain is on speech and language functioning of the patients. The typical linguistic deficits are: impaired language comprehension, abstraction and making inferences, difficulty with acquisition of age appropriate receptive and expressive linguistic skills, impaired ability to express complex information, problems in word fluency, word retrieval and dysarthria.[12,13,14]

The fourth domain is on the sensorimotor functioning of the patients. Patients with TBI may have visual deficits such as hemianopia, diplopia, blurred vision and even cortical blindness.[15] Some patients may have visual perceptual deficits.[16] Besides, many patients may have fine and gross motor problems. Those motor problems may result in decreased mobility, impaired balance, decreased activity tolerance, fatigue, general weakness, slow handwriting and poor self-care activities skills.[17]

Lastly, we should disclose the behavioral function of the patients. Change in adaptive behavior of these patients is common.[18] Social problems with peers and family members tend to be their most persistent problem.[19]

(2) Teaching the teachers

One of the main obstacles to successful reintegration of patients in school is the lack of teachers' training. Teachers need more information and knowledge on the medical problems and functional impairment of these patients, their possible recovery trend, potential problems faced by the patients and possible way to avoid, minimize and handle them in school. There is a widespread misperception that students with TBI having learning difficulties are like students with specific learning difficulties, and their attention problem are like those of students with attention deficit disorder. While their superficial symptoms may be similar, their pathophysiology and need for rehabilitation are different. Therefore, it is important for us to explain to the school personnel on the underlying problem and unique characteristics of these patients.

(3) Discussion on school accommodations

Patients with TBI required various accommodations based on their current function in different aspects. Our team would recommend remedies and accommodations in all areas including physical, sensory, cognition, learning, language and communication, and adaptive behavior. The discussion may include the timing to start school, duration of schooling, changes in enrolment status, subject load, subject type, teachers' and peers' assistance, special arrangement for assessment and examinations, environment modification and facilities that are required to support the patients, and whether they need an Individualized education plan (IEP).

(4) Educating their peers

After getting the consent from patients and their parents, our team would recommend teachers to educate the peers on difficulties faced by the patients and their need of help from teachers and peers.

(5) Preparing patients to return to school

Prior to their return to school, the patients should build up a regular daily routine and prepare to catch up with the school work during their absence. Socially, they should try to practice to explain to peers what has happened to them and why they would need assistance. The patients and their families are also encouraged to participate in community self-help group (e.g. Hong Kong Brain Injury Association for the Youth) so as to gain social support during this critical period.

Ongoing Monitoring Phase

After initial school conference and return of patients to school, the case manager would communicate with the school representative regularly on their progress. Based on the improvement of patients, the previous accommodation should be modified. It includes the length of schooling, school work load, participation in physical education lesson, level of teachers' and peers' assistance, etc. The patients, their parents and teachers should also participate in the discussion so as to gain better mutual understanding and arrive at a consensus.

Transition Phase

Following a traumatic brain injury, patients would go through different transition phases including transition from one school grade to another, transition from elementary to middle school, and then high school. Beyond that, the student will transit to post-secondary education, employment and community living. Our team may need to reassess the patients at critical points, and give further recommendation on school placement, accommodation, examination allowance and vocational training. We try to work with other partners in the hospital and community in order to provide transitional service for patients entering adulthood. Our occupational therapist will advise on prevocational and vocational training and liaison with other service providers to provide job opportunity for them. Many patients also suffer from psychological and psychiatric illness, which requires the input from our clinical psychologists and further referral to adult psychiatrists. Our experience is that ongoing support of these patients and their families is of paramount importance in their successful rehabilitation.

Conclusion

There are four phases to assist children and adolescents to go back to their school and community after the impact of brain injury. They include (1) Preparation phase before discharge from hospital to home, (2) Going back to school phase, (3) Ongoing monitoring phase and (4) Transition phase. Patients with TBI will face different challenges in each phase. A successful school reentry program should adopt a multi-disciplinary and inter-disciplinary approach so as to address the functional impairment of these patients in various aspects.

Our team has established a comprehensive School Reintegration Program which serves to bridge the rehabilitation gap between hospital, school and community. With this effort, it is hope that the school and community can understand the need of these patients better, more efficient rehabilitation interventions can be carried out in a coordinated manner among different parties, and ultimately contributes to the successful rehabilitation of these patients.

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Assessment and Rehabilitation of Speech and Language Impairment in Children and Adolescents with Traumatic Brain Injury

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Introduction

Children and adolescents with Traumatic Brain Injury (TBI) is a very diverse population. No single or even multiple formal tests can adequately assess their speech and language function. They may have head injury to different area of their brain with different severity. Injury to the same location of brain may result in different skill deficits in different children.[1] For those children with mild head injury, most often they seem to recover well with no apparent need of further assessment and rehabilitation.[2] However for those children with moderate to severe head injuries, especially those with diffuse involvement, they have many cognitive processing problems which affect their overall functioning in everyday life. Their speech and language is commonly affected to a certain extent, ranging from minor subtle problems to severe impairment in verbal comprehension and expression.

For adults, speech therapist can assess the aspects of picture naming, orientation to time and place, memory of written sentences and pictures, calculation ability, praxis (e.g. imitation of gestures) and visual fields. For children, speech and language skills are developing from birth till adulthood. In Hong Kong, we only have a few standardized language tests for paediatric population, let alone a standardized test for assessment of patients with TBI. Therefore, formal tests, informal tests and clinical observation are all used to assess this group of patients.

Formal language tests

Overseas

Tests for the presence of aphasia include:

- Minnesota Test for Differential Diagnosis of Aphasia (MTDDA): A comprehensive assessment in all language modalities such as reading and writing, speech and language.
- Porch Index of Communicative Ability (PICA): It tests four language modalities, object manipulation, visual matching and copying abstract forms. It provides a measurement of the degree of deficit and amount of recovery.
- Boston Diagnostic Aphasia Examination (BDAE): It helps in the diagnosis of aphasia, leading to inferences concerning the location of brain damage. It includes test on auditory comprehension, self-initiated and conversational speech, word retrieval and repetition.
- The Token Test for Children: A test for auditory comprehension.
- Word Fluency test
- The Children's Aphasia Screening Test: It comprises of tasks of object and picture

matching and identification, confrontation naming and serial speech.

- Clinical Evaluation of Language Fundamentals-Revised, Peabody Picture Vocabulary Test-Revised and the Boston Naming Test are also used in the assessment of children.[3]

Hong Kong

In Hong Kong, the Cantonese version of the Western Aphasia Battery (CAB) has been reported by to be widely used in adult services.[4] This is a Cantonese aphasia test battery with quantitative criteria for assessing the linguistic skills of spontaneous speech, auditory comprehension, repetition, naming, reading and writing.[5] It can be used in adults with aphasia but not suitable for children.

For paediatric population, the Reynell Developmental Language Scales (2nd edition, 1987) for preschool children and HK Cantonese Oral Language Assessment Scales (1996) for school aged children are commonly used. When children with TBI become medically and physically stable, standardized assessment should be used to identify their level of ability and areas of difficulty. No battery of test can assess all the language problems of these patients. The effects of cognitive stress on language comprehension and expression (e.g. the demands of speeded performance and organization), the ability to process linguistic abstractions, the ability to maintain effective communication in different social contexts and the ability to learn new things should all be considered in the process of assessment.[3]

What aspects should we look at?

Presence of apraxia

Though verbal apraxia is commonly known a developmental phenomenon, it may occur after brain injury which affects motor planning and speech production. It reflects a high level of damage to the nervous system as shown by the incoordination of articulation.[6]

Presence of dysarthria

Dysarthria is a motor speech disorder characterized by a slurred, indistinct speech affecting effective communication. It is often associated with TBI in children. Five major components of speech production are affected including respiration, phonation, resonance, articulation and prosody.[7] Different type of dysarthria occurs in different children, but the breath control for speech, voice quality, articulation and the prosody of voice may all be affected.[2] In a study of children with TBI, there was a marked variability in speech outcome, which emphasize the need for a full perceptual and physiological assessment of the speech apparatus of children with dysarthria following TBI.[7] One should also provide appropriate individual tailored treatment program for these children with realistic treatment goals. When traditional treatment methods do not work, compensatory techniques such as Augmentative and Alternative Communication should be considered.

Presence of Language impairment/ Aphasia

Differential diagnosis

During assessment of these children, it is important to assess whether their language impairment is due to aphasia following brain injury and whether they have developmental language delay prior to the injury. Poorer premorbid functioning was reported to predict an increased likelihood of persistent deficits in children.[8] Therefore, detailed case history should be obtained to support the diagnosis of aphasia as well as the type and severity.

Definition of Aphasia

Aphasia is the reduced capacity to interpret and formulate language symbols following an injury to the language center of the brain, most commonly located in the left hemisphere of majority of people.[9] Aphasia syndrome occurs although it is not common in children with TBI.[3]

Assessment

During the initial stage of assessment, one should look at the functional communication skills of these children including their verbal and nonverbal responses to simple conversational speech. More structured assessment can be done later, such as pointing to familiar objects or pictures on request, and following simple instructions or a sequence of requests.

Subsequently, we should assess the following speech and language difficulties which are common in children with TBI:[2]

These children may undergo an initial period of mutism which they appear unable to use spoken language, and often unable or reluctant to communicate even with alternative methods. A reduced speech initiative may be present. Although they are able to speak, they lack the motivation. For example, they may give short or monosyllabic answers to direct questions, refuse to spontaneously initiate speech but may repeat phrases on request.

Dysfluency may be found in their earlier phases of recovery. Typically, their spoken language is slow and effortful, and lacks the normal features of speech.

The syntax of speech is simplified when they use more spoken language. It may appear as a simplified form of language with sentences similar to those made by younger children. They tend to use content items and omit function words and word-endings which affect the grammatical structure of the sentences. Word-finding or naming deficits are also common. Although receptive language skills are often impaired in patients with severe TBI, they are less obvious in the assessment process.

Assessment of discourse is another critical component. Common elicitation tasks include describing single or sequential pictures, reporting procedural events, telling or retelling stories, and conducting monologues or conversations.[4] Discourse processing is impaired in many children with TBI as it requires both the input of linguistic and cognitive abilities such as attention and memory.[10] Clinicians should select client-relevant stimuli when probing for language samples. It has been widely reported in cross-linguistic studies that culturally inappropriate pictures, topics, or stories can affect the validity of the assessment.[4]

Assessment of pragmatic and social skills is also very important. Effective assessment depends on observation and analysis of conversation and social interaction in naturalistic contexts with typical communication partners.[9] Pragmatic skills can also be assessed by structured observation using pragmatics ratings scales,[11] profiling communication behaviours,[12] conversational analysis of transcripts of naturalistic communication samples[13] or using elicitation tasks.[14] Adults with TBI was reported to show insignificant improvement in their conversational abilities with time and made more pragmatic errors when compared to the controls.[13] Children with TBI was reported to have more difficulty in understanding indirect speech acts (e.g. irony and empathy) but not in direct speech acts when compared to age and gender matched children.[15]

Reading and writing difficulties are also common. They occur in those patients who have made apparent good recovery in other aspects.

Rehabilitation

Many of the techniques used in intervention for children with TBI are similar to those employed for students with language-learning disorders. It is because the cognitive and communicative patterns in these children are similar in many ways.[16]

Techniques that can help to reintegrate this group of children in community and school include:

- Plan small-group activities to help in development of interaction skills
- Pause when giving instructions to allow extra processing time
- Give extra time to respond in view of their slow processing speed
- Arrange a classroom “buddy” to help them to keep on top of instructions and assignments
- Consider use of assistive devices when need e.g. computer, calculator
- Modify assignments by reducing the number of questions and amount of reading materials

Training on discourse production: Jointly-produced discourse (with a familiar communication partner) is found to be more effective than monologue discourse in facilitating the participation of these patients in everyday life.[17] They were able to produce more informational content in their narratives when facilitated by their friends. However it did not help in the productivity (producing more words) and cohesion of narratives. Therapist can also use videotapes to teach pragmatic skills such as gaze and paralinguistic skills by asking these children to observe and rate the behaviors they see in the tape. Structured discourse training sessions can also be held. Routine speech acts such as greetings, introductions, requests for repetition and clarification can be modeled and practiced. Less routine speech acts such as requesting, describing, suggesting, negotiating and expressing feelings in controlled settings can also be taught.[16]

Therapy of pragmatic deficits may adopt approaches of individualized communication skills training, group interventions, and building and enhancing social networks that are more acceptant towards these group of patients.[9]

How can carers or significant others help?

Emotional and physical support by significant carers is extremely important in the recovery of these children. Carers should have a comprehensive understanding of their child's problem, to empathize and to have a correct attitude towards the child's disability. Moreover, the carry-over of training focus to daily living could only be conducted by carers at home and in school. They should learn adequate communication strategies and use appropriate conversation skills to facilitate their child's attempt in making effective conversation with others.

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Physical Assessment in Children and Adolescents with Traumatic Brain Injury

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Introduction

Traumatic brain injury (TBI) is the most common form of acquired brain injury, and is the leading cause of death and neurological disability in children. The recovery after TBI can be striking but very difficult to predict.[1] It is a heterogeneous group and varies a lot in outcomes which can range from persistent vegetative states to significant physical and cognitive disabilities that disrupt learning and social participation of a person.[2,3]

Assessment of physical abilities is fundamental to the rehabilitation planning and outcome documentation for a child or adolescent with TBI. Motor recovery varies greatly. Many have good recovery with less obvious motor deficit which therefore is considered a less pervasive problem than cognitive and psychological deficits.[1,3] Though a majority of children regain independent ambulation, studies showed that children with severe TBI had decreased balance performance, decreased gait speed and increased variability of step length as compared to healthy age matched children.[4,5,6] It was also found that deficits in strength, agility and coordination persisted 4 years post injury, which limited the participation of children suffered from TBI in sports and other physical activities.[7] Besides, they frequently complain of fatigue and decreased functional walking capacity and endurance.[8] A simple test that is sensitive to the physical and cognitive constraints unique to TBI, reliable and responsive to change in the patient's endurance capacity is lacking.[9] Hence, various physical assessment scales were developed for patients with TBI to assist therapists in assessing their specific motor problems, selection of therapy goals and interventions, monitoring of progress and as an indication of program outcomes.

The Community Mobility Assessment (CMA)

CMA is a multi-dimensional mobility scale developed for TBI, measuring aspects of mobility that have greater cognitive requirements, such as ability to safely cross a road with and without pedestrian lights, ability to catch public transport, ability to follow maps, signs, instructions etc.[10] High level of mobility is important for many leisure, sporting and social activities. Mobility scales that focus on the functional aspect of mobility are multi-dimensional, which means that they quantify mobility across a wide range of everyday situations that require inputs from other dimensions apart from motor abilities. However, CMA is able to identify a functional mobility restriction but not able to identify whether it is owing to motor problems specifically. Hence, there are limitations using CMA for patients with TBI.

The High-level Mobility Assessment Tool (HiMAT)

HiMAT was developed to quantify motor performance in TBI patients.[11,12] It was to test motor performance alone rather than the integration of motor, cognitive and behavioral control mechanisms required for functional mobility, and the content validity and discriminability were tested to be high.[12] It consists of nine distinct items which generate 13 scores, which takes about 5 to 10 minutes to administer. The equipment required are minimal, namely stopwatch, tape measure, house brick, a 20 meter walkway and a flight of 14 stairs.

Traditionally used mobility assessment tools may not be able to capture the balance problems in mild TBI patients owing to the ceiling effects. A study used HiMAT as an outcome measure of balance and mobility problems in patients with mild TBI, showed satisfactory measurement properties, except that there were some ceiling effects on the stair walking items. The most challenging items tested are skipping, running and hopping.[13] However, HiMAT lacks integrated multidimensional dynamic tasks such as reversing direction quickly or integration of the use of upper limbs. No quality of movement patterns is considered.[14]

The Acquired Brain Injury-Challenge Assessment (ABI-CA)

The recovery of advanced motor skills for participating in sporting and recreational activities is an important goal in rehabilitation of children and adolescents after TBI.[15] The underlying components of advanced gross motor skills include balance, postural control (both static and dynamic), coordination, speed and agility, and strength. Advanced motor activities include running, hopping, jumping and reversing directions quickly as well as skills which required combined use of arms and legs together, such as running to catch a ball or jumping with a skipping rope.[15]

ABI-CA was developed for outcome evaluation of high-functioning school aged children and adolescents with TBI and other acquired brain injury. A pilot study was done for item generation and item selection.[16] The balance and postural control categories were acknowledged to be the gross motor function components that were most essential for a child's independence. Moreover, the items were first judged with respect to safety to decrease risk of falling and injury which are common to these patients. Then, the selected items were assessed for the importance for reintegration into home, school and community environments. Twenty three items were eventually selected, with 6 items in balance, 7 in coordination, 6 in agility and 4 in strength. The final stage of development of ABI-CA will be to determine its reliability, validity and responsiveness before it can be widely used in the near future.[16]

The Six-Minute Walk Test (6MWT)

Most patients with TBI commonly complain of fatigue and decreased functional walking capacity and endurance.[8] Timed walk/ run tests have been in use for more than 50 years to measure the cardiorespiratory fitness of these patients. The gold standard for measuring endurance capacity and cardiorespiratory fitness is a graded exercise test during which oxygen consumption (VO2), carbon dioxide production, and pulmonary ventilation are measured.[9] The Six-Minute Walk Test (6MWT) is a reliable and valid functional test for assessing exercise tolerance and endurance in other patient populations, such as children and adolescents with cystic fibrosis,[17] severely ill children and children with cardiopulmonary diseases.[18] It was found that the 6MWT is also good to estimate peak aerobic and endurance capacity in patients in the post-acute phase of recovery from TBI. The 6MWT combined with a measure of heart rate response could replace the more sophisticated and complex measure of peak VO2, and help to assess the effectiveness of cardiopulmonary conditioning programs in a simple and cost effective way in patients with TBI.[9] Improving cardiorespiratory fitness should be part of a holistic approach to the physiotherapy treatment for these patients.

The School Function Assessment (SFA)

School re-entry has been identified as a quality of care indicator. SFA measured a wide and varied range of activities which has shown to be valid and reliable in measuring functional school based tasks and guiding service delivery for pupils with TBI.[19] It is designed for pupils in primary school, aged 4 to 12, and it consists of a lengthy, judgment-based questionnaire completed by professionals who are familiar with, and have observed the child, in various settings across the school. It is made up of 3 parts, namely participation, tasks supports and activity performance. The participation includes six different settings: classroom, playground, transport, toileting, meal-time, and transition around the school site. The tasks measure the amount of support or assistance the pupil required in order to participate in school life, which covers physical and cognitive/behavioral tasks. The activity performance includes 12 physical tasks such as traveling, eating and drinking, and 9 cognitive/behavioral tasks such as behavior regulation, memory and understanding.[20]

SFA has proved to be a valuable tool for identifying areas where a pupil may have difficulty in participating in school and its associated activities. Individual SFA profiles demonstrate the wide variability of challenges to participation in school-based tasks for a group of pupils with severe TBI.[19] It can identify the amount of support a pupil will need when they return to school when participating in physical and cognitive school-based functional tasks.

Conclusion

For evidence based practice, it is essential that clinicians are able to use valid and reliable physical assessment tools for children and adolescents with TBI. The above is a few examples which are sensitive to pick up the specific motor problems, identify needs and detect changes during the course of rehabilitation for those who are able to regain independent ambulation. Very often, a child's age expected motor mile stones should also be determined accurately to establish proper therapeutic goals.[21] Intensive home-based task oriented exercise programs have been found to improve the motor performances of these patients, especially their balance skill.[22,23] Appropriate advice, support and school recommendations are also important for successful school re-integration. Physical health promotion through physical activity assessments and appropriate activity prescriptions are some of the areas needing further exploration to enable children and adolescents with TBI to return to community maintaining their health best.

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A Case Report - Neurocognitive sequelae of an 8-year old boy with meningitis

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Introduction

Meningitis is one of the common causes of acquired brain injury in children. Long-term sequelae were documented in survivors of childhood bacterial meningitis, of which a majority were behavioral and/or intellectual deficits, including Low IQ/cognitive impairment, academic limitations, ADHD, behavioral deficits, and mental retardation.[1] A prospective and longitudinal study of childhood bacterial meningitis survivors showed that even at 12 years post-illness, children with a history of meningitis were at greater risk of impairment in intellectual, academic, and executive ability.[2]

However, such cognitive and behavioral sequelae could be overlooked or misunderstood in real life situation. The following case report illustrates the multiple difficulties encountered by a child due to the neurocognitive sequelae post meningitis and parents' and teachers' lack of understanding of his problems. A comprehensive and multidisciplinary assessment was conducted, and conference with parents and school teachers was held to help them understand child's difficulties from neurocognitive perspectives and to formulate plan to support child at home and at school.

Case Background

TH, an 8-year old boy, was referred to the Child Assessment Service for neuropsychological assessment after meningitis and operations. He suffered from meningitis (likely to be mycoplasma) with raised intracranial pressure, underwent an operation with shunt insertion, and was hospitalized for a month. He returned to school a month after hospitalization, with significant coping difficulties reported. He was seen by child assessment service after completing a school term.

Learning and memory

TH was reported to be weak in word learning since preschool years. After meningitis, he displayed even more significant difficulty in word learning and comprehension. He failed all main subjects in school exam. Also, significant memory problems in daily life after the illness were reported. He would confuse recent events, confabulate, lose things often, forget verbal instructions, and forget names of classmates and teachers.

Attention and behavior

TH also displayed significant inattention, hyperactivity and impulse control problems after meningitis. He displayed aggressive behavior towards his younger brother and talked back to mother more often than before.

Social and emotions

After returning to school, child became more socially withdrawn and less popular among peers. He participated less in physical and extra-curricular activities due to his physical condition. His mood was also reported to be more labile and emotionally reactive. For instance, he fought back to peers who teased him, which he had never done that before the illness.

Behavioral Observation during Assessment:

TH was alert, cheerful, and forthcoming. He was able to comprehend testing instructions and express self in sentences with clear articulation. He displayed good eye contact and spontaneous social interaction. He showed weakness in attention control. As testing progressed, he displayed more frequent off-task behaviors and complained about the test. He was generally cooperative and, yet he needed verbal prompting and encouragement to be redirected to tasks.

Test Results

General Intelligence

Wechsler Intelligence Scale for Children – Fourth Edition WISC-IV (HK) was administered to evaluate child's level of general intellectual functioning. His Full Scale IQ fell within the "Low Average" range. His performance on working memory subtests was relatively better (within "Average" range), while his performance on verbal comprehension, perceptual reasoning and processing speed subtests was within "Low Average" range.

Learning

Hong Kong Test of Specific Learning Difficulties in Reading and Writing for Primary School Students HKT-P(II) was administered to assess child's Chinese word reading and dictation. TH's performance on Chinese literacy skills fell within the deficit range. His speed of naming digits was also significantly behind his age peers. The test profile could be classified as Dyslexia.

Memory

Verbal memory – Hong Kong List Learning Test 2nd Edition HKLLT-II, a verbal memory and rote learning test, was administered. His immediate learning ability was within "borderline" range. However, his performance on immediate (10 minutes) and delayed (30 minutes) recall trials were within moderately impaired and mildly impaired range respectively. On recognition trial, his performance became severely impaired. He seemed unsure and frequently made corrections to his own answers. He also made a lot of intrusion errors, i.e. making up a lot of words, which some were totally unrelated to the word list.

Visual memory – Rey Complex Figure Test and Recognition Trial RCFT was administered to assess his visual memory. He showed impaired performance in copying the complex figure, and he copied it piece by piece. His performance on the immediate (3 minutes) and delayed (30 minutes) recall trials fell within the moderately impaired range. His performance on recognition trial was better, which fell within the "Below Average" range.

Sustained Attention

Conners' Continuous Performance Test – II CPT-II was administered to assess his sustained attention. Overall, the results indicated that child's profile resembled children with significant attention problems. On behavioral observation, he remained in seat but displayed frequent off-task behaviors.

Behavior / Emotions

On the Child Behavior Checklist (CBCL), a self-report questionnaire completed by mother, the profile revealed significant problem in externalizing behavior domain. On the Teacher's Report Form (TRF) completed by teacher, the profile revealed significant problems in externalizing and internalizing behavior domains. On a checklist of AD/HD symptoms, significant symptoms of AD/HD were endorsed by mother with high or very high frequency.

Language, motor coordination, and vision

Assessment findings by the team (including pediatrician, speech therapist, occupational therapist, physiotherapist, and optometrist) revealed that child also had moderate aphasia, fine motor and handwriting problems, gross motor problems, diplopia and dilated pupil.

Discussion

Despite that TH would appear "normal" when interacting with people (having normal intelligence and spontaneous social responses), he was assessed to have significant Dyslexia, visual and verbal memory impairment, secondary AD/HD symptoms, moderate aphasia, fine motor and gross motor problems, and diplopia, which significantly affected his learning and daily functioning. However, these multiple difficulties were not addressed when child returned to school, and child's parents lacked understanding of these possible impacts on child after meningitis. From mother's description, mother was confused and frustrated in dealing with TH who behaved "drastically different after the illness". Teachers seemed to assume that child had fully recovered when he resumed schooling, and regarded child's manifestations of learning and behavioral problems as "attention-seeking", "claiming to be unable to learn" and "being in sick role". Child also reported feeling of frustrations, and described himself as "being naughtier" after illness which he could not control.

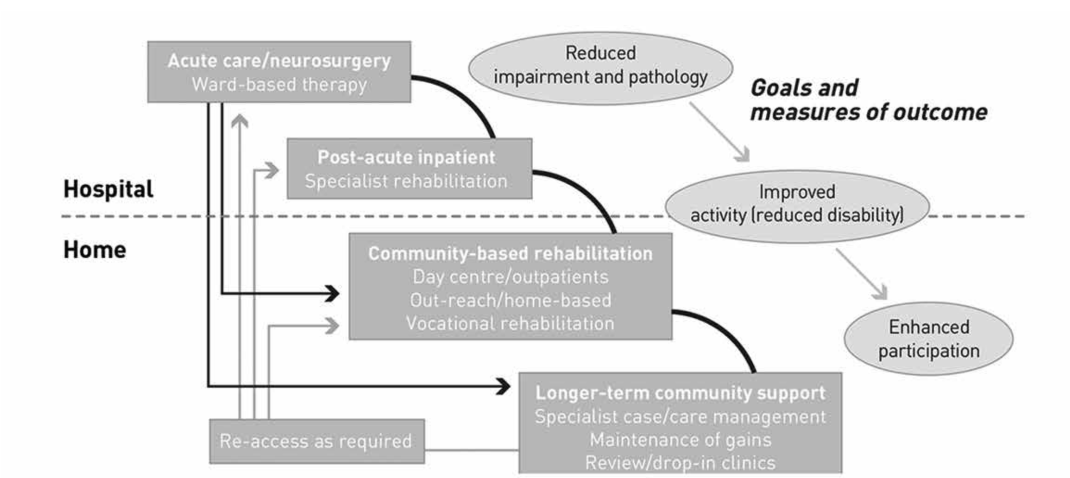
Recommendations

Conference with parent and school personnel was held after the assessment. Assessment findings were shared with parent and school teachers to enhance their understanding of child's difficulties holistically from the perspectives of neurobehavioral sequelae and adjustment after acquired brain injury. Several recommendations to address his multiple problems were made after discussion, including: a) repeating grade, with remediation and accommodation at school to address his learning, memory, fine motor, handwriting problem, and vision problems, b) behavioral support and seating arrangement to enhance his attention and behavioral control in class, c) monitoring for need of medication to treat his AD/HD symptoms and referral to the child psychiatric service for follow-up, d) referral to speech therapy, occupational and physiotherapy services, e) encourage participation in physical activities which child used to enjoy, f) and intervention by school social worker on parental counseling and dealing with child's peer relationship problems.

Challenges and future ahead

Communication gaps - TH is one of the many children that required rehabilitation services following acquired brain injury. Time gaps between discharge from hospital, assessment, and school reintegration had left TH and his family alone to cope with the problems. His multiple impaired neurocognitive functions had caused significant difficulties in his daily functioning, yet these could have gone unrecognized without detailed assessment and efficient communication. Transition from hospital to school could be smoother, if assessment service and rehabilitation plan could be provided in time.

With reference to the National Clinical Guidelines on rehabilitation following acquired brain injury published by the British Society of Rehabilitation Medicine (BSRM),3 a model of rehabilitation, referred as a "slinky model", illustrated that patients may need to access different services as they progress, their transition between services should be smoothed by excellent communication and sharing of information between services so that they progress in a seamless continuum of care through different stages.



Availability of cognitive rehabilitation therapy – Cognitive rehabilitation is an integral component of brain injury rehabilitation, which could improve rehabilitation outcome of children with acquired brain injury. Cognitive rehabilitation is defined as a "systematic, functionally oriented service of therapeutic cognitive activities, based on an assessment and understanding of the person's brain-behavior deficits."4 Quoted from the position statement by the National Academy of Neuropsychology,5 "it became dramatically evident to professionals, patients and their families that cognitive impairments, which interact with personality disturbance, were among the most critical determinants of ultimate rehabilitation outcome". At present, availability of local cognitive rehabilitation services in the community was limited and scattered. Collaborative effort by different health and educational professionals in providing timely, continuous, evidenced-based, tailor-made, and comprehensive assessment and treatment services to individuals with acquired brain injury will be essential for future development.

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The Hong Kong Brain Injury Association for the Young (HKBIAY)

Introduction

Founded on 1.6.2012 and listed as a charitable institution or trust of a public character which is exempt from tax under section 88 of the Inland Revenue Ordinance since 8.12.2013, the Hong Kong Brain Injury Association for the Young (HKBIAY) (香港青少年腦創傷協會) aims to provide mutual help, support and assistance to those brain injured youths under the age of 25 years and their families, promote public awareness and understanding on brain injured youth and their families, advocate the welfare and the rights of those brain injured youths and their families.

With a view to building up mutual support among the members and their families and enhancing the self-confidence of the brain injured youth, HKBIAY has organized a wide range of recreational and training-oriented activities, including but not limited to adventure exploration, brain exercise, war game, camping, etc. for the past three years. To widen the exposure of the members, the association also teamed up with other self-help group such as Brain Care (腦友心) to organize joint programmes to promote the public awareness and understanding of brain injured youth.

In future, the association tasks to arouse community concern and understanding on the impact of brain injury and the types and levels of care involved throughout the rehabilitation process by various means of public education.

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