**Abusive Head Trauma -**

**Shaken Baby Syndrome, Revised**

**Introduction**

 I wanted to learn more about shaken baby syndrome, more accurately referred to as abusive head trauma (AHT), because I have had the opportunity to work with several young children with AHT in the home setting as a part of an early intervention program.1 I chose the child with the most severe injuries (CS), as I have learned through this assignment that this is by far the most predominant outcome for this population.

 I have weighted this assignment heavier in the epidemiology and pathology/pathophysiology areas for two reasons. First, it is important for health care providers to stay updated on the information about risk factors and precursors of AHT in order to improve both prevention and early detection efforts within our work, home and community environments. Secondly, the awareness of the complexity, diversity, diagnostic nuances and growing research related to the pathology and pathophysiology of AHT will assist physical therapists in developing optimal interventions and communicating more effectively and expediently with the family, physicians, and other members of the health care and educational team. Towards this end, I felt it was also necessary to go beyond the usual assignment length to give these parameters an effective voice.

**Epidemiology**

 Abusive head trauma (AHT) is among the most devastating of injuries in terms of long-term consequences for the individual, family and society.  Abusive head trauma, also more commonly referred to as shaken baby syndrome (SBS), has also been referred to as inflicted traumatic brain injury (ITBI),2 non-accidental head injury (NAHI),3 pediatric acquired injury (PABI),4 and inflicted childhood neurotrauma (ICN).5 In 2009, the American Academy of Pediatricians recommended that the term ‘abusive head trauma’ be used medically and legally to “describe the constellation of cerebral, spinal, and cranial injuries that result from inflicted head injury to infants and young children.”6 The Centers for Disease Control (CDC) defines Pediatric AHT as “an injury to the skull or intracranial contents of an infant or young child (< 5 years of age) due to inflicted blunt impact and/or violent shaking.” The CDC definition for AHT excludes accidental injuries resulting from neglect and gunshot wounds, stab wounds or penetrating trauma.7  The term ‘shaken baby syndrome’ is considered a subset of AHT, and it is also used for advocacy, prevention and for educational materials for the general public to continue to develop awareness of the hazards of shaking, which is considered a primary cause of AHT especially for children under the age of one. For example, the National Center on Shaken Baby Syndrome (NCSBS) at [www.dontshake.org](http://www.dontshake.org), is a non-profit organization that continues to use this moniker towards their efforts in preventing infant abuse through education, training, and research.8

 It is estimated that as many as 3-4 children a day are at risk for severe or fatal AHT in the US,8 and that AHT is one of the leading causes of abuse-related fatalities for children < 2 years old. AHT is responsible for 50-80% of all head trauma-related deaths for children < 2 years of age, and mortality rates from AHT are estimated at 13-35%.10 AHT injuries have been observed in children up to 5 years of age, with the majority of AHT occurring with children under 1 year of age and a peak incidence at 3 months of age.10,11 One 5-year study reported 80% of the survivors of AHT occurring < 1 year of age sustained severe neurological injuries; only 10-15% of the survivors recovered to mild to no evident impairment.10 Estimates of AHT may be underreported due to inaccurate diagnoses, or that the eventual diagnosis may have occurred after repeated incidences of abuse – 45% of children with AHT in one North Carolina study showed signs of previous injuries.9 In a four year retrospective study of children 0-12 months that had been admitted to emergency rooms with an apparent life-threatening event (ALTE), 1.4% were ultimately diagnosed with AHT, but only 56% of those with AHT were diagnosed in the emergency department (ED).12

 The higher incidence of AHT with the <1 year group has been tied to responses by shaking the children in attempts to quiet them. Early normal crying behaviors in the first few months of life may be prolonged, unsoothable, without apparent reason, and may occur more in the late afternoon and evenings. In a study comparing the data of the duration of crying behaviors in normal infants and the frequency of SBS, a correspondence was found between the two curves. Normal crying behaviors show a “n-shaped” developmental curve starting at 2-3 weeks, peaking at 5-6 weeks and then decreasing through the first year. The incidence of SBS starts at 2-3 weeks, peaks at l0-13 weeks, shows a gradual incline into 36 weeks, plateaus at 36-52 weeks, then continues to show a decline after the first year. Both curves show a similar starting point and a similar curve, but with a later peaking of the SBS curve. This is thought to be possibly related to the later diagnosing that would follow the cumulative damage of shaking episodes, or due to the delayed response time of the caregivers in seeking help for the child.13

 Perpetrator risk factors for causing AHT, in the order of highest incidence, are: related males, boyfriends or stepfathers, male babysitters, mothers, and female babysitters or caregivers. Other more variable risk factors include prior military service, social/family stressors, socioeconomic factors, multiple births, or a history of child abuse of the perpetrator. Developmental delay and prematurity are also increased risk factors, along with being male, first born, lower socioeconomic status, and a child of a younger, unmarried mother.4,9

**Diagnosing AHT**

*“Few pediatric diagnoses engender as much debate as AHT, in part because of the social and legal consequences of the diagnosis. The diagnosis can result in children being removed from their homes, parents losing their parental rights, and adults being imprisoned for their actions. Controversy is fueled because the mechanisms and resultant injuries of accidental and abusive head injury overlap, the abuse is rarely witnessed, an accurate history of trauma is rarely offered by the perpetrator, there is no single or simple test to determine the accuracy of the diagnosis, and the legal consequences of the diagnosis can be so significant.”14*

 *- Cindy Christian, MD*

 The National Center for Shaken Baby Syndrome lists the following as common symptoms for AHT: lethargy, decreased or increased muscle tone, rigidity, extreme irritability, decreased appetite, poor feeding or vomiting without apparent reason, poor suck or swallowing, difficulty breathing, seizures, inability of eyes to focus or track, uneven pupil size, bulging soft spot on head, head or forehead appearing larger, inability to lift head, and lack of smiling or vocalization. Bruising on the chest or arms may also be present, but this is a less common sign.15

AHT injuries may include subdural hematoma, diffuse axonal injury, cerebral edema, retinal hemorrhages, and fractures.11 It is not always easy to distinguish AHT from traumatic brain injury (TBI), particularly if the perpetrators are not forthcoming with providing an accurate history of events. In a meta-analysis of 19 studies, Piteau et al compared the symptomology of AHT and TBI for children up to 6 years of age. Relevant symptoms that pointed to AHT included subdural hemorrhage(s), cerebral ischemia, retinal hemorrhage(s), skull fracture(s) with intracranial injury, fracture(s) of the metaphysis, long bone, and/or ribs, seizure(s), apnea and inadequate medical history. With non-inflicted TBI, more significant associations were with epidural hemorrhage(s), scalp swelling and isolated skull fracture(s).16 In looking at retinal hemorrhages (RH), a review of 66 studies by Togioka et al showed that RH was present in 53-80% of children, they tend to be bilateral (62.5-100%); there is a much lower incidence of RH (0-10%) found in children with accidental TBI.17 Spinal trauma, although more commonly associated with accidental incidents, was estimated in a review by Kemp et al to be coexisting in about 1% of children with AHT, with an association of cervical spinal injuries to younger infants (median – 5 months) and thoracolumbar spinal injury in older infants (median -13.5 months), and half of the spinal injuries reviewed were not identified at the initial visit.18

 Emergency department recommendations from the Guenther et al study include that AHT should be considered as a differential diagnosis for all children admitted to the ED with an ALTE, that clinical predictors for increased risks of AHT include a history of vomiting, irritability, seizures, and a 911 call by the caretakers, and that the ED providers consider additional brain imaging and ophthalmologic consultation for patients with ALTE nonsuggestive initial presentations.12 Laskey et al also advocates for the more frequent use of CT or MRI, as 29% (n=51) of a group with AHT that were diagnosed by neuroimaging, showing signs of intracranial injury *without* the children showing other neurological symptoms.19 Based upon a systematic review of neuroimaging studies for children suspected of AHT, Kemp et al found that if an MRI was done following an abnormal early CT, 25% showed additional findings, including further subdural hematoma, subarachnoid hemorrhage, shearing injury, ischemia, and infarction as well as helping to estimating the date of injury. Diffusion weighted imaging (DWI), done during the MRI, also helped to identify ischemic changes and to gauge prognosis.20 Kemp et al, based upon their review of spinal trauma associated with abuse, recommends that children < 2 years with suspected abuse have a skeletal survey, including lateral imaging of the cervical spine, lateral and AP of the thoracolumbar spine, and followed by an MRI of the spine if abnormal findings are indicated or suspected, as the MRI may detect the presence and extent of spinal subdural hemorrhages.18 Another promising diagnostic test currently being researched is an analysis of blood serum biomarkers to indicate the presence of TBI, which may be especially useful in the detection of mild TBI in infants without apparent symptoms.21

*– CS was brought to the EMS at 2 ½ mos, diagnosed w/ AHT with acute subarachnoid hemorrhage, right hemisphere seizure, bilateral retinal hemorrhages, fracture of R clavicle and healing R humeral fx.*

**APTA Guide Patterns**:

 In addressing the often complex issues for the individual with AHT, the following practice patterns in the APTA Guide to Physical Therapist Practice may apply in varying degrees:22

• Musculoskeletal

4A: Primary Prevention/Risk Reduction for Skeletal Demineralization

4B: Impaired Posture

4C: Impaired Muscle Performance

4D: Impaired Joint Mobility, Motor Function, Muscle Performance and Range of Motion (ROM) Associated with Connective Tissue Dysfunction

4E: Impaired Joint Mobility, Motor Function, Muscle Performance and ROM Associated with Localized Inflammation

4G: Impaired Joint Mobility, Motor Function, Muscle Performance, and ROM Associated with Fracture

• Neuromuscular

5B: Impaired Neuromotor Development

5C: Impaired Motor Function and Sensory Integrity Associated With Nonprogressive Disorders of the Central Nervous System – Congenital Origin or Acquired in Infancy of Childhood

5H: Impaired Motor Function, Peripheral Nerve Integrity, and Sensory Integrity Associated with Nonprogressive Disorders of the Spinal Cord

5I: Impaired Arousal, ROM, and Motor Control Associated With Coma, Near Coma, or Vegetative State

• Cardiovascular/Pulmonary

6A: Primary Prevention/Risk Reduction for Cardiovascular/Pulmonary Disorders

6B: Impaired Aerobic Capacity/Endurance Associated with Deconditioning

6E: Impaired Ventilation and Respiration/Gas Exchange Associated With Ventilatory Pump Dysfunction or Failure

• Integumentary

7A: Primary Prevention/Risk Reduction for Integumentary Disorders

7B: Impaired Integumentary Integrity Associated with Superficial Skin Involvement

**Pathology/Pathophysiology of Systems Affected and Impairments:**

 The majority of surviving infants and children with AHT are severely disabled, estimated up to 80%, with only 10-15% of the survivors recovering to mild to no impairment.10 The following information is largely based upon information for children with non-specified TBI with moderate to severe disabilities, which would include both AHT and accidental TBI. As a whole, outcomes for children with accidental TBI fare better than AHT, but the following descriptors may still provide a representative picture of the pathology that most survivors with AHT may face:23.24

• **Neurological and Neuromuscular**

Seizures – Two categories of seizures need to be considered, post-traumatic seizures (PTS) and late onset seizures. PTS may contribute to secondary brain injury by increasing cerebral edema or hypoxic/ischemic effects. PTS risks are higher with more severe brain injuries, and risk factors include children < 3, Glasgow Coma Scale (CGS) < 8 and contusion, subdural hematoma, and cerebral edema. The presence or continuation of more severe seizures is also predictive of poorer outcomes.

Muscle tone/movement dysfunction - Neurological damage may produce varying degrees of spasticity, rigidity, hypotonia and ataxia, which may result in loss of flexibility, joint contractures, decreased postural control, loss of balance, loss of functional movement and mobility, and pain.

Neurogenic pain is usually associated with somatosensory damage, and is common with individuals with TBI. In a one-year followup study of adults with TBI, 47% reported mild to moderate pain, and 25% reported moderate to severe pain. Pain responses can be mixed (nociceptive and neurogenic). Headaches may be a frequent cause of pain, and if associated with progression, altered consciousness, nausea or nocturnal occurrence may indicate hydrocephalus, increasing edema or hemorrhaging. Pain management in infants and young children may often be overlooked due their inability to communicate or localize pain.

Hydrocephalus - Individuals with TBI are at higher risk for post-injury onset of hydrocephalus as well as progressive or late onset hydrocephalus.

Sleep – sleep maintenance problems are more common than sleep onset difficulties.

Autonomic instability may occur following brain injury, especially with injury to the brain stem or hypothalamic axis. It may affect heart rate, blood pressure, temperature and other functions of auto-regulation. Hyper-sensitivity to environmental stimulation or stressors that can trigger episodes of autonomic imbalance may also occur.

Vision – Visual and visual perceptual deficits are estimated at 20%, which may be due to dorsal or ventral stream dysfunction secondary to injury.

Hearing – Conductive or sensorineural hearing loss deficits is estimated to affect 20% of this population.

Psychiatric or psychological – dysfunction in cognition and behavior are common symptoms of TBI, including challenges with attention, impulsivity, motivation, memory, agitation, mood, anxiety, coping mechanisms, motivation, and anxiety disorders.

Endocrine – damage along the neuro-endocrine axis as a result of TBI may cause imbalances and deficiencies in hormone levels, which may include deficiencies in growth hormone (GHD), lower testosterone levels in males and early puberty. These abnormalities may also contribute to rapid weight gain and slower growth.

• **Musculoskeletal** –

 Fractures – AHT can also be accompanied by fractures of the skull, long bones, and vertebrae that occurred concurrently with the injuries.

Heterotopic ossification (HO), also known as periarticular new bone formation (PNBF), is abnormal bone development within the soft tissues, usually next to the larger joints. The PNBF location may be at multiple sites, but is usually located at the hip and knee, followed by shoulder and elbow, and occasionally nonjoint locations. The risk of PNBF is about 14% in the pediatric population with TBI, with increasing risks with the presence of multiple fractures or prolonged immobilization.

Range of Motion limitations can be as a result of spasticity, fractures, PNBF, and immobility, and lead to progressive joint contractures

Muscle weakness may occur due to coma and prolonged bedrest, spinal nerve injury, immobility and sedentary behavior.

**• Cardiovascular/Pulmonary** –

Cardiovascular symptoms are less common unless affected by the instability in autonomic regulation mentioned previously. Deep vein thrombosis and pulmonary embolism are not common symptoms, but there is a slight increased risk, especially for infants, compared to the general pediatric population.

Pulmonary - TBI may require tracheostomy placement and ventilation, especially with severe injuries, with management and weaning off of these supports as the child tolerates. Immobility and limited movement of respiration secondary to weakness and spasticity may also increase the risks for respiratory infections.

• **Integumentary –**

The incidence of pressure ulcers ranges from 2-8%, with the buttocks, perineum and occiput as the most common sites for skin breakdown; the severity of injury and degree of immobility increases the risks for skin breakdown.

**• Gastrointestinal –**

Feeding intolerance and difficulties with swallowing and oral motor coordination due to neurological injuries may require use of a nasogastric (NG) tube, if short term recovery is anticipated, or a gastrostomy tube for longer recovery periods. Difficulties with eating, nutrition and maintaining GI health may include impaired gastric emptying, gastro-esophageal reflux (GERD), emesis, diarrhea and constipation.

- *At 3 years of age, CS has severe physical and cognitive disabilities and severe visual impairment; she is at Level V on the Gross Motor Function Classification System – Expanded and Revised (GMFCS – E & R). Medications include phenobarbital for seizure control, Prevacid for GERD, oral Baclofen to decrease muscle tone, and Melatonin for sleep disturbances. Her caregivers noted decreased crying behaviors and fussiness once she started taking Baclofen, and she was able to sleep through the night after Melatonin was prescribed. She is below the l0%ile for weight and height.*

**Outcomes/Activity/Participation/Environment – It All Ties Together**

    Given that higher rates for AHT occur in the first year, with the greatest incidence at 2-3 months, consequent damage to an immature and vulnerable brain may result in less potential that the child may benefit from positive neuroplastic changes. In addition, the risks also increase for negative neuroplasticity contributing to secondary disabilities, such as late onset posttraumatic seizures.25 Higher risk factors for poorer outcomes include Glasgow Coma Scale scores <8, lack of spontaneous movement for more than 72 hours, seizure(s), requiring CPR, and loss of consciousness at the time of admission or during initial hospitalization.10.25

 Significant environmental changes may also be a factor in outcomes, which may be a positive factor in some instances – in a one-year follow up study, half of the children with ATH were in foster care, and about half were with the grandmother, compared with 7% of the TBI group cared for by extended family.25

*–CS lives with extended family. She is dependent in all self-care and ADL. She is able to roll slowly prone to supine, sit when propped and stand with support with moderate to maximum assistance. She attends a self-contained classroom for children with physical disabilities at a public preschool program.*

 The World Health Care’s (WHO) model of the International Classification of Functioning, Disability and Health (ICF), activity is defined as “the execution of a task or action by an individual”, participation as “involvement in a life situation”, and environmental factors as “the physical, social, and attitudinal environment in which people live and conduct their lives.”26 For the child with ATH with severe physical and cognitive disabilities, the ICF functions of activity and participation may have to rely upon a great deal of support provided by physical environmental supports, which may include assistive technology and personal assistance, facilitation, and support by others. The missive for the physical therapist is developing, in conjunction with the family, meaningful family-centered activities or interventions that help to support and develop the child’s functional movement, mobility and quality of life given these more restricted and demanding parameters.

**Interventions – working together**

 The APTA Guide to Physical Therapist Practice defines interventions as “the purposeful interaction of the physical therapist with the patient/client and, when appropriate, with other individuals involved in patient/client care, using various physical therapy procedures and techniques to produce changes in the condition that are consistent with the diagnosis and prognosis.”27 A routine-based intervention “embeds interventions during the child’s naturally occurring learning opportunities, during activities and routines that are meaningful to the child and part of daily life.”28 Embedding effective interventions into the child’s routine is a collaborative, evolving process involving the child, family, and other therapy and educational providers.

 In study by Chiarello et al, 172 parents of children with severe disabilities completed the Occupational Performance Measure (COPM) to identify priorities in self-care (personal care, functional mobility, community management), leisure (active or quiet recreation, socialization), and productivity (play for younger children, school, household management, work). Across all age groups (<6, 6-12 years old, and 13-21 years old), the highest priority was related to the self-care category, particularly in personal care activities.30

 For the child with severe disabilities, an intervention to address greater participation in daily activities and to promote health, postural control, function, and active movement might be the use and integration of a stander into the home and/or school setting.31,32,33 A small study by Gibson et al (n=6) showed increased hamstring lengthening and improved ease of ADLs as reported by parents and caregivers following a 1 hour 5x/wk standing program in the school setting for 6 weeks. There was a tendency towards hamstring shortening after 6 weeks of nonstanding, suggesting that the routine use of a stander, embedded in everyday activities may help to improve hamstring flexibility and ease of ADL care in transfers, general positioning, dressing, bathing and toileting.33 Another study showed improved bone mineral density (BMD) following an 30 minute 5x/wk standing program for 8 weeks for 3 out of 4 children – two were using a dynamic style stander and two were in a typical (static) stander; both children in the dynamic stander showed improved BMD.33 Although there continues to be a paucity of evidence-based literature on many interventions for this population, including the values of using a stander, it is hoped that further research studies will help us to close this gap.

*- At the age of 14 months, CS started to use Mulholland supine stander at her preschool program, building up tolerance to 30-45 minutes day in about 2 weeks. The stander initially had shoulder supports to help provide upper trunk support and alignment. She progressed from a reclined position up to vertical standing over a 3-month period. At about 2 years of age she no longer needed the shoulder supports and was using the stander about 45 minutes 5x/wk, and she uses the stander during one of her preschool activities. Her reaching and grasping ability for toys and items placed on her tray have shown improvement and a greater understanding of her preferences.*

**Environment – prevention, public policy and provision of services**

This assignment has not only served to increase my understanding of the etiology and consequences of this “constellation of cerebral, spinal, and cranial injuries”6 that comprises AHT, but it also opened my eyes to the constellation of environmental initiatives, programs and changes to help further prevention, research, and rehabilitation efforts for those with AHT, pediatric TBI, and for those at risk for these injuries.7,8,34,35,36,37

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