Neuroplasticity and Early Intervention:

Effectiveness on Children with Perinatal Stroke

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ABSTRACT

This study evaluates current treatment for perinatal stroke, a stroke prior to or shortly after birth. Modern treatments benefit the patient via mechanisms involving neuroplasticity, the ability of the brain to recover function after traumatic injury. This "re-wiring" of the brain is a process that is strongest in early childhood during rapid brain development (Kolb, 1995). I predicted that early intervention in children who have suffered from a perinatal stroke is one of the most effective treatments, leading to the highest success rate. Modern literature on brain plasticity and perinatal stroke was evaluated and compared to the case of a young adult who experienced a perinatal stroke. By studying the medical records and interviewing the patient and family members, I was able to compare the patient's treatment and outcome relative to those identified in the current scientific literature. As a result, I was able to observe how this patient reacted to early intervention and the recovery process following traumatic brain injury.

Keywords: neuroplasticity, perinatal stroke, cerebral palsy, early intervention

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Ischemic stroke occurs when blood circulation (and thus oxygen supply) to a specific area of a brain is lost for a brief moment, usually because of a blood clot or an abnormal narrowing of the blood vessels This potentially leads to extensive brain damage in the affected area; widespread bodily effects are often most noticeable. While strokes are frequently associated with the elderly population, strokes in utero or early infancy are also common. Data indicate that these strokes, called perinatal strokes, exhibit a high risk: 1:4000 live births (Lynch, 2001).

Perinatal strokes occur from the twenty-eighth week of gestation to approximately one month after birth. Perinatal strokes are specifically limited to those caused by asphyxia, or lack of oxygen to the brain. Asphyxia can be caused by, among other events, umbilical cord compression or hemorrhaging.

Cerebral palsy is often a result of stroke in infants and children wherein substantial death of brain cells occurred. About half of children affected by cerebral palsy also suffer from seizures, most often tonic-clonic in nature (previously referred to as grand mal seizures). Seizures occur due to hyperexcitability of neurons; in a brain with vast injuries following a stroke, the damaged neuronal regions become increasingly susceptible to this misfiring (Stanton, 2012).

Despite the prevalence of perinatal stroke, very little is known about its causes. Complications during the pregnancy and during birth are often present alongside perinatal stroke; however, there is no definitive evidence to support these complications as the cause. Otherwise normal pregnancies may also result in an infant with perinatal stroke, therefore confounding researchers' pursuit to identify the causal origin of perinatal stroke. Currently, there is very little

research on preventative approaches to perinatal stroke; as such, it is important to advocate for early intervention in the child's life.

Brain plasticity plays a major role in early childhood, allowing the ongoing development of the young brain to "re-wire" after a traumatic injury to compensate for brain damage. Outside of injury, neuroplasticity is the dogma by which many early childhood educators and interventionists follow. Therefore, it is important to treat the consequences of a perinatal stroke as early as possible to ensure optimal rehabilitation of the brain; this may include physical and speech therapy, as well as family support.

This paper will examine Lila (name changed to protect privacy), a twenty-year-old female who suffered a stroke prior to her birth. Analyzing Lila's medical history as well as her development over the course of twenty years, I sought to establish a case advocating early intervention and parental involvement.

Literature Review

Neuroplasticity, as Kolb explains, stems from the brain's ability to alter itself with experience; new connections are made between neurons for every task or piece of information learned. These processes are recruited again after a traumatic brain injury to reorganize and allow lost connections to be somewhat reestablished (1995). Kolb continues that in the case of brain damage, indirectly affected neurons either die, have reduced input, or are re-innervated (1995). Generally, regrowth and reorganization is the creation of new synapses.

Following stroke, Kertesz showed quick recovery of language after aphasia (the loss of ability to understand or express speech) within the first year, depending on the age and severity of the injury (1979). Paul Broca (whom Broca's Area is named for) noted that childhood injury in language centers of the brain rarely resulted in aphasia (Kolb, 1995). A famous study by

Lenneberg in 1967 took Broca's observations and paired them with the growth of language processes from ages 2 to 5. He predicted and demonstrated that brain damage to the left hemisphere during this period of growth would allow the brain to shift language processing to the right hemisphere (Lenneberg, 1967).

Duncan and Lai concluded in their study that hemiparesis is initially observed after a stroke, which is then followed by rapid recovery in a period of time up to six months (1997). The damaged area's responsibilities may shift to another area, and can usually perform the lost task in a different way (Levin & Grafman, 2000). However, epilepsy and other forms of seizure, which are often comorbid with ischemic stroke, can interfere with this period of recovery (Engel, Schwartzkroin, Moshé, & Lowenstein, 2001).

Basu's paper discusses why ischemic stroke is so dangerous in newborns; unlike adults, who quickly present with stroke symptoms, infants present with seizures, lethargy, and poor feeding (2014). Likewise, there is very little immediate treatment for these infants and usually only involves stabilization. Basu calls early intervention in these cases "damage control," aiming to help the child during their first few years of life, during developmental changes (2014).

Among Basu's suggestions for initial treatment, she lists therapeutic hypothermia, stem cell transplantation, and non-invasive brain stimulation (2014). Most of these are still in clinical trials, thus unavailable at this time. Basu advocates initiation of therapy in infancy to ensure the best potential for recovery. Physical therapy helps affected muscles and limbs; social therapy involves playing with other children their age to trigger mirror neurons (2014). Mirror neurons are those that are activated when a child watches another complete a task and tries to mimic their movements. Basu hypothesizes that these neurons are key to helping affected children recover brain function and capabilities.

Another study conducted at the University of Alabama explored the possibility of Constraint-Induced Movement therapy (CI therapy), to assist children affected by stroke to recover some use of their limbs. CI therapy involves restraining less affected limbs so the child is forced to use their weaker arm (Taub, Griffin, Nick, Gammons, Uswatte, & Law, 2006). They found that CI therapy significantly improved ability in adults to use an extremity that had been affected by stroke (Taub et. al. 2006). Therefore, they explored whether this therapy would be more effective in children due to neuroplasticity. While adults and children undergo very different functional tests, they were able to compare the two groups and discovered that young children performed substantially better with a wide margin for error (Taub et. al. 2006). They concluded that while CI therapy was not a complete treatment for cerebral palsy, it significantly improved motor functioning, presumably due to brain plasticity (Taub et. al. 2006).

In evaluating cognitive and physical development in children, often the most difficult aspect is acquiring reliable information (Simeonsson & Rosenthal, 2001). Children are still growing and learning, and thus do not have equivalent capacities as adults; therefore different kinds of evaluation are required. These assessments have three major goals: determine a diagnosis, plan intervention, and monitor the child's progress (Simeonsson & Rosenthal, 2001). Children with disabilities often develop at different rates than their peers without disabilities, such that typical assessment standards commonly require adjustment. These adjustments could include different standards that take into account the child's starting level of capability, as well as different evaluative techniques to better recognize incremental improvements in skills.

Ponsford outlined what she has identified as key to a child's recovery and success in ten steps; a few are specifically pertinent to this paper. First, it is important to have multiple members of a rehabilitation team that all work together, in order to ensure all aspects of

traumatic brain injury are accounted for (Ponsford, 2004). Involvement of the family and the child is important to ensure a strong support network and that the therapy is actually effective (Ponsford, 2004).

This support network extends beyond the immediate family to include other adults that have the chance to influence the developing child. This includes teachers, childcare providers, and programs that offer early screening and intervention. The state of Oklahoma offers a program, Sooner Start, that provides services such as counseling, training, therapy and evaluation free of charge to children and their families for the first three years of age. The Education for All Handicapped Children Act of 1975 (Public Law 94-142) was signed into law to meet the educational needs of disabled children. This law, and its amendments, were some of the first laws enacted that recognized the importance of early intervention and the child's support network in development. In 2004, the Individuals with Disabilities Education Act (IDEA) added aspects of Public Law 94-142 to its coverage, ensuring care of infants and toddlers with disabilities. The U.S. Department of Education, in a report to Congress, showed that a majority of children who had been covered under the IDEA improved in five developmental areas: cognitive, physical, communication, adaptive, social/emotional, and communication (U.S. Department of Education, 2007).

Limitations of These Studies

The most notable limitation of studies focusing on perinatal stroke in children is that it is initially a purely observational study. As it is unethical to induce stroke, researchers are limited to studying events only after they have occurred. This results in fewer controls in experiments (e.g., pre-stroke) and researchers must acknowledge that these circumstances do affect the results

of their experiments. Interpretation of data and findings must then take place within the scope of these limitations.

Other complications arise when working with children; they have different capabilities than adults and are in a different psychological state. Young children may not be able to voice their experiences and may be uncooperative with treatment. Informed consent is also not possible with children; this task falls to their parents.

While many of these problems are unavoidable, perhaps having extensive medical background and interviews with an affected child who is now entering adulthood will provide insight into development and responsiveness.

Methods

Assessment of current knowledge and research findings available through publications were compared to a study of a twenty-year-old female perinatal stroke victim. Medical records were obtained from the patient's mother, and HIPPA protocols were followed to ensure the privacy and security of the patient. A series of three interviews were conducted with the patient and patient's immediate family. These interviews were structured as question and answer sessions, with time for comments from participants. Interviews took place in the patient's home by their request.

Case Study

Lila (name changed for privacy purposes) was delivered via spontaneous vaginal birth. Her mother experienced a high risk factor, placenta previa (partial or complete blockage of the cervix with the placenta), which resolved itself at 38 weeks without intervention. The umbilical cord was found to have been wrapped slightly around Lila's neck, known as a nuchal cord. Initial observation and assessment showed acrocyanosis, which is blueish discoloration of extremities

such as hands and feet, evidence of low oxygen blood circulation. Lila received a 9 on the Apgar test at minutes 1, 5, and 10, indicative of a healthy newborn.

However, the following day, Lila was admitted to the Neonatal Intensive Care Unit for apnea and cyanosis, as well as decreasing temperature overnight. Upon first admission to the NICU, suspicion of neonatal seizures was very low, and a plan involving a CT scan of the brain and cardiac workup was followed.

The CT scan revealed a large infarction of the right hemisphere, and an EEG was found to be abnormal, presenting waves indicating seizures. These seizures were described as "very frequent electrographic seizures originating from central region were seen. These lasted for up to 100 seconds in duration." At this point, outlook of survival was very low and all medical records from this time period refer to Lila as "Girl" to avoid parental attachment in case of death. Phenobarbital was prescribed to minimize convulsions. Lila experienced nine apneic episodes within the NICU, which resolved the day before discharge.

Five days after birth, Lila was found to have improved and was released from the hospital with a home apnea monitor. Approximately one month later, Lila was taken for a physical therapy evaluation to treat the apparent hemiparetic cerebral palsy that affected the left side of her body. This condition included weakness in her left arm and leg, called hypertonicity, which causes spontaneous movements of her left extremities to be diminished. Shortly thereafter, she received a neurological follow-up that indicated some abnormalities in brain functions (due to brain damage), but significantly decreased instance of seizures. At this point, it was uncertain if Lila would be able to achieve normal developmental stages.

Lila's parents continued to take her to physical therapy as well as speech therapy for some verbalization problems. Lila attended a private preschool; upon attending public school

Lila was supported by a team of counselors and therapists who worked to ensure her success. Lila obtained an Individualized Education Program (IEP) that extended deadlines for homework, allowed for one-on-one time with teachers, and provided opportunities for Lila to attend therapy and programs with other children under similar circumstances. At age thirteen, Lila received her first psychological evaluation to assess potential mental disabilities. Despite earlier doubts about her future, Lila scored average on the Wechsler Intelligence Scale for Children and showed very few developmental delays. This evaluation also screened for ADD and ADHD; the results were found to be negative. Lila was also administered the Autism Diagnostic Observation Schedule; this indicated that Lila could be considered borderline and she received a diagnosis of Autism Spectrum Disorder. Other noted concerns included decreased social awareness and high levels of withdrawal/depression. No further steps were taken at this time to treat suspected disorders.

At age seventeen, Lila had a new onset seizure, which eventually led to recurring seizures. After a follow-up exam, Lila was equipped with a portable EEG to monitor abnormal brain activity. Several seizures were observed, and as a result, she was prescribed levitracitam, an antiepileptic Lila had several appointments with a neurologist, who also observed aforementioned symptoms.

As of our last meeting, Lila continues to thrive. Lila reports that the levitracitam has so far suppressed any seizures. Lila is attending college with some self-reported difficulties, but is achieving much more than was initially predicted at her birth.

Discussion

Lila's case is not unusual; the prevalence of births involving an infant that has suffered a perinatal stoke is predicted to approach 1:4000 (Lynch, 2001). While complication during pregnancy is often cited as a potential contributor, that is not always the case. However, in Lila's

case, it was observed that she was born with a loose nuchal cord. At the time, it was deemed to be unrelated to any complication in Lila's development or birth. It is possible that the umbilical cord could have tightened at any point around Lila's neck. A compression of the umbilical cord could have led to lowered blood flow and hypoxia, either of which can cause stroke.

Lila experienced a type of cerebral palsy, hemiparetic, which is not uncommon in the case of stroke. Cerebral palsy is often comorbid with epileptic seizures; Lila's seizures are, therefore, not entirely unexpected (Stanton, 2012).

If anything is to be gleaned from Lila's case, an increase in awareness and training for medical staff is warranted. There were multiple signs of complications in her birth, including the nuchal cord and acrocyanosis. As Basu had pointed out in her paper, many times infants with ischemic stroke are often misdiagnosed and treated for seizures, lethargy, and poor feeding, all of which Lila presented with (2014). The earlier the newborn is treated for stroke, the better their chances for survival and recovery.

In line with what the reviewed material suggested, Lila received physical therapy very early on, approximately one month after her birth. She continued physical therapy alongside speech therapy, with excellent family support the entire time. While Lila did not experience other treatments mentioned before, such as therapeutic hypothermia, stem cell transplantation, non-invasive brain stimulation, and CI therapy, it is likely that these treatments would have also helped her recover.

Conclusion and Future Study

All of the studies and resources evaluated throughout this paper support early intervention, a key in exploiting neuroplasticity. To ensure optimal recovery from ischemic stroke, beneficial approaches include quick stabilization, early physical therapy, and social

exposure. Lila presented as a typical perinatal stroke victim, and her apparent success is likely due in part to the early intervention she received.

Research to identify better methods of therapy and support for continued clinical trials is justified. These topics are the best hope for future affected children with ischemic stroke. "Damage control" therapies and providing parents and other influential adults with information to support the development of these children proves to create the best outcome after perinatal stroke.

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