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Traumatic brain injury

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Abstract

During my freshman year in college, I met many interesting students, professors, and professionals. One of my most memorable acquaintances was with a young gentleman, approximately 19 years old, whose physical appearance and personality was relatively different from most other students on campus. As I spent the first few weeks of precalculus class sitting directly behind him, I became increasingly puzzled by his peculiar speech and his persistent need to have mathematical concepts and instructions continuously repeated. During mealtime, I regularly observed him sitting alone or with "superficial" friends in the same general section of the resident's dining area. His bizarre persona and academic difficulties perplexed me. In some ways his behaviors reminded me of a mild mentally retarded individual who struggled academically and socially, yet intuitively I knew this was probably not the case.

TRAUMATIC BRAIN INJURY

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TABLE OF CONTENTS

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Introduction

During my freshman year in college, I met many interesting students, professors, and professionals. One of my most memorable acquaintances was with a young gentleman, approximately 19 years old, whose physical appearance and personality was relatively different from most other students on campus. As I spent the first few weeks of precalculus class sitting directly behind him, I became increasingly puzzled by his peculiar speech and his persistent need to have mathematical concepts and instructions continuously repeated. During mealtime, I regularly observed him sitting alone or with “superficial” friends in the same general section of the resident’s dining area. His bizarre persona and academic difficulties perplexed me. In some ways his behaviors reminded me of a mild mentally retarded individual who struggled academically and socially, yet intuitively I knew this was probably not the case.

Being naive, ignorant, somewhat apprehensive of this individual, and admittedly concerned about my own social reputation, I avoided this student during the majority of the first semester. It was only through college gossip that I learned he had been in a serious motorcycle accident approximately one year prior and had sustained a traumatic brain injury (TBI). While I regrettably avoided him, my college roommate (having grown up with a brother in special education) sought him out and became probably one of the closest friends he had since the accident. I never quite understood their friendship because my roommate would often complain about his strange affect and frequently disinhibited behaviors that would often embarrass her.

By the end of the first semester, I found myself only more perplexed and having many more questions than answers. During Christmas break I returned home to my family and any concerns regarding this gentleman were quickly replaced with anticipation of the Holidays. I also learned at this time that my roommate had decided not to return to school for the second semester and was planning to leave college and take a nanny position on the east coast.

Upon returning to campus that second semester, I had little contact with this gentleman except for occasionally passing him in the hallway on my way to class. Then one cold morning in late January I awoke to the very sad and distressing announcement that at approximately 3:00 a.m. this student had jumped to his death off the sixth floor penthouse of his resident hall. While I was greatly disturbed by his death, I somehow managed to focus my energy on my studies. Nonetheless, his peculiar behaviors and unfortunate death remained a mystery during the remainder of my undergraduate years. Not until being employed by the Veterans' Administration Psychology Service where I assessed a variety of head injured patients did the scattered pieces of this mystic puzzle begin to fall into place.

Purpose

The purpose of this paper is to provide vital information regarding traumatic brain injury so that educators and other related professionals might gain insight into the unique physical, behavioral, social, emotional, and cognitive needs of traumatic brain injured individuals; become less fearful in how to approach them when meeting their needs; and treat them with the respect and human dignity they deserve.

Incidence, prevalence, and demographics

Traumatic brain injuries (TBI) are a significant cause of physical disabilities, psychological dysfunction, morbidity, and mortality among individuals (Sosin, Sacks, and Smith, 1989). As a result of different methods of case definition, mild head injured victims failing to seek medical attention, and lack of other essential data, arriving at an accurate estimate of the incidence of head injuries is not an easy task. Despite this challenge, the annual incidence of TBI occurring in the United States is estimated to be somewhere between 3 and 7 million (Beers, 1992; Savage and Pollock,1985). Of these cases, at least 500,000 are admitted to hospitals (Savage et al.,1985), 70,000 to 300,000 manifest significant residual physical and/or psychological impairment (Beers, 1992; Chance,1986; Savage et al., 1985), and a minimum of 100,000 of TBI victims die annually (Savage et al., 1985; Sosin et al., 1989). Currently, the annualized head-injury associated death rate (HIAD), derived from U.S. mortality data collected from 1979 to 1986 stands at 16.9 per 100,000 residents (Sosin et al., 1989). Given this relatively high mortality rate, the projected figures that 20-40% of mild head injured victims escape medical attention (Beers, 1992), and the established fact that TBI symptoms may only begin to first appear months after the injury, traumatic brain injury has been appropriately labeled the “silent epidemic” (Beers,1992).

While traumatic brain injury has little preference for its victims, current demographic data on head injury supports that certain subgroups tend to be at greater risk for TBI than others. Examination of the head injury-associated death statistics (Sosin et al., 1989), as well as incident reports of emergency room admissions (Savage et al., 1985; Thompson, Thompson and Rivara, 1990), reveal several specific factors related to an increased risk for traumatic brain injury. At-risk correlates include age, gender, race, urbanization, type of accident, time of accident, and pre-injury personality/behavioral characteristics (Beers, 1992; Locke, 1983; Savage et al., 1985; Sosin et al., 1989).

Of the 3 to 7 million annual TBI victims, approximately 95,000 are children and adolescents, accounting for 11% of pediatric emergency room admissions (Slifer, 1993). Research consistently reports that the frequency of head injury increases for individuals less than 24 years of age and peaks particularly between the ages of 15-24 years (Beers, 1992; Sosin et al., 1989). While males have an overall consistently higher risk for head injury than females, during the period from 15-24 years males have twice the associated risk of sustaining a traumatic brain injury (Sosin et al., 1989). Incidence of traumatic brain injury also increases for individuals over 75 years of age (Sosin et al., 1989).

Interaction effects between age and accident type demonstrate that infants and toddlers are most susceptible to TBI associated with falls or collisions against the windshield or dashboard in a motor vehicle accident (Sattler, 1992). Children between the ages of 5 and

14 years tend to have the highest risk for TBI in bicycle related accidents (Thompson et al.,1990). Individuals 15-24 years of age are most affected by motor vehicle accidents, while those ages 25 to 34 years old are most likely to be injured or die as a result of accidents related to firearms (Sosin et al. 1989). Lastly, persons 75 years or older tend to be most vulnerable to TBI associated with unintentional falls (Sosin et al., 1989).

When race is considered as a factor, motor vehicle accidents are the leading cause of head injury associated death for both whites and blacks; however, the HIAD rate for whites is 39% higher than for blacks. Conversely, firearm related HIAD rates are 39% higher for blacks than for whites. Furthermore, blacks have higher HIAD rates than whites across all age groups except those individuals between the ages of 15 to 24 years of age and those persons 75 years or older (Sosin, 1989).

Urbanization also tends to be related to an increased risk for TBI. In a study of 638 children under 18 years of age who were being treated for head injuries in an inner city hospital of Los Angeles, Locke (1987) reported an increased incident of TBI emergency room admissions as compared to other local medical centers within the Los Angeles area. An attempt to explain this finding yielded an important insight; Of the 638 medical evaluations, nearly 30% qualified as non-accidental cases with the nature of their injuries being generally more severe. Non-accidental cases primarily encompassed those related to known or alleged child abuse, injuries inflicted by other children or adults other than one's parents, and injuries traced to neglect and/or poor parental/caretaker supervision. Considering this study is only one isolated report, future research remains to explore potential increased risk factors associated with inner city environments encompassing increased poverty, high unemployment, and increased immigration rates.

Pre-injury personality and social characteristics also tend to place particular individuals at-risk (Beers, 1992; Lehr, 1990; Wood, 1987). Researchers suggest that the premorbid personality and social characteristics of maladjustment, risk-taking (Beers, 1992), immaturity, violence, and/or antisocial behavior (especially when combined with alcohol consumption or low intelligence) (Wood, 1987) predispose certain individuals to TBI. Additionally, individuals who have previously sustained a cerebral insult are more likely to sustain subsequent injuries. This is most likely a result of impaired judgment and insight associated with the earlier cerebral injury (Beers, 1992). Furthermore, when Powell (1979, cited by Wood, 1987) compared a group of head injured patients to a group of orthopedic patients, he discovered a higher incidence of premorbid psychiatric abnormality among patients in the head injured group.

Temporal trends have also been identified in relationship to TBI. For head injuries occurring in bicycle related accidents, the spring and summer months of April through September contain the highest frequencies of head injuries. Additionally, it is of little surprise that Saturday and Sunday also contain the highest incidence (nearly 50%) of bicycle related head injuries (Thompson et al., 1990).

Examination of HIAD rate trends from 1979 through 1986 reveal that death rates per 100,000 residents have generally declined since 1982 (Sosin et al., 1989). Although this data may suggest that the incidence of TBI is declining, it is more plausible that many individuals are surviving traumatic brain injuries as a result of more sophisticated medical technology and treatment (Gualtieri, 1988;). Accordingly, more TBI victims are requiring evaluation, rehabilitation, and reintegration back to their jobs or school post-injury (Blosser and DePompei, 1989; Carney and Gerring, 1990).

TBI effects and mediating factors

The effects of TBI encompass a wide range of sequelae including impediments in physical functioning, deficits in affective and psychosocial functioning, and cognitive and information-processing impairments. Deficits most commonly associated with physical and motor deficits include hyperkinesis, awkwardness in locomotion (e.g. clumsiness, tremors or asymmetry of facial musculature), awkwardness in skilled movements (e.g. writing), postural rigidity, speech difficulties, numbness and loss of sensation, and difficulty copying geometric designs or body gestures (Sattler, 1992). Emotional problems which frequently appear following TBI include agitation, irritability, apathy, poor impulse control, egocentrism, depression, withdrawal, affective lability, logorrehea, and/or anxiety (Howard and Blieberg, 1983; Sattler, 1992). Common cognitive and informational processing deficits encompass attentional problems (e.g. selective attention, perseveration, hemi inattention or unilateral neglect), confusion, difficulty with organization, difficulty carrying out a plan of action, memory impairment, expressive and/or receptive language functioning, impaired judgment, specific learning deficits, inflexible thinking, and disorientation. Psychosocial dysfunction may manifest itself as interpersonal difficulties, immaturity, antisocial behaviors, disturbed self-concept, compulsive and perseverative tendencies, impaired social judgment, denial, and insecurity (Sattler, 1992). While physical recovery is often more rapid and more complete, psychological, cognitive, emotional, & behavioral recovery is often more prolonged and more subtle (Paul and Epanchen, 1991). Furthermore as a result of a variety of mediating factors, children typically manifest different sequelae than adults and may consequently require alternative and individualized evaluation and/or treatment.

Several factors that mediate the psychological effects of TBI include developmental issues, severity of injury (Paul et al., 1991), lesion site and type of injury (Wood, 1987), and pre-injury and personality characteristics (Lehr, 1990). Children and adolescents are particularly susceptible to these mediating factors.

Developmental processes

Developmental processes mediate brain injury's effects by specifying which structures and processes are most susceptible to injury at a particular time. During the first five years of life, cortical development and myelinization occur at its most rapid rate. Although this period encompasses the most significant amount of cerebral plasticity, increasing evidence suggests that children under 5 years of age tend to be most susceptible to the deleterious effects diffuse brain injury (Sattler, 1992). Depending upon the child's stage of development, diffuse brain injuries may affect development in a variety of ways. In infancy, cell migration and brain organization are most likely to be affected by brain injury, whereas during the middle school aged period, frontal and limbic structures are more susceptible (Paul et al., 1991). Accordingly, similar brain injuries may manifest themselves differently depending upon the person's stage of development. For example a brain injury occurring at age two may affect the development of speech and language, whereas at age three, spatial-symbolic manipulations may be most affected. By 11 and 12 years of age, a more mixed pattern of deficits emerge that more closely resemble deficits found in adults. The most striking difference between children and adults who have sustained a traumatic brain injury is that adults generally experience a loss of function, whereas children experience a disruption of developmental processes that may have subtle repercussions throughout the rest of their lives (Sattler, 1992). Consequently, it is possible for children and adolescents who have sustained TBI to have delayed effects that may not surface until confronted by more complex cognitive, social, and behavioral tasks (Sattler, 1992).

Injury severity

Severity of injury, classified by measures including duration of post-traumatic amnesia and coma, depth of coma and/or global severity, also serves as an indicator of degree of impairment (Benedict, 1989) and degree of recovery from TBI's effects (Paul et al., 1991).

However, this does not negate the significant impact that minor head injury can also have on cognitive, emotional, and behavioral functioning (Beers, 1992; Roberts, in prep.; Savage and Pollock, 1985;).

In a historical prospective study examining the full spectrum of head injury and its associated effects, Rutter and his colleagues (1981, cited by Wood, 1987) discovered a linear relationship between severity of injury and the extent of cognitive deficits for persons who had sustained a severe head injury (specified by Post-traumatic amnesia (PTA) lasting at least 7 days); however, no linear relationship was found for individuals who had sustained a mild head injury (specified by PTA greater than one hour, but less than 7 days). The authors concluded that deficits in the severe head injury group were due to brain injury, but that the mild head injured group's deficits were most likely the result of poorer premorbid functioning because no recovery curve was established.

Since this study's publication, many other researchers have become actively involved in the controversial issues surrounding mild head injury, its effects and treatment. A recent review of the literature (Beers, 1992) suggests that numerous investigators generally concur upon the neuropsychological sequelae of mild head injury (e.g. problems in attention, concentration, memory, judgment, and psychomotor speed etc.); however,the course of recovery is still highly debated. Inconsistent operational definitions of mild head injury, lack of sophisticated technology, inadequate methodology, and difficulty disentangling premorbid levels of functioning from post-morbid sequelae are largely responsible for this unresolved conundrum. Beer's (1992) emphasizes: "One cannot assume that a good recovery indicates a mild injury. It is not how *hard* one is hit, but the consequences of the injury that are important. The degree of severity of head injury required to produce documentable changes in mental functioning for both adults and children appears to be far less that previously thought".

Pre-injury and personality characteristics

In addition to severity of injury, pre-injury and personality characteristics also mediate TBI's immediate and long term effects by determining the degree of susceptibility a child has for developing new problems. If a child functioned well in psychosocial areas preceding the injury, the child is less likely to develop new problems in this area than a child who experienced difficulty prior to the injury (Lehr,1990).

Lesion site and type of injury

Finally, lesion site and type of injury also influence TBI's cognitive, affective and neurobehavioral effects (Wood, 1987). By examining the anatomy and pathophysiology of the human brain, the nature of these effects becomes somewhat more clear. Consisting of a firm gelatin-like substance, a significant portion of the human brain rests on a rigid and bony surface known as the fossa. The inner/medial surfaces of the temporal lobes and the orbital surfaces of the frontal lobes are particularly vulnerable to injury resulting from rapid movement over the anterior and middle fossa, as well as from direct impact against the anterior and posterior portions of the skull. This particular type of injury, labeled coup and contrecoup injury, is most often sustained in rapid acceleration/deceleration accidents, especially those involving motor vehicle accidents (Savage and Wolcott, 1988).

Additionally, the brain also rests on a relatively thin column known as the spinal cord. Given the considerable size and weight of the brain, the spinal cord is small and gives relatively little support to the brain. As a result, rotational forces frequently have detrimental effects, especially to areas within the brain stem including fibers of the reticular activating system that may result in reduced arousal or coma (Savage et al, 1988).

Another type of injury can result form rapid deceleration. The forces associated with this type of injury typically result in microscopic shearing of tissue, nerve fibers, and/or blood vessels. Disturbances in some of the most complex mental functions, including memory, attention, and emotional recognition (Gualtieri, 1988; Savage et al., 1988), are often related to this type of injury.

To further clarify the pathophysiological nature of TBI, injuries have been also categorized according to two major types: 1) Diffuse axonal injury (DAI) and 2) Focal Cerebral Contusions (FCC) (Benedict, 1989). This categorization should not be considered discrete from the subtypes of injuries described earlier. Rather, this categorization should be considered as two distinct components of those injuries, particularly injuries involving acceleration/deceleration forces. DAI, defined by "scattered shearing of axons usually in the parasagital white matter of the cerebral hemispheres", is often displayed by symptoms of decreased arousal, delayed information processing, lack of initiation and decreased vigilance (Benedict, 1989). In contrast, FCC results in damage to specific areas of the brain, particularly the frontal and temporal poles, and is often related to residual deficits of disinhibition, impulsivity, and loosely-connected thoughts (Benedict, 1989). Type of lesion becomes increasingly important when determining the reasons for poor performance on a cognitive, social, or behavioral task. For example, poor cognitive performance on a recall task may occur because of slow processing speed (a DAI deficit), tangential thought (a FCC deficit), or a combination of both factors (Benedict, 1989). Accordingly, patients may respond differently to remediation strategies depending upon the type of injury sustained.

Neuroimaging technology

As a result of increasingly sophisticated technology, (e.g. Computed Axial Tomography (CT), Magnetic Resonance Imaging (MRI), Electroencephalogram (EEG), Positron Emission Tomography (PET), and recently Single Photon Emission Computed Tomography (SPECT) etc.), neurologists and other medical professionals have become better equipt to document and evaluate the pathophysiology of TBI (Kuperman, Gaffney, Hamdan-Allen, Preston, and Venkatesh, 1990). However, many more advances remain to be made in order to detect some of the more subtle effects of TBI, especially those sustained in mild head injury.

Contemporary neuroimaging technology can be split into two primary areas. The first area emphasizes brain structure and anatomy (e.g. CT and MRI), while the second area emphasizes brain function (e.g. EEG, PET, SPECT). Individual methods have inherent advantages and disadvantages and accordingly have different usages among adult and pediatric populations (Kuperman et al., 1990).

Computed axial tomography and magnetic resonance imaging

CT scans have the primary strength of depicting calcified tissue well, while MRI scans are superior at delineating the brain's grey and white matter. CT scans have the disadvantages of having bone artifacts disrupting the image, radiation causing an allergic reaction to patient, and the risk of exposing children to a higher proportion of radiation. Conversely, MRI scans have relatively few of these disadvantages. In addition to superior grey and white matter delineation, MRI scans are capable of quality imaging without the use of contrast material, have more flexible image parameters, do not generate bone artifacts, and use no ionizing radiation. However, MRI scanning does pose the risk of chemical toxicity and is not able to be used when patients have a pacemaker, aneurysm clip, are pregnant, or are claustrophobic. Accordingly, CT scans and MRI scans have complementary uses (Kuperman et al., 1990).

Electroencephalogram

Of the various imaging techniques used to analyze brain function, EEGs are used most frequently. This is most likely because they are easier and cheaper to perform, noninvasive, and use no radiation.

Although computers are now being used to collect and analyze EEG data (CEEG), there is still much controversy over the clinical usefulness of this technique. Neuronal activity is often distorted through bone, scalp, muscle artifact, and electrical noise. Furthermore, scientific study is still questing to prove actual significance of current EEG tracings (Kuperman et al., 1990).

Positron emission tomography and SPECT

PET and SPECT scanning are two neuroimaging techniques that share the common function of measuring cerebral blood flow. PET scanning generally consists of injecting a chemically reactive tracer into a persons blood stream and recording the image produced by the reaction of a positron (an antimatter electron) encountering an electron. Early chemical tracers before the 1950's used nitrous oxide, while the most common tracers today include the inert gases of xenon and krypton. As chemical substances evolved, imaging devices also improved. With the introduction of computers, a 3-dimensional representation of cerebral blood flow activity was made possible and became what is known as SPECT imaging. As a result of being relatively new technology, SPECT scanning is prone to the disadvantages of limited spatial resolution compared to PET, extracranial contamination, measurement errors, and white matter lesions being less easily detected. However, its 3-dimensional imaging capabilities offers great promise for the future of neuroimaging (Kuperman et al., 1990).

Intervention and treatment

By examining the mediating factors of TBI's effects, it is apparent that TBI victims are not a homogeneous population. This is especially true for children and adolescents who are in the process of developing. Other factors increasing TBI's population heterogeneity include: Time elapsed since injury, preexisting intellectual skills, type of environment since the injury, motivation for recovery, and the nature of the family constellation and level of involvement (Howard et al., 1983). Consequently, the physical, social, affective, behavioral, and cognitive presentation of TBI victims is extremely varied. Accordingly, intervention efforts, especially those incorporating research design, often employ an individualized approach (Wood, 1987; Wilson, 1987).

Treatment of individuals who have sustained a traumatic brain injury often encompass a variety of approaches depending upon the quantitative and qualitative nature of the injury, as well as unique physical, psychological, and psychosocial characteristics of the TBI victim. Some of the more widely researched interventions involve neuropharmacotherapy, social skills intervention, behavioral modification, and cognitive remediation and compensatory strategies. However, before delineating specific aspects of these interventions, it is important to recognize the role of spontaneous remission in recovery from TBI, particularly for persons who have sustained a mild head injury.

Spontaneous remission

Research conducted by Levin and colleagues (1987) suggests that deficits in memory, attention, and information-processing speed, as well as somatic complaints and affective malaise are significantly resolved within the first three months following minor head injury. Other studies of both adults and children have also consistently discovered a recovery time of between 3 to 6 months post-injury; However, these later studies have raised important issues regarding the full extent of recovery (Beers, 1992). In her review of the literature, Beers (1992) cites work positing that significant changes in children's academic achievement can be documented up to 2 years post-injury. Additionally, she also cites work suggesting that although most persons significantly recover within the first year post-injury, the recovery may actually be based on an individual's ability to learn new coping skills and become more comfortable with the disability. While this later research consistently conveys substantial natural recovery from TBI, the important issues raised by these authors implies other significant interventions are necessary.

Neuropharmacology

Advances within the field of neuropharmacology offers one promising avenue of treatment for TBI. Many of these advances are directed at alleviating specific neurological sequelae (e.g. headaches, post-traumatic epilepsy, and spasticity), rectifying neuropsychological deficits associated with various cognitive processes (e.g. attention, memory, arousal, and executive function), and eliminating or reducing psychiatric symptoms that may be directly related to the injury or occur as an indirect consequence of coping with a resulting handicap (Gualtieri, 1988). While these advances appear theoretically discrete, pharmacological therapy does not just treat the target symptom or symptoms; medications that are used to treat one aspect of TBI are likely to affect other systems as well. For example medication that is used to treat post-traumatic seizures or depression may result in memory impairment and/or decreased motor performance (Gualtieri, 1988). Moreover, medication that works well for one patient's particular problems may not be therapeutic for another person who has similar symptomatology (Gaultieri, 1988). Clearly, pharmacotherapy for TBI patients must employ an individualized and carefully monitored approach.

As a result of limited research available on the neuropharmacological treatment of TBI patients, treatment analogues have generally consisted of a "trial and error" approach derived from treatment effects in other patient populations (i.e. attention deficit/hyperactive, learning disabled, mentally retarded, behavior disordered, autistic, and dementia patients). Accordingly, the information that follows is largely based on a few case studies and research articles that Gualtieri (1988) examined in his review of the literature.

The pharmacological effects of psychostimulants used in TBI patients was found to most closely parallel existing treatment indications for psychiatric populations. Psychostimulants, such as ritalin and dexedrine, have been effectively used to improve symptoms of inattention, distractibility, hyperactivity, emotional lability, anergia, long term memory, and perceptual-motor function. Additionally, psychostimulant medication may also be therapeutic for frontal lobe symptoms of disorganization, disinhibition, reduced flexibility, and poor planning.

Similarly, anticonvulsants (especially carbamazapine) have also been found to have parallel psychiatric indications for behavioral problems manifested by TBI patients. The inherent ability of carbamazapine to effectively control post-traumatic epilepsy, as well as improve affect among TBI patients, has led it to become the anticonvulsant of choice among physicians. However, carbamazapine and other anticonvulsants must be carefully monitored to avoid toxicity and other dangerous side effects including increased irritability, agitation, assaultiveness, sedation, and impaired memory in some individuals. Additionally, there is a class of epileptic patients whose seizures worsen when taking carbamazapine. Therefore, like any other treatment regimen, medication ingestion and blood levels should be carefully monitored and observed regularly. (Gaultieri,1988).

A third class of pharmacological agents often used in treating TBI victims is tricyclic and monoamine oxidase inhibitor antidepressants. Unlike psychostimulants and anticonvulsants, prescriptions of particular TCA's and MAOI's have different effects for TBI patients versus psychiatric populations. TBI patients are more likely to be treatment resistant to antidepressant medications, have multiple contraindications such as post-traumatic epilepsy, and have higher risk for suicide which make TBI patients extremely vulnerable to antidepressants since all TCA's are toxic in overdose situations (Gualtieri, 1988).

Other psychopharmacological agents that have been examined for usage among TBI patients include dopamine agonists (L-dopa), lithium, cholinergics, neuroleptics (tranquilizers and antipsychotics), beta-blockers (propranolol), calcium channel blockers (verapamil), nootropes, opiates, and neuropeptides. However, the majority of drugs within these classes have, or are suspected of having, equivocal effects for TBI patients. Accordingly, alternative/supplementary interventions are often necessary for treatment of TBI's behavioral, social, and cognitive sequelae.

Behavioral analysis and modification

Behavioral analysis and modification efforts applied to TBI patients are generally classified according to two major classes: 1) antecedent based conditioning and 2) positive reinforcement based procedures. The former emphasizes modifying environmental conditions and employing external cueing devices to help elicit specific behaviors from the TBI patient, while the latter addresses changes within the environment after the patient has emitted the behavior. Both types of behavioral approaches have demonstrated preliminary success. Studies that have systematically employed an antecedent based approach have demonstrated effectiveness for reducing behavior problems, teaching daily living and safety skills, and increasing compliance. Positive reinforcement based techniques such as contingency contracting, point systems, interval-token economies, and positive reinforcement schedules, have also demonstrated modest success in reducing unwanted behaviors and increasing mare desirable behaviors. While behavioral analysis and intervention research is relatively limited, behavior modification techniques appear to be a promising approach for behavior problems associated with TBI, particularly episodic dyscontrol, 'frontal' aggression, sexual and social disinhibition, restlessness, impulsiveness, attention, and disturbances in sleep and appetite (Slifer et al., 1993; Wood, 1987).

Psychosocial intervention

Another significant area related to the psychological management of TBI involves psychosocial assessment and intervention. Three primary psychosocial areas frequently compromised by TBI include emotional reaction to the injury and associated deficits, neurological aspects of the injury that may affect emotional perception and control, and premorbid personality (relates to adults) and temperament (relates to children and adolescents who are in the process of developing) changes as a result from the injury. The interaction of these components may affect both prognosis for recovery and intervention selection (Lehr, 1990).

Thorough assessment of psychosocial functioning following TBI should include information obtained from a variety of sources including parents, teachers, and friends of the victim. These collaterals enable an integration of perspectives and provide information about the individual's premorbid and post-morbid personality style. Collaterals are often necessary because they provide information that the TBI victim is likely to be unaware of due to the nature of the injury. Nonetheless, it is also important to directly and indirectly assess the TBI victims own perception of himself/herself post-injury in order to evaluate the degree of unawareness present in the TBI victim (Lehr, 1990).

One of the most significant psychosocial areas affected by TBI is the individual's post-injury relationships with family and friends (Lehr, 1990). If a family is given little preparation prior to the victim's discharge from an acute care setting, family members may be overwhelmed in attempting to care for the individual as well as reacting to the individual's changes in affect and behavior. In the majority of cases, family members experience a grief-like reaction when responding to their TBI family member. The pre-injury family member no longer exists and is replaced by someone who may resemble that person, but whose personality and behavior is completely foreign. Additionally, family members of the TBI victim may often react to the post-morbid behavior as if the individual had regressed to an earlier developmental stage, rather than perceiving the behavior as a change of temperament/personality. If the TBI victim is a child, siblings may react negatively to their TBI brother/sister by experiencing associated feelings of guilt, hostility, and blame. Furthermore, the TBI victim himself/herself may experience adjustment problems, not only in dealing with the effects of the injury, but also the with reaction of his/her family members to him/her. Clearly, all family members may experience post-injury adjustment problems. Accordingly appropriate psychosocial assessment should involve the entire family, but only after maladaptive patterns emerge should family intervention be applied since not all families experience adjustment difficulties (Lehr, 1990).

The TBI victim may also experience difficulty initiating and maintaining friendships post-injury (Malkmus, 1989). As a result of the injury, the TBI victim may exhibit alterations in social cognition and social behavior such as difficulty understanding jokes or teasing, exhibiting embarrassing disinhibited behaviors, and/or becoming socially withdrawn. Previous friends may perceive these behaviors as rejection and consequently believe that their head-injured friend no longer likes them. Furthermore, if these friends feel they cannot do anything to modify their head-injured friends behavior, they are likely to distance themselves from their head-injured friend and set a downward spiral in motion. Experiencing loss of friends may increase the TBI victim's degree of social withdrawal and lead to social dislocation (Malkmus, 1989; Lehr, 1990).

Psychosocial intervention typically employs an integrated approach of dealing with TBI victims, their family, and their friends (Lehr, 1990). Individual psychotherapy is increasingly being tried with adults and older adolescent TBI victims to assist them in understanding and coping with their experiences. For young children, equivalent forms of play therapy are being applied. Group approaches are also potentially effective. Groups may consist of all head-injured victims that focus on direct teaching of social skills by utilizing techniques such as verbalizations of nonverbal social behavior, imagery, self-instruction, and step-by-step problem solving. Alternative group approaches may consist of educating classmates and friends about traumatic brain injury, or involving close friends and siblings of the TBI victim in a more intense group intervention that is used to support and help the TBI victim cope more adaptively with the injury's effects. Family therapy, family support groups, and Family education programs are also effective means of maintaining and fostering the development of all family members despite stressful transitions (Lehr, 1990).

Cognitive rehabilitation

In addition to Neuropharmacological, behavioral, and psychosocial intervention, cognitive rehabilitation is also a viable alternative in treating and managing the multidimensional effects of TBI. Cognitive rehabilitation programs and strategies are generally subdivided according to two distinct types: 1) those which attempt to remediate cognitive deficits and 2)those which compensate for cognitive impairment. Remediation approaches are generally grounded in cerebral plasticity theory and emphasize the importance of placing information processing demands upon the damaged brain in order to maximize recovery (Sattler,1992; Benedict, 1989). In contrast, compensatory approaches accept unrecoverable loss of function and provide head-injured persons with strategies that circumvent impaired functions (Benedict, 1989). It is important to recognize that remediation and compensatory strategies are not entirely discrete; Numerous strategies may employ components from both perspectives.

One of the most common and detrimental cognitive effects of TBI is memory deficits (Howard et al., 1983; Lawson & Rice, 1989). Memory dysfunction plays a crucial role in mediating cognitive performance of

TBI victims. Depending on the severity of injury, memory dysfunction can range from occasional forgetting of names to a more global loss of all events after a short period of time (Howard et al., 1983). Memory deficits may include difficulty recalling earlier events from the day, difficulty staying oriented to a schedule, difficulty searching memory banks to retrieve stored information (Savage et al., 1988), problems recalling procedural or declarative information (Sohlberg & Mateer, 1989), problems with word retrieval errors (Benedict, 1989; Blosser et al., 1989), and/or difficulty recalling text (Glasgow, 1977; Wilson, 1987).

The wide range of memory deficits TBI victims commonly display has required the investigation of a variety of mnemonic techniques to determine their remediative utility on memory performance. In a review of the literature, Benedict (1989) compared the effectiveness of visual imagery, semantic association, elaborative encoding, and a combination of multiple strategies to enhance memory performance among TBI adults. His findings suggest that the effectiveness of visual imagery and semantic association techniques is highly dependent upon the TBI victim's ability to supply self-generated cues to improve recall performance. A second review of the literature on mnemonics also supports Benedict's findings regarding visual imagery's failure with brain injured subjects (Cook, 1989). Additionally, Benedict states that teaching TBI subjects several concurrent mnemonic techniques is often an inadequate strategy for improving recall performance because it is impingent upon the TBI subject's cognitive processing capacity. Lawson and Rice (1989), further elucidate the importance of cognitive processes on memory performance by describing a TBI victim who could use trained strategies when externally cued, but couldn't spontaneously initiate their use without prompting. Lawson and Rice's work (1989) emphasized the importance of an external executive system for directing the use of memory strategies when moving beyond the training context.

While Benedict (1987) described highly inconsistent results among studies that employed visual imagery techniques, semantic association strategies, and concurrent training of multiple strategies, his review of the literature recognized the potential importance of elaborative encoding strategies for improving recall performance. The most successful strategy Benedict reviewed was the PQRST technique originally developed by Robinson (1970).

Glasgow et al.'s (1977) case study focused on an undergraduate student who had difficulty recalling reading assignments and lectures. To improve her recall performance of academic materials, Glasgow et al. employed a modification of Robinson's (1970) PQRST technique which trained their subject to 1) <u>preview</u> the material , 2) ask standard <u>questions</u> about the content, 3) <u>read</u> silently and actively to answer those questions, 4) <u>state</u> or repeat the information that had been read, and 5) finally <u>test</u> herself by answering the standard questions. After four weeks of training sessions, recall performance (measured by percentage of main points and details recalled , as well as the percentage of multiple-choice items correct) consistently improved compared to her recall performance assessed during a 2 week baseline period. Wilson (1987) also investigated this method's effectiveness in her treatment of 8 TBI adult patients. During six training sessions involving the use of a simple rehearsal strategy for one paragraph and the PQRST method for a different paragraph, recall performance was improved for those paragraphs in which the PQRST method was used. Both investigators demonstrated positive results for improving text recall performance among TBI adults; However, both studies included methodological flaws warranting cautious interpretations. Glasgow's case study failed to control for the length of time each reading passage was presented, while Wilson's repeated measures design failed to include a pretreatment baseline. Neither studied investigated whether Robinson's (1970) PQRST technique is applicable to TBI children exhibiting verbal memory deficits.

A recent case study by Roberts and Franzen (in prep.) who employed Robinson's PQRST technique in a resource room model demonstrated successful results for a minor head-injured 10 year old girl. Verbal recall performance, measured by percentage of ideas freely recalled from two independent reading passages, as well as percentage of clozed and multiple-choice questions answered correctly, consistently improved over a seven week intervention period when compared to the subject's baseline performance. However, these results should only be considered preliminary because the study failed to control for practice effects as well as attention related components. Furthermore, this single subject design will only acquire increased validity if future studies repeatedly demonstrate similar findings among similar populations. Therefore additional research is required to confirm/disconfirm the effectiveness of this cognitive rehabilitative technique. Nonetheless, cognitive remediation strategies used with alternative populations, such as learning disabled children, appear to be a viable treatment option for TBI individuals.

Summary and conclusions

Traumatic brain injury (TBI) impacts a significant proportion of adults and children annually throughout the United States. Due to increasingly sophisticated technology and treatment, the number of TBI survivors is rising steadily. Additionally, increased awareness of the effects of minor head injury is prompting a substantial need for medical and educational systems to pool together their knowledge and resources in order to better address the unique concerns of TBI individuals and their families, particularly as TBI individuals are reintegrated into the classroom and the community.

Indisputably, the public education system is the largest provider of services to children and adolescents with TBI. Although medical facilities serve these TBI individuals for up to several weeks or a few months post-injury, in most cases the school is responsible for these individuals during their remaining years as students. Accordingly, educational programming must recognize and address the unique and ever changing status of TBI students. Moreover, educational programs must respond with flexibility and understanding in order to best serve the academic and social needs of these students within the least restrictive environment (Ylvisaker, Hartwick, and Stevens, 1991).

As a result of TBI students being a heterogeneous population with varying ages, developmental stages, pre-trauma educational histories, TBI deficits, and support systems, educational programming must be highly individualized. However, some general guidelines should be considered when serving TBI students (Ylvisaker et al., 1991). First, the child's abilities and needs should be properly understood. Particularly for initial reentry planning, medical and rehabilitative staff should be consulted in order to accurately identify the TBI child's strengths and difficulties. Additionally, a communication plan for efficient information flow between the school, medical facility, and family should be developed and fully understood by each party.

Second, flexibility and creativity should by applied to decisions about classification, placement, and modifications in services over time so that the child and his/her family has whatever support system necessary to meet their academic and social needs. Obtaining optimal blending of medical and educational funding requires ingenuity and perseverance, but it is possible. Insurance and Medicaid benefits do not have to cease when the child returns to school.

Third, significant people in the child's environment including parents, siblings, peers, educators, and other relevant community professionals should be properly oriented and trained (Ylvisaker, et al., 1991). Individuals who have not encountered a TBI student often have difficulty understanding the behaviors or problems exhibited by this population (Blosser et al., 1989). Parents should be given information about Public Law 94-142 and should be acquainted with the services available in their school district and the process of acquiring those services (Ylvisaker, 1991). Siblings and peers need appropriate information so that they do not experience negative feelings of guilt or hostility, but can serve as an asset in helping other children understand and adjust to the TBI child. Educators should be trained to understand the TBI child's needs and abilities. Few educators and/or special educators receive preservice training in the area of TBI. Therefore staff inservices utilizing head-injury consultants should be conducted to inform educators about the unique needs of TBI students. Included in these discussions should be a list of characteristics that differentiate TBI students from other handicapped groups. For example, TBI students do not typically begin their academic career as a handicapped student and as a result may have a sense of being normal that persists from the premorbid period, or that TBI students may demonstrate inconsistent patterns of performance which may be associated with variability and fluctuation in the recovery process, etc (Blosser et al., 1989).

Finally, the TBI child's educational program should be effectively monitored and modified as he/she changes and responds to instruction, frustration, developmental transitions, and social obstacles over time. Inevitably, this guideline implies appropriate and ongoing case management. Ideally, this role should be assigned to someone understanding both school services and TBI so that appropriate recommendations for change occur as they are needed, and that optimal use of available resources prevail (Ylvisaker, et al., 1991).

In conclusion, traumatic brain injury does not affect only the individual. The effects of TBI are experienced by nearly everyone that comes into direct or indirect contact with the person who has sustained TBI. Accordingly, the individual, the family, and the community are all affected by TBI. Therefore, it is important that everyone understand the eminent implications of TBI. If everyone does not, all will remain its silent victims.

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