The pathology and sequelae of pediatric traumatic brain injury (TBI) differ from those of the adult TBI population. In childhood TBI, cognitive impairment and secondary delays are often overlooked in the referral and intervention process. Although TBI is the leading cause of acquired disability in childhood, most children with TBI are discharged from acute care to home with little or no rehabilitation. This literature review provides current information germane to the occupational therapist on sequelae and functional limitations that may exist or develop after TBI in children. Further, methods by which these deficits can be addressed within the context of Individuals With Disabilities Education Act guidelines are described. Children with a history of TBI should be screened regularly because some cognitive problems emerge years after the injury as developmental demands on the child increase. In this article, school-based therapists are urged to look beyond a child's motor limitations to address the cognitive and neuropsychological problems typical of this population.

Lazar and Menaldino (1995) identified traumatic brain injury (TBI) as the leading cause of acquired disability in childhood, estimating that 5 million children sustain TBI yearly. No typical clinical picture of TBI exists because differences in the original brain insult can result in widely disparate outcomes. Early in the recovery process, most children with TBI are classified by degree of impaired consciousness based on the Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974). The GCS is used to predict rehabilitation outcomes (Jennett & Bond, 1975) on the basis of four categories: mild (good recovery), moderate (independence in activities of daily living [ADL] with disability), severe (dependency), and vegetative state (see Table 1). More than 90% of children with TBI fall within the mild or moderate range (Lowenthal, 1998; Shurtleff, Massagli, Hays, Ross, & Sprunk-Greenfield, 1995). Most are discharged to their home communities, often with little follow-up or support services (DiScala, Osberg, Gans, Chin, & Grant, 1991).

Children with motor limitations are often referred for physical therapy and occupational therapy during the recovery period after TBI. Although research indicates that even children with mild or moderate TBI without motor impairments demonstrate reduced functional performance, children without obvious motor or medical limitations seldom receive specialized therapy or support (Coster, Haley, & Baryza, 1994; Kinsella et al., 1997). Psychosocial and behavioral sequelae of pediatric head injury are less likely to

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receive medical attention, although they are consistently reported to be present and problematic (Lazar & Menaldino, 1995; Serio, Kreutzer, & Gervasio, 1995).

Asarnow, Satz, Light, and Neumann (1991) reported a high incidence of behavior problems in children with TBI. Researchers agree with this finding regarding children with severe head injuries but have contested it for the mild and moderate groups (Massagli et al., 1996). Some of the discrepancy between results may stem from the types of assessments typically used with children. Tests of cognitive performance do not assess function in natural environments. Current research indicates that cognitive status does not accurately predict level of behavioral functioning or adaptive skills (Lazar & Menaldino, 1995).

Children recovering from TBI are seldom referred for rehabilitation services of any kind. DiScala, Osberg, and Savage (1997) followed 24,021 children and adolescents hospitalized for TBI. They found that 27% left the hospital “with apparent functional limitation” (p. 5), as defined by these researchers. Functional limitations considered were those in the areas of vision, hearing, speech, self-feeding, bathing, dressing, walking, cognition, or behavior. Of this group, 75% were discharged to home. According to the researchers, “[A]mong school-age children with limitations who returned to their homes, only 1.8% were referred for special education services” (p. 8). They expressed concern regarding the apparent discrepancy between numbers of children with TBI eligible for and those receiving special education and related services under the Individuals With Disabilities Education Act of 1990 (IDEA; Public Law 101–476).

In this article, I review the literature on motor, communication, cognitive, behavioral, and psychosocial sequelae of pediatric TBI. Issues in family adjustment, community function, and implications for school-based occupational therapists are considered.

### Traumatic Brain Injury: Pathology and Complications

Traumatic head injuries usually occur as part of a multi-trauma event, such as an automobile accident or a fall. At the time of the incident, the child often presents with contusions, cranial fractures, extradural or intracranial hematomas, cranial nerve injuries, and edema (Blaskey & Jennings, 1999). Cerebral damage after head injury may be primary to the trauma or secondary to complications of the injury. Secondary damage includes insults that immediately follow the impact and insults that occur during the emergency medical intervention process. Primary cerebral damage is usually permanent (Bruce, 1990). Both types of damage can lead to limitations in functional outcomes.

In children, most primary focal injuries are frontal and temporal (Blaskey & Jennings, 1999). Computed tomography scan after an injury helps the clinician predict the types and degree of functional limitation likely to follow. Diffuse axonal injuries (DAI) are the result of shearing forces at the time of impact. DAI are usually identified through the use of magnetic resonance imaging and involve the brainstem and corpus callosum (Berker, 1996). DAI often result in edema, increased intracranial pressure, and diffuse axonal deafferentation accompanied by deterioration hypersensitivity (Povlishock & Christman, 1995).

Children’s brain tissue is developmentally different from that of adults, and very young children are particularly vulnerable to damage from secondary trauma (Johnston, 1995). Secondary trauma complications include vasospasm, cerebral swelling, cerebral edema, and hematomas (Pang, 1985), which typically result in increased intracranial pressure, hypoxia, ischemia, and hypotension. Infarction, brain herniation, and pressure necrosis may occur in the immediate posttrauma period. In children, damage from these secondary complications is more likely to be diffuse than in adults and more likely to resolve during the child’s recovery and rehabilitation period. About 59% of pediatric TBI cases are classified as mild, 8% as moderate, and 11.5% as severe (DiScala et al., 1997).

In DiScala et al.’s (1997) sample, the mean length of hospital stay of children with TBI was 6 days, and 90% of the children were hospitalized for less than 15 days. The children were screened for functional limitations before discharge, although the methodology associated with this screening was not presented. More than 68% of the children discharged were described as having no functional limitations, and 16% were described as having one to three limitations. Within these groups, all of the children with no functional limitations and more than 90% of those with one to three limitations were discharged to home. Less than one third of the children discharged to home were recom-

<table>
<thead>
<tr>
<th>Category and Score</th>
<th>Description</th>
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<tr>
<td>Vegetative state (&lt; 5)</td>
<td>A persistent state of impaired consciousness.</td>
</tr>
<tr>
<td>Severe (5–8)</td>
<td>Child is conscious but requires 24-hour care and supervision because of cognitive, behavioral, or physical disabilities. Slow response time and difficulties with short-term memory predominate.</td>
</tr>
<tr>
<td>Moderate (9–12)</td>
<td>Child is expected to achieve eventual independence in activities of daily living and home and community activities with persistent disability. Children in this group may have memory impairments, hemiparesis, dysphagia, ataxia, and other neuromotor problems.</td>
</tr>
<tr>
<td>Mild (13–15)</td>
<td>Good recovery is expected. Child is able to reintegrate into normal social life. There may be mild persisting sequelae.</td>
</tr>
</tbody>
</table>

mended for outpatient rehabilitation services. Epidemiological evidence suggests that only children with severe impairments following TBI are referred to rehabilitation hospitals (DiScala et al., 1997). According to DiScala et al.:

A large gap exists between percentages of children discharged to home with specific types of limitations and those receiving post-acute referrals. Over half of the children were discharged with limitations in walking, bathing, and/or dressing, while only 13.2% were referred to occupational therapy, and only 23.7% to physical therapy…. A total of 18.7% of these children were discharged with cognitive limitation, but only 1.8% were referred to special education. (p. 6)

The authors also reported low referrals for children with TBI to community-based services. Even fewer children actually received the services because of limitations in financial, social, and emotional resources. Families may lack an understanding of the potential problems, or some cultural influences may exist that lead the family to avoid “medical” support (Humphry & Case-Smith, 1996; Vessey, 1997).

**Prognostic Indicators**

The functional impact of head injury includes physical, mental, information processing, language, socioemotional, and medical impairments (Blaskey & Jennings, 1999). Rehabilitation of persons with TBI focuses on nonphysiologic interventions directed at these impairments. Traditionally, length of coma, changes in the GCS score in the first 24 hours, age, and the availability of rehabilitation services are considered prognostic indicators (Blaskey & Jennings, 1999). Gilchrist and Wilkinson (1979) questioned the predictive validity of the GCS for functional outcomes and suggested that a better predictor of outcome is the rate and quality of return of intellectual and memory functions.

**Pediatric TBI and Rehabilitation**

The benefit of rehabilitation services at any stage of recovery is poorly documented (Hall & Cope, 1995; High, Boake, & Lehmkuhl, 1995). Although they did not use control groups, several studies have demonstrated positive relationships between improved functional outcome and rehabilitation. Decreased length of coma (Mackay, Berstein, Chapman, Morgan, & Milazzo, 1992), improved functional outcomes (Heinemann et al., 1990), and decreased hospital stays (Hall & Cope, 1995) are attributed to early rehabilitation services. Because of the lack of uniformity within these studies and difficulties with instrumentation, researchers still debate whether rehabilitation actually optimizes functional outcomes or “simply expedite[s] the time to reaching a functional plateau” (Hall & Cope, 1995, p. 11). Hall and Cope (1995) responded to this argument with the following statement:

There is substantial evidence that plateaus do not represent maximum functional improvement, based on the positive changes reported by numerous studies in “stable” populations. If rehabilitation only expedited time to maximum function for an individual, then improvement might not be evidenced in many cases for years after injury. (p. 11)

The occupational therapy literature tends to deal with TBI in terms of specific impairments. The rehabilitation approach varies by individual limitations, point of service delivery, and length of time after trauma. Occupational therapy interventions in acute stage head trauma recovery include positioning, range of motion, and sensory stimulation (Scott & Dow, 1995; Winkler, 1995). In intermediate care, interventions broaden, including improving motor control and training in ADL, cognitive-perceptual remediation, and community reentry skills. Cognitive disability can greatly limit recovery because voluntary control and independent function rely on cognition (Blaskey & Jennings, 1999). In their study of children with multisystem trauma discharged to home, Wesson et al. (1992) reported a substantial incidence of physical and psychosocial morbidity as much as 1 year after discharge. Their study compared children with TBI to children experiencing other types of severe multisystem trauma and reported that many injured children in both groups are left with behavioral disturbances and lower academic scores after discharge.

The IDEA legislation requires states and schools to provide eligible children with special services, including occupational therapy, physical therapy, and speech therapy, to assure academic access. TBI is a disability category under IDEA, and children exhibiting functional problems are eligible for referral and screening for early intervention or school services. The public schools and school-based therapists are well placed to identify and recognize the special needs of children recovering from TBI (Blosser & Pearson, 1997). According to D’Amato and Rothlisberg (1996), any child having a history of TBI should be considered at-risk for academic problems, so ideally, schools will be informed if a student incurs, or has incurred, a TBI. Not every child returning to school after TBI will need special services, but classroom monitoring of these children is recommended.

**Brain Injury From a Developmental Perspective**

The medical and physical needs that result from childhood trauma are the focus of emergency room and acute hospital caregivers. After the child is medically stable, the developmental issues become more prominent. According to Lazar and Menaldino (1995):

> In the context of a child recovering from TBI, taking a developmental perspective refers to recognizing that the dynamic process of recovery from TBI is superimposed in time over maturational/developmental changes in neural structures, as well as developmental changes in cognitive, behavioral, emotional, and social functioning. (p. 56)

This recovery approach underlies the recent interest in longitudinal studies of pediatric TBI. The effects of TBI grow more complex as the child matures and faces new challenges. Although neuroplasticity allows young children to develop alternative neural pathways, these alternative pathways may be less efficient and may compromise the
original function of the compensating structures (Lazar & Menaldino, 1995). Through alternative pathways, the child may develop compensatory or atypical strategies to achieve desired skill levels. These strategies will improve function at the child’s current developmental level but may interfere with the overall developmental process and cause delays at some future point in development. The child’s compensatory “swapping” of functions allows the overriding of a system or a function that the young child does not yet need, resulting in other impairments that appear much later. The very young child is considered particularly vulnerable to impairment, as studies have shown that developmental skill areas undergoing rapid change are more vulnerable to damage secondary to TBI (Ewing-Cobb et al., 1997). Preschool children are believed to fare less well than older children and adults after TBI (Lazar & Menaldino, 1995).

Impairments Associated With Brain Injury in Children

Children with severe brain injuries are most likely to exhibit motoric impairment. Children with motor impairments after TBI are reported to have a good prognosis (Blaskey & Jennings, 1999; Winkler, 1995). Children with mild and moderate TBI have fewer limitations but often experience a number of transient impairments that may affect school performance (Kinsella et al., 1997; Shurtleff et al., 1995).

Decreased Motor Control

Common motoric problems seen in children with TBI include velocity-dependent muscle stiffness (i.e., spasticity), velocity of movement problems (i.e., ataxia), changes in muscle elastic properties (i.e., contractures), paralysis, and speech impairments. The incidence and severity of these motor disorders increase with the length of coma following the head trauma (Blaskey & Jennings, 1999). Between 5% and 30% of children with TBI manifest some motor control sequelae and may show improvements for up to 7 years after the injury (Klonoff, Clark, & Klonoff, 1993). Some long-term musculoskeletal problems are muscle contracture, altered joint mobility or stability, muscle disuse resulting in atrophy or muscle weakness, and decreased muscular endurance (Winkler, 1995). The clinical intervention literature clearly describes interventions for both the immediate and long-term problems associated with motor impairment secondary to TBI (Blaskey & Jennings, 1999; Scott & Dow, 1995; Winkler, 1995).

Orthopedic Impairments

Spasticity and prolonged posturing during the recovery period may lead to limitations in joint range of motion. Blasier and Letts (1989) documented the common orthopedic problems associated with severe brain injuries and the average time of deformity onset. Contractures can be prevented through ongoing skilled positioning and motor interventions (Moseley, 1997; Nuismer, Ekes, & Holm, 1997; Prosser, 1996). In addition to occupational therapy and physical therapy, several surgical and pharmacological treatments are available to address motor problems.

Somatosensory System Impairments

Sensory perception may be impaired following TBI. Commonly reported difficulties are impaired postural awareness and orientation, sensation impairments (e.g., impaired proprioception, tactile hypersensitivity), difficulty grading muscle force, and increased latency before muscle firing (Blaskey & Jennings, 1999). In addition, children may demonstrate impaired motor planning, tactile sensory dysfunction, and spatial disorientation (Carney & Gerring, 1990). These problems sometimes lead to specific problems with swallowing and eating (Porr, 1999).

Sensory System Impairments

Audiological and visual system impairments may develop as a result of brain injury (DiScala et al., 1997). Common visual problems include diplopia, hemianopsia, and changes in visual acuity (Massagli et al., 1996). Visual perceptual problems are described for the adult TBI populations and are assumed to be equally common in children, although little literature exists to support this assumption (Farmer, Clippard, Luehr-Wiemann, Wright, & Owings, 1996; Massagli et al., 1996).

Cardiopulmonary Impairments

Hypertension and decreased heart rate variability are common afferent effects of TBI (Blaskey & Jennings, 1999). Although the bulk of the problems are expected to resolve with neurological recovery, in some cases, continued cardiopulmonary inefficiencies persist. These persistent inefficiencies are attributed to brainstem disturbances and secondary deconditioning. Cardiopulmonary limitations of this type could exaggerate the functional impairment associated with other limitations the child may have in motor performance or cognitive organization.

Cognitive Impairments

Deficits in cognition cause some of the most severe sequelae of TBI. The motor problems described previously are interrelated with cognitive and behavioral problems (Warren, 1991). The most common persistent cognitive deficit areas in children with TBI are attention, concentration, judgment, and impulse control (Anderson, Fenwick, Manly, & Robertson, 1998). Functional limitations associated with these cognitive deficits can include poor initiation of tasks and poor task orientation. Difficulties with memory and decreased information processing speed often are lasting changes following TBI (Porr, 1999).
Postconcussion syndrome may be seen after any type of head injury, including mild injuries. This syndrome involves personality changes, mood lability, loss of self-confidence, impaired short-term memory, headaches, and other subtle cognitive impairments (Walleck & Mooney, 1994). Functional problems described as part of postconcussion syndrome are lack of goal direction and initiative, social withdrawal, depression, denial of disabilities, immature behavior, apathy, self-centeredness, disinhibition, and aggression (Carney & Gerring, 1990; Miller, 1991). Brown, Chadwick, Shaffer, Rutter, and Traub (1981) found an increased rate of psychiatric disorders in children with TBI. Coster et al. (1994) reported that the functional performance of young children from 1 month to 5.6 years of age ($M = 2.97$ years) with head injuries did not differ from their uninjured peers at 1 month or 6 months after discharge, but there was evidence of increased caregiver assistance in self-care and social functioning required by the group with head injuries. The children with head injuries were performing the same activities as their age peers but needed more supervision and direction to complete the task. Similarly, Mazaux et al. (1997) reported a loss of social autonomy in adults with TBI. Behavioral adjustment and adaptive functioning impairments are more severe in children with more severe injuries but can be found to a lesser degree throughout the post-TBI population (Lazar & Menaldino, 1995).

Most studies find no relationship between cognitive outcome and behavioral adjustment (Lazar & Menaldino, 1995; Perrot, Taylor, & Montes, 1991). Based on the absence of premorbid behavior data on the children in these studies, whether the child’s behavioral difficulties predated the head injury is unclear. Some authors accept this “premorbid problem” approach; others have suggested “a cumulative negative effect of the interactions of the child’s early cognitive deficits; loss of self esteem; the impact of the head injury on family, friends, teachers; and their responses” (Lazar & Menaldino, 1995, p. 59). It is believed that the cumulative impact of these pressures on the child starts a downward spiral, resulting in a pattern of maladaptive behavior (Shurtleff et al., 1995).

Communication Impairment

Impairments in both expressive and receptive language are common in children with TBI (Ewing-Cobb et al., 1997). In children with mild to moderate TBI, expressive language tends to be more impaired than receptive. Commonly noted are deficits of memory, word retrieval, labeling, verbal organization, efficient verbal learning, and effective use of spoken language (Porr, 1999). Improvements in speech (expressive language) correlate with improvements in motor function. Receptive language improvements correlate with gains in cognitive and perceptual function (Ewing-Cobb et al., 1997).

Long-Term Developmental Impairments

Of the few studies describing long-term recovery from pediatric head injury, most indicate that children have far fewer residual deficits than adults (Bruce, 1990). Recent studies suggest, however, that children demonstrate less damage early in recovery, but deficits can emerge later as the child matures (Lazar & Menaldino, 1995). All of the children in Ewing-Cobb et al.’s (1997) study showed improvement on neuropsychological testing throughout the first 6 months after the trauma; during the subsequent 18 months, a combination of persistent deficits impaired the children’s ability to acquire new skills. As in the 6-month trends of Coster et al.’s (1994) study, $5\%$ ($n = 79$) of the adult participants in Mazaux et al.’s (1997) 5-year study continued to need supervision in one or more areas of daily function. Common problems included need for supervision in administrative tasks and financial management, writing letters and calculating numbers, driving, planning the week, and using public transportation. These problems can be subtle and difficult to identify in children because during childhood, autonomous function gradually develops.

School and Community Reentry Needs

There is extensive documentation of academic difficulties in children with TBI (Lazar & Menaldino, 1995). Educators indicate a need for support and additional education in managing students with TBI (Clark, 1996; Kehle, Clark, & Jenson, 1996). The child with TBI must be supported in the transition to school and provided continuing support “beyond the point of apparent cognitive recovery” (Lazar & Menaldino, 1995, p. 59). Recommended transition services are (a) establishing communication among all persons involved in caring for the child, (b) initiating the evaluation process, (c) integrating assessment information in an interdisciplinary forum, (d) planning and adapting education programs to meet the student’s needs, (e) preparing the student for transitions, and (f) providing ongoing monitoring for late-emerging functional deficits (Blosser & Pearson, 1997; DiScala et al., 1997; Shurtleff et al., 1995).

Some children with head injuries exhibit chronic neurobehavioral and psychosocial impairments, necessitating ongoing monitoring and intervention in community settings. Families may need support well beyond the time of hospital discharge (Lazar & Menaldino, 1995; Serio et al., 1995). Community-based access to rehabilitation services in either outpatient settings or the public schools is limited by low referral rates, poor interagency communication, inadequate family resources, and incomplete understanding of long-term sequelae by families and community service providers. Protocols for school reentry abound in the literature (DiScala et al., 1997; Kinsella et al., 1997; Parkin, Maas, & Rodger, 1996), but they rely on the family reporting the TBI to school personnel. According to Shurtleff et al. (1995), “Because of their often excellent physical recov-
ery, the cognitive and behavior effects of TBI may go unrecognized or be minimized” (p. 65). Mild cognitive problems often result in vague signs that families may not link to the injury (Savage, 1991). Researchers argue that school and primary care personnel need education on the signs of “late” problems that are likely to appear only after an extended period.

**Occupational Therapy Intervention in the Community and Implications From the Literature**

**TBI in Infants: Early Intervention Services**

Children who sustain a TBI before 3 years of age are an at-risk population and eligible for early intervention services. Because there is usually excellent physical recovery in this population, it is easy to overlook functional problems associated with cognition (Coster et al., 1994). Occupational therapists in early intervention programs may need to carefully assess the amount of caregiver support a child needs to perform age-appropriate activities. Children with TBI may pass the items on a developmental scale yet function in a manner atypical for their developmental level in terms of the external support needed. Increased need for caregiver assistance may reflect problems in cognitive functioning that emerges as greater developmental demands are placed on the child. Interventions for these problems are parent support, education, and training to create an environment that maximizes the child’s ability to work independently. The occupational therapist following the young child with TBI can consult with the family about transition planning. One of the common cognitive impairments associated with TBI is difficulty processing new information and acquiring new skills. As the child matures, impairments may become more apparent as the child is expected to learn in new and different ways.

**TBI in Preschoolers: School-Based Services**

IDEA mandates preschool (3–5 years) services, including occupational therapy, for children qualifying for special education. TBI is one of the diagnostic categories that will qualify a child for services under IDEA if the resulting impairments affect his or her ability to benefit from special education. Children in this age group with impairments from TBI may be seen by an occupational therapist following the young child with TBI. In a classroom setting, the occupational therapist may see difficulties with handwriting and atypical classroom behavior. All children with TBI should be reviewed periodically for the need for special services (Blosser & Pearson, 1997; DiScala et al., 1997; Lazar & Menaldino, 1995; Shurtleff et al., 1995). As with younger children, a concern in the school-age population is the amount of caregiver assistance required for ordinary function. The occupational therapy evaluation provides needed information for the educational team. The therapist collaborates with the team to obtain this information and to alert other team members of the potential for late-emerging deficits. Table 2 lists common problems that children with mild brain injury experience. These indicators of possible TBI-related impairments should be made available to the child and to all persons involved in the child’s care.

**Conclusion**

Because TBI is the leading cause of acquired disability in childhood, clinicians and educators need to be aware of the potential immediate and late-emerging sequelae of pediatric TBI. Education is needed for specialists and families about the potential challenges that even children with mild and moderate injuries may face. Providing information on the common psychosocial and physical problems reported in children with TBI and offering therapeutic support in the classroom setting may maximize these children’s opportunities for success. ▲

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Common Problems After Mild Brain Injury in Children</th>
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<tr>
<td><strong>Problem</strong></td>
<td><strong>Description</strong></td>
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</table>
| **Physical** | • Dizziness (rare after 8 weeks)  
• Fatigue  
• Headaches  
• Visual complaints  
• Sleep disturbance |
| **Thinking** | • Difficulty concentrating  
• Memory problems  
• Poor reasoning and judgment  
• Difficulty in school  
• Acting on impulse  
• Slow to complete tasks  
• Difficulty putting thoughts into words |
| **Behavior and emotions** | • Depression  
• Anger outbursts  
• Irritability  
• Personality changes  
• Difficulty getting along with friends |

References


