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Pediatric Brain Tumors & Subsequent Communication and Swallowing Disorders.

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PEDIATRIC BRAIN TUMORS AND SUBSEQUENT COMMUNICATION AND SWALLOWING DISORDERS

By
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DEDICATION

This thesis is dedicated to my Lord and Savior Jesus Christ who makes all things possible and to my parents who have supported me throughout this project. This thesis would not be complete without their encouragement and faith in me, even when I had little faith in myself.

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ABSTRACT
PEDIATRIC BRAIN TUMORS AND SUBSEQUENT COMMUNICATION AND SWALLOWING DISORDERS
(Under the direction of Dr. Carolyn Wiles Higdon)

This study was designed to determine if there were speech, language, or swallowing disorders in a child with a brain stem glioma tumor or medulloblastoma tumor. It also was designed to determine if motor speech was more affected than swallowing in a child with a brain stem glioma tumor and in a child with a medulloblastoma tumor. Thirdly, this study investigated the incidence and treatment of speech, language, or swallowing disorders through survey. The surveys were sent through the United States Postal Service to speech-language pathologists (SLPs). The SLPs worked in pediatric hospitals or hospitals with pediatric floors. The purpose of the surveys was to gain information regarding the SLPs' perceptions regarding prevalence of communication and/or swallowing disorders and type and duration of communication and/or swallowing disorders found following medical management. The researcher's first hypothesis was that there were no diagnosed disorders of speech, language and/or swallowing in a child with a brain stem glioma tumor or medulloblastoma tumor. The researcher's second hypothesis was that swallowing disorders were the primary communicative disorders identified and treated by SLPs in a child with a brain stem glioma tumor or medulloblastoma tumor. The results of this study showed the first hypothesis to be rejected due to the identification of speech, language and/or swallowing disorders in children with the two types of tumors. The results of this study also showed no significant difference between the number of SLPs who identified swallowing disorders and the number of SLPs who identified motor speech disorders in children with brain stem gliomas or medulloblastomas.

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INTRODUCTION

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INTRODUCTION

Brain tumors are the second most common form of pediatric cancer behind leukemia, affecting between 1,500 and 2,000 children annually (Tomita, 2000). Such tumors result from the abnormal growth of brain tissue. Some common types of pediatric brain tumors, or neoplasms, are astrocytomas, medulloblastomas, or ependymomas (see Appendix H for a list of definitions). Astrocytomas are central nervous system (CNS, Appendix G) neoplasms derived from astrocytes, which are cells found between blood vessels and neurons (Greenberg, 1997). The term "medulloblastoma" describes a series of tumors found in the cerebellum of a child's brain (Bailey & Cushing, 1925). An ependymoma is a type of glioma that comes from ependymal cells, which are cells that line the ventricles within the brain and the center of the spinal cord (Capodano, 2001).

Children diagnosed with brain tumors have symptoms of headaches, blurred vision, drowsiness, weakness in their limbs, balance problems and impaired speech. These children also may have seizures, vomit suddenly, exhibit changes in behavior, and exhibit an increase in head size. Brain tumors are classified according to their size, location, and cell origin. Treatment for most tumors may include chemotherapy,

radiation therapy and/or surgery. Children often require extensive rehabilitation following medical treatment. This may include speech-language therapy, physical therapy, and occupational therapy to address resultant problems in communication, motor activities and activities of daily living (ADLs), as well as cognitive and educational therapy.

Physicians diagnose brain tumors through the use of computed tomography (CT) scans, which were developed in the mid-1970s (Tomita, 2000). These CT scans show the skull framework, and presence of blood clots and tumors. CT scans allow physicians to obtain a more comprehensive understanding of the pathological changes that may have occurred due to the blood clots or tumors. Tumors appear white, while the rest of the brain appears grey, helping physicians' identification. Also, cerebrospinal fluid (CSF), fat, and air appear black on CT scans helping to identify pathological changes (Tomita, 2000). Possible changes could include hydrocephalus, brain edema, hemorrhages, cysts, or calcifications. Physicians also use magnetic resonance imaging (MRI) to identify brain tumors. MRIs, introduced in the 1980s, give a three-dimensional image that is clearer and crisper than CT scans by combining high-frequency radio waves and a strong magnetic field to produce an image of the inside of the brain (Jallo & Epstein, 2004). Magnetic resonance angiography (MRA) provides information on the vascularity of the tumor, and magnetic resonance spectroscopy (MRS) provides information on the chemical make-up of the tumor to differentiate tumors from other growths (Tomita, 2000).

Medical treatment options for pediatric brain tumors include chemotherapy, radiation and surgery (Packer, 1999). Chemotherapy attempts to inhibit cell growth

and metabolism so that the mutant cells will not continue to reproduce, and therefore the tumor will not grow (Rood, n. d.). Each type of chemotherapy drug affects cells in a different way; therefore multiple chemotherapy drugs are used in treatment. The problem with chemotherapy is that the drugs affect not only just the cancer cells, but also the healthy cells, which weakens the child's immune system. For brain neoplasms, chemotherapy can be administered through the carotid artery (intra-arterial) or directly to the CSF (intrathecal) (Rood, n. d.). Intra-arterial chemotherapy is given to either side of the posterior fossa, and the circulation delivers a high concentration to the intended area. Intrathecal chemotherapy is given directly to the CSF space and along the CSF pathway. This type of chemotherapy delivers a higher concentration to the tumor cells lurking in the CSF pathway. Intrathecal chemotherapy can be administered via spinal taps or catheter. Physicians choose and change the chemotherapy protocol (whether intra-arterial or intrathecal) based on the child's type of tumor and his/her response to previous treatment. (Rood, n. d.)

Physicians use radiation therapy for children with malignant brain tumors or unresectable benign brain tumors in order to hopefully eradicate the microscopic cells that may have escaped surgery. These residual tumor cells are the main cause of recurrent tumors. High energy rays infiltrate the dermis and internal skull structures during external beam radiation therapy (EBRT), where the beam is directed from an outside source such as a linear accelerator (Black, 2006) and exposes everything in the radiation's path (Tomita, 2000). As a result, EBRT may also affect hair cells and bone marrow which may cause children to lose their hair and to have a decreased number of white blood cells, platelets, and red blood cells. EBRT may also affect the

endocrine organs, pituitary gland function, thyroid gland function and blood vessels. Internal radiation therapy (IRT), as opposed to the EBRT, involves surgeons inserting a catheter containing small radioactive seeds in the tumor. The surgeon then removes the seeds after the prescribed dose of radiation is delivered (Tomita, 2000). This procedure administers the radiation just to a single area reducing the risk of exposing healthy brain tissue to high doses of radiation (Merchant, 2008). Intellectual deficits resulting from secondary effects of radiation therapy are a concern (Spiegler, Bouffet, Greenberg, Rutka & Mabbott, 2004).

Surgery is the primary treatment of pediatric brain tumors, especially benign tumors. Even when total resection is not possible, surgery may be beneficial to children with large, malignant tumors by removing as much of the tumor as possible, allowing chemotherapy and/or radiation therapy to have a stronger effect. As technology improves, surgical resection techniques improve giving surgeons the means to completely remove brain tumors (Stargatt, Rosenfeld, Maixner & Ashley, 2007). Preoperative CT scans and MRI images guide the neurosurgeon to the exact location of the tumor during surgery, greatly increasing the surgeons' ability to find and remove the tumor. Tumors invading the brain stem, diencephalons, or optic chiasm, however, are unresectable, but they may be operable (see Appendix I for diagrams of the brain). Surgical complications that may occur include hemorrhaging, swelling in the cranial cavity, infection, and neurological deficits. These complications are also possible precursors to speech, language, hearing, and swallowing issues. (Tomita, 2000)

In this thesis, the main tumors considered are medulloblastoma tumors and brain stem glioma tumors. These tumors were chosen for the study because they both originate in the posterior fossa portion of the brain and are two of the most common brain tumors in children. A medulloblastoma tumor is one type of malignant brain tumor that arises in the fourth ventricle and cerebellar vermis, or the posterior fossa region of the brain (Stargatt, et. al., 2007). Scientists believe these tumors originate from the posterior medullary velum, but the exact cellular origin is still unknown. These tumors account for 20% of childhood brain tumors, and 15% of medulloblastomas occur in the cerebellar hemisphere (Gajjar & Doyle, n.d.). In most cases these tumors occur in the first ten years of a child's life with 50% occurring in the first five or six years (Disease Information, Medulloblastoma/PNET, n. d.). Children usually have headaches and vomiting, and may also appear clumsy exhibiting problems with motor tasks such as handwriting, with symptoms worsening over time. If the tumor has spread to the spinal cord region, children may experience back pain, problems with walking, and/or lose control of their bladder. Physicians most often treat medulloblastoma tumors with surgery, radiation, and/or chemotherapy. Individuals with medulloblastoma neoplasms have a high survival rate (60% to 80%) due to surgeons' ability to remove a majority of the tumor during initial surgery and due to the rehabilitative therapies following surgery. Children also must undergo postoperative radiation and chemotherapy in order to ensure there are no cancerous cells still lurking in the brain. (Tomita, 2000)

Brain stem glioma tumors are tumors that arise along the midbrain, pons, or medulla, deep in the posterior portion of the brain with a majority of brain stem

glioma tumors occurring in the pons. These brain stem tumors account for 25% to 30% of childhood brain neoplasms and most often occur in children between the ages of five and ten years old (Al-Shatoury, Galhom & Engelhard III, n. d.). Pontine brain stem gliomas, in particular, affect the cranial nerves causing abducens nerve and facial nerve palsy, dysarthria, ataxia, and hemiparesis (Tomita, 2000). Abducens palsy affects the sixth cranial nerve, which controls eye movements (Ehrenhaus & Hajee, 2006). Surgery is not usually a viable option for brain stem gliomas because these tumors entrench themselves over too large an area of the brain stem making complete removal of the tumor difficult. Surgery, however, may be an option for localized brain stem gliomas because it can be used to remove parts of the tumor (Disease Information, Brain Stem Glioma, n. d.). Radiation and chemotherapy are introduced to reduce the growth of a brain stem glioma tumor, with radiation therapy, usually being the initial choice for treatment (Disease Information, Brain Stem Glioma, n. d.). Children with pontine gliomas rarely survive 12 or 14 months post diagnosis, but children with a midbrain or medullary glioma have a 65% to 90% chance of survival (Tomita, 2000).

The incidence of pediatric brain tumors has increased from 2.5 to 4 per 100,000 per year (Packer, 1999) to 4.5 per 100,000 per year (CBTRUS, 2007-2008). This number has risen not only due to improved diagnostic methods and increased awareness, but also due to environmental factors (Tomita, 2000). The following statistics are according to the 2007-2008 Central Brain Tumor Registry of the United States (CBTRUS). Every day nine more children in the United States are diagnosed with a brain tumor, and there are over 120 types of brain tumors. Only sixty-six

percent of children diagnosed with brain tumors survive more than five years. Survival rate has improved only slightly over the past few years, a fact supporting the need for an increase in research on pediatric brain neoplasms. Researchers are currently striving to understand the changes that can occur in tumor cells to create cancer (Tomita, 2000). Scientists believe that studying the genetic characteristics of these cells will help identify tumors requiring particular types of treatment. Radiation oncologists are investigating how to provide radiation therapy in a manner that will lessen the damage to normal brain cells (Disease Information, Brain Stem Glioma, n. d.). Scientists at St. Jude Children's Research Hospital, (www.stjude.org), are also conducting stem cell research to develop new ways to use high-dose chemotherapy. They are also testing using more intensive chemotherapy on children with low-risk and high-risk tumors (Disease Information, Medulloblastoma/PNET, n. d.). Specifically for medulloblastoma tumors, much research is being directed toward finding ways to reduce the intelligent quotient (IQ) loss which often occurs post-treatment (Disease Information, Medulloblastoma/PNET, n. d.). Scientists are studying new drugs for brain stem neoplasms which will enhance radiation therapy and as well as new radiation techniques which provide for more localized therapy (Tomita, 2000).

The author of this study is familiar with the great strides in cancer research made by St. Jude Children's Research Hospital's (Memphis, Tennessee). The author developed an interest in the role of the speech language pathologist (SLP) in the management of children diagnosed with pediatric tumors, after volunteering at the Ronald McDonald House and Target House, which house families of patients being

treated at St. Jude Children's Research Hospital. Personal appreciation of the devastating effects that a speech, hearing, and/or swallowing problem resulting from treatment for a brain tumor creates for families led to this research project.

CHAPTER TWO

LITERATURE REVIEW

CHAPTER TWO

LITERATURE REVIEW

Research on pediatric brain tumors covers many aspects, such as the causes of tumors, differences between the tumors, primary and secondary effects of the tumors, treatments for tumors, and different surgical strategies. Although some tumors are considered treatable in children, many are not treatable. The growth of these tumors may be slowed down, but they are often unresectable (Tomita, 2000). Tumors considered unresectable, yet operable, are those entrenched in the brain stem, diencephalons, or optic chiasm (Tomita, 2000). The prescribed course of treatment depends on the size and location of the tumor, and the prognosis given by the physician (Packer, 1999). Physicians also consider the possible side effects of treatment and how these side effects may affect the child's daily life (Packer, 1999). Researchers are investigating these side effects as well as treatment options in hopes of increasing survival rates and improving the children's quality of life.

The purpose of this literature review is to give the reader general information about pediatric brain tumors, to identify research concerning both brain stem gliomas and medulloblastomas (the two tumors studied in this thesis), to give information about speech and language disorders occurring as a result of the brain tumors, to

explore posterior fossa syndrome and to consider whether oral and pharyngeal dysphagia may occur as a result of these two pediatric brain tumors. The literature is divided into five sections: general information, information on brain stem gliomas, information on medulloblastomas, information on speech, language and/or swallowing disorders that may occur as a result of the tumor and/or treatment, and information on posterior fossa syndrome.

General Information

There are 1,200 to 1,500 children under 16 years of age diagnosed with brain tumors yearly (Robertson, 1998). Carpentieri, Waber, Pomeroy, Scott, Goumnerova, Kieran, Billett, and Tarbell (2003) claimed that because the treatment of brain tumors has advanced and survival and cure rates have increased, the quality of life issues, including neuropsychological outcomes, have greater relevance. Thus, identification of factors associated with the tumors and medical treatments that can affect the outcome of the rehabilitative treatments is extremely important.

Sala, Colarusso, Mazza, Talacchi, and Bricolo (1999) studied brain tumors in children under the age of three years after the introduction of magnetic resonance imaging (MRIs). Their research indicated that the incidence of brain tumors in children under the age of three has increased because of the introduction of MRIs, but that the risk factors (including sex, age, duration of symptoms, intracranial hypertension on admission, tumor location, surgical removal, and histology) have not been completely identified. The most common symptoms of these tumors were vomiting, delayed development, increase in head circumference, lethargy, irritability, and motor deficits. The majority of early childhood brain tumors identified in Sala,

et. al.'s study (1999) occurred in midline structures in the brain, especially the fourth ventricle and the hypothalamus region. These tumors were referred to as low-grade tumors, which are more localized and grow slower (Disease Information, Astrocytoma/Glioma, n. d.).

Poggi, Liscio, Galbiati, Adduci, Massimino, Gandola, Spreafico, Clerici, Fossati-Bellani, Sommovigo, and Castelli (2004) researched general cognitive and psychological disorders as a result of brain tumors in children and adolescents. Discrete lesions in the cerebellar vermis and deep nuclei can have profound effects on cognitive functions and often are reasons for some cognitive disorders following treatment of pediatric brain tumors (Wisoff & Epstein, 1984, Humphreys, 1989, Pollack, Polinko, Albright, Towbin, & Fitz, 1995). Cognitive and psychological disorders comprised the most frequently observed pathological conditions following pediatric and adolescent brain tumors. A reason, according to Stargatt, Rosenfeld, Maixner, and Ashley (2007), is because there is a range of tumor and treatment complications. The exploration of psychological disorders resulting from tumor growth has been scarce, with the main focus directed to diagnosis and treatment of resulting motor and sensory disorders. An overall decrease in children's intelligent quotient (IQ) scores was reported during neuropsychological studies, and the main risk factors appeared to be age, site of lesion, infections, treatment regimen, and increase in intracranial pressure. The primary psychological problems, according to the *Child Behavior Check List (CBCL)* (Achenbach & Edelbrock, 1983), were withdrawal (22.6% of the population studied), decrease in social skills (22.6% of the population studied), and internalizing problems (48.4% of the population studied).

All three test groups were impaired cognitively, but the oldest children in the study were more cognitively impaired. Researchers found a parallel between cognitive and psychological disorders as a result of a brain tumor. The cognitive disorders identified appeared to cause more learning difficulties and then indirectly create the psychological disorders (Poggi, et. al., 2004).

Brain Stem Gliomas

Over one-half of all pediatric brain tumors are glial tumors. Low-grade glial tumors occur in the posterior fossa and diencephalic region (Packer, 1999). More than 90% of these children die within 18 months of diagnosis, because of the speed and progressive nature of these tumors. One notable advancement, however, is the understanding that not all brain stem tumors are diffuse intrinsic brain stem glioma tumors. Twenty percent (20%) will be more focal lesions, which are usually astrocytomas, and have a more favorable prognosis in terms of survival. Surgery for brain stem gliomas may help control the growth and prolong life for a time, but may also cause neurological impairments. Chemotherapy or radiation may result in more long-term disease control, and less neurological impairments (Packer, 1999).

Benesch, Lackner, Moser, Kerbl, Schwinger, Oberbauer, Eder, Mayer, Wiegele, and Urban (2001) explored the long-term effects of radiochemotherapy for pediatric brain stem gliomas. The children were given simultaneous radiochemotherapy during the first cycle of chemotherapy. Doctors found neurological deficits in all children after diagnosis of the brain tumor, but no increase in these deficits after neurorehabilitation. The median survival rate for children with brain stem gliomas was less than one year, according to Benesch et al's study.

Researchers found, in most cases, that the long-term survival rate was just as high in patients treated only with radiation as those treated only with chemotherapy.

Medulloblastomas

Medulloblastomas were the other type of pediatric brain tumor researched throughout this literature review. Many medulloblastoma tumors arise from the cerebellum and surrounding structures (Stargatt, et. al., 2007). According to Schmahmann and Pandya (1997), the cerebellum is strongly interconnected with the cerebral hemispheres in both feed-forward and feed-back directions. Because of this fact, researchers suggested the cerebellum could play a role in higher cortical functions, such as attention regulation and information processing (Stargatt, et. al., 2007). Such observations are important for children with posterior fossa tumors because of the link between cerebellar damage and long-term cognitive disorders. Researchers have observed cognitive disorders in this population (Beebe, Ris, & Holmes, 2001; Copeland, De Moor, Moore, & Ater, 1999; Karatekin, Lazareff, & Asarnow, 2000; Le Barro, Zeltzer, Zeltzer, Scott, & Martin, 1988; Levisohn, Cronin-Golomb, & Schmahmann, 2000; Palmer, Gajjar, Reddick, Glass, Kun, Wu, et. al., 2003; Riva & Giorgi, 2000; Riva, Panelaeoni, Milani, & Fossati, 1989; Scott, Stoodley, Anslow, Paul, Stein, Sugden, et. al., 2001). One complication of medulloblastoma resection surgery (surgery to excise the tumor) is hydrocephalus (Jacobs, Northam, & Anderson, 2001; Stargatt, et. al., 2007). Hydrocephalus significantly impacts cognitive development in children with brain tumors (Anderson & Taylor, 1999; Anderson, Northam, Hendy, & Wrennall, 2001; Jacobs, et. al., 2001), especially in information and attention processing, and memory, language and

executive deficits (Anderson et al, 2001). Postoperative cerebellar mutism syndrome (CMS) and posterior fossa syndrome were observed in many children with medulloblastoma tumors following medical treatment.

Speech-Language Disorders after Brain Tumors

Goncalves, Radzinsky, da Silva, Chiari, and Consonni (2006) observed the speech, language, and hearing development of children with brain tumors. The speech-language pathologists (SLPs) evaluated the children, through clinical protocol, in the areas of swallowing, voice, speech, oro-facial evaluations, language, and hearing development to identify the primary communication and swallowing disorders. Most of the children (41%) complained of swallowing disorders over speech or language disorders (29%), but 81% of the children were diagnosed with a speech, language, and/or hearing disorder. Testing revealed additional disorders, including dysphonia (14%), which is a phonation disorder characterized by breathy voice quality, hearing problems (9%), and facial palsy (6%). The results of the study reinforced the presence of speech, language, hearing, and swallowing disorders in children with these particular brain tumors.

Levisohn, Cronin-Golomb, and Schmahmann (2001) studied the neuropsychological consequences of cerebellar tumor resection in children. The children in their study did not receive radiation or types of chemotherapy drugs that were shown to have cognitive or behavioral effects. The researchers found these children had impairments in a) planning, sequencing and visual-spatial functions, b) expressive language, c) verbal memory, and d) modulation of affect. In combination, these deficits form the characteristics of cerebellar cognitive affective syndrome. The

children were tested with a battery of neuropsychological tests, to include the *Wechsler Preschool and Primary Scales of Intelligence (WPPSI-R)* (Wechsler, 1989), *Differential Abilities Scale (DAS)* (Elliott, 1990), *Naming Vocabulary* (McGrew & Flanagan, 1998), *Logical Memory Passages for Children* (Wechsler, 1945), *Beery Visual Motor Integration (VMI)* (Beery, Buktenica, & Beery, 2006) and the *Gardner Expressive One-Word Picture Vocabulary Test (EOWPVT-R)* (Gardner, 1990), pre and post surgery. Physicians considered these children to have a deficit in cognitive or behavioral effects if they noticed a persistent, postoperative change. Thirty-four of the children evaluated in this study were diagnosed with medulloblastomas. Most of the 34 children in this study exhibited visual-spatial difficulties, deficits in expressive language, deficits in memory, and affective changes.

Docking, Ward, and Murdoch (2005) studied the language outcomes as a result of brain stem tumor treatment in children. Four of the children were diagnosed with low-grade astrocytomas, one child was diagnosed with an ependymoma, and one child was diagnosed with a brain stem glioma. Previous research stated that transitory mutism and dysarthria were related to the removal of midline cerebellar tumors (Lalonde & Botez-Marquard, 2000). Docking, et. al. (2005) evaluated the children in the areas of general language and high-level language/phonological awareness using several tests which are listed in Table 2.1 below.

Test Name	Test Purpose	Author	Year
Clinical Evaluation of Language Fundamentals-Third Edition (CELF-3)	General Language Assessment	Semel, Wiig, & Secord	1995
Clinical Evaluation of Language Fundamentals-Preschool (CELF-P)	General Language Assessment	Wiig & Secord	1992

Peabody Picture Vocabulary Test-Third Edition (PPVT-III)	General Language Assessment	Dunn & Dunn	1997
Hundred Pictures Naming Test (HPNT)	General Language Assessment	Fisher & Glenister	1992
Test of Problem Solving-Elementary, Revised (TOPS-Elementary)	High Level Language	Zachman, Huisingh, Barrett, Orman, & LoGiudice	1994
Test of Problem Solving-Adolescent (TOPS-Adolescent)	High Level Language	Zachman, Berrett, Huisingh, Orman, & Blagden	1991
Test of Word Knowledge (TOWK)	High Level Language	Wiig & Secord	1992
Test of Language Competence-Expanded Edition (TLC-E)	High Level Language	Wiig & Secord	1989
Queensland University Inventory of Literacy (QUIL)	Phonological Assessment	Dodd, Holm, Oerlemans, & McCormick	1996
Test of Phonological Awareness (TOPA)	Phonological Assessment	Torgesen & Bryant	1994

Table 2.1. Communication Tests Administered in the Docking et al Research

Researchers did not find a significant difference between the general language abilities and high-level language abilities in children treated for brain tumors and children who did not have a brain tumor.

Research has also shown that cranial radiation therapy is associated with adverse neuropsychological sequelae (abnormal conditions resulting from a previous disease) in all children treated for cancer (Anderson, Smibert, Ekert, & Godber, 1994; Cousens, Waters, Said, & Stevens, 1988; Heideman, Packer, Albright, Freeman, & Rorke, 1997; Packer, Sutton, Atkins, Radclif, Bunin, D'angio, et. al., 1989). Short-term memory, attention and cognitive processing in general were reported to be affected (Pfefferbaum-Levine, Copeland, Fletcher, Reid, Jaffe, & McKinnon, 1984). The results of earlier studies (Hoppe-Hirsch, Renier, Lelliuch-Tubiana, Sainte-Rosen, & Pierre-Kahn, 1990) showed a decline in IQ that progressed over time, but

evaluations of more recent treatment protocols showed a plateau of decline occurring at six years post-treatment for younger children (Palmer, et. al., 2003).

Papazoglou, King, Morris, and Krawiecki (2008) studied the relationship between adaptive functioning and cognitive abilities. They cited the fact that "childhood brain tumor survivors continue to be vulnerable to altered cognitive, social and behavioral functioning," based on Aarsen, Van Dongen, Paquier, Van Mourik, and Catsman-Berrevoets' 2004 article, "Long-term Sequelae in Children after Cerebellar Astrocytoma Surgery." Papazoglou, et. al. (2008) cited the lack of research done on the relationship between adaptive functioning and cognitive abilities with the pediatric neurological population. The authors proposed that tumors in different locations would lead to different types of cognitive disorders. These cognitive disorders would then be a factor in the adaptive functioning outcomes. Papazoglou, et. al. (2008) explained adaptive functioning as "assessing the ability of people to take care of themselves and interact with and assist others at an age-appropriate level." The authors then described the possible effects of tumor location, stating that cerebellar tumors may particularly affect attention skills because of proximity to the ascending reticular activating system and other subcortical and cortical areas that control attention and arousal. Tumors growing in the third ventricle were also included in this study because the third ventricle is the location of the hypothalamus, thalamus, fornix, and basal forebrain. Research results have confirmed memory disturbances in children treated for tumors in the third ventricle (Micklewright, King, Morris, & Morris, 2007). The study was retrospective using 36 children who were treated for tumors in either the third ventricle or cerebellar regions.

The patients were tested using the *Vineland Adaptive Behavior Scales (VABS)* (Sparrow, Balla & Cicchetti, 1984) and the *Rey Auditory Verbal Learning Test (RAVLT)* (Rey, 1958). The VABS provided data about each child's communication, daily living skills, and socialization. The RAVLT assessed auditory attention span and verbal memory. The results suggested that "there are differential cognitive predictors of adaptive functioning according to brain tumor location (Papazoglou, et. al., 2008)."

Gilmer Knight, Kraemer, and Neuwelt (2005) looked at the effect of platinum-based chemotherapy, which used the platinum drugs cisplatin and carboplatin, in children with brain tumors. A study was conducted using audiological evaluations including otoscopy, frequency-specific auditory brain stem response, conventional audiometry, conditioned play audiometry, visual reinforcement audiometry, and pure tone audiometry, on 67 children from eight months to 23 years old, who had received platinum-based chemotherapy. The platinum agents (cisplatin and carboplatin) in the chemotherapy correlated with adverse effects such as ototoxicity and permanent hearing loss (Blakeley & Myers, 1993; Brock, Bellman, Yeomans, et. al., 1991; Li, Womer, & Silber, 2004; Ilveskoski, Saarinen, Wiklund, et. al., 1998; Montaguti, Brandolini, Ferri, et. al., 2002; Skinner, Pearson, Amineddine, et. al., 1990). Hearing loss that results from ototoxicity can be significant, influencing speech and language development, educational achievement, and social-emotional development (Blair, Peterson, & Viehweg, 1985). The results of this study stated that 61% of the children studied showed bilateral decreases in hearing. The

children diagnosed with medulloblastoma tumors, osteosarcoma tumors, and neuroblastoma tumors had a greater incidence and more severity of hearing loss.

Rekate, Grubb, Aram, et. al. (1985) were the first to describe cerebellar mutism in children with cancer. For the purpose of their study cerebellar mutism was defined as a "transient and not uncommon complication following surgical resection of posterior fossa tumors." Mutism after posterior fossa surgery in children included the additional neurological deficits of ataxia, hemiparesis, cognitive deficits, cranial nerve palsies, and bulbar palsy. Children with this type of mutism have good comprehension, without evidence of oral apraxia before any type of surgical intervention (Clerico, et. al., 2002).

Posterior Fossa Syndrome

Posterior fossa brain tumors account for 54% to 70% of all known pediatric brain tumors according to Al-Shatoury, et. al. (2008). The most common types of posterior fossa tumors are medulloblastomas, cerebellar astrocytomas, brain stem gliomas, and ependymomas (Hudgins & Edwards 1987, Packer, et. al., 1987). Doxey, Bruce, Sklar, Swift, & Shapiro (1999) researched the risk factors and irreversible complications of posterior fossa syndrome. Physicians noticed this syndrome, also referred to as cerebellar mutism, as a changeable condition that could occur after posterior fossa surgery in children (Rekate, et. al., 1985). The condition resolved in most cases after only a few days, but could persist for a year. The researchers defined this type of mutism as "the inability to articulate single monosyllabic words."

The study discussed 18 children, who were reported to have posterior fossa syndrome 24 to 48 hours after surgery. One child was reported to have posterior fossa syndrome four days post-surgery; another child developed posterior fossa syndrome seven days post-surgery; and one child spoke immediately after surgery, then demonstrated mutism within the next 24 hours. Once the children began to regain their speech, their speech took on dysarthric characteristics then their speech intelligibility improved in stages. Similarities among the children led the researchers to believe that the location of the tumor contributed to the development of posterior fossa syndrome. All children were diagnosed with tumors affecting the brain stem or the middle cerebellar branch or both areas. Doxey, et. al., (1999) believed other factors, such as the piercing of the vermis during surgery, injury to the middle of the cerebellum during surgery, and the involvement of the dentate nucleus, could contribute to postoperative mutism in children. Levisohn, et. al., (2000) found that extensive vermis damage in children who underwent posterior fossa surgery led to posterior fossa syndrome in five out of the nine cases studied.

Boghen and Aoichane (1991) described a case where the child lost reaction in her pupils. This loss of pupillary reaction was probably a secondary effect of aqueduct obstruction and ensuing hydrocephalus as well as functional interference with visceral motor nuclei of the third nerve. According to Arthur Skarin in the *Journal of Clinical Oncology* (2001), "these neurofunctional features can belong to the posterior fossa syndrome, a complex cohort of signs and symptoms characterized by mutism but also by long tract signs and neurobehavioral abnormalities whose cognitive and affective outcome is still a matter of study."

Siffert, Poussaint, Goumnerova, Scott, LaValley, Tarbell, and Pomeroy (2000) also conducted a study to determine the features of cerebellar mutism. They observed a decrease in not only speech output, but also speech comprehension. They also observed, following treatment, apathy in speech, inattention, eye closure, swallowing difficulties, hemiparesis, and bowel and bladder malfunction, confirming mutism as only one of the possible outcomes following posterior fossa tumor treatment. The more global neurological dysfunctions, including cerebellar dysfunction, expressive and receptive language difficulties, inattention, apathy, hypokinesis, irritability, hemiparesis, oromotor apraxia, eye opening difficulty, and bladder control are the principal reasons for intensive rehabilitation needs. Although symptoms varied in the children studied, with children demonstrating a decrease in speech output post-surgery, verbal comprehension was most likely to be the initial factor that improved.

The literature cited in this chapter shows that post-treatment communication and swallowing disorders are common in children with brain tumors, specifically brain stem gliomas and medulloblastomas. However, the literature does not sufficiently address the etiology of these communication and swallowing disorders or the course of clinical treatment and/or treatment setting options needed for these children, which supports the need for this current research. As the survival rates rise for these children because of advances in technology and treatments, the importance of understanding the post-treatment disorders increases. What we know is that historically brain stem glioma tumors and medulloblastoma tumors are two of the most prevalent types of brain tumors in children. We also know that treatment for these tumors often results in speech, language, and/or swallowing disorders, but the

exact etiology still remains unclear and additional information is needed as to the nature of these post-treatment disorders and how they are currently managed. Researchers are still exploring the adverse effects of chemotherapy, radiation, and surgery for children with brain tumors. This research was directed to study the prevalence of diagnosed disorders of speech, language, or swallowing in children with a confirmed brain stem glioma or medulloblastoma tumor, and to provide additional information on type of disorders noted and the nature of their management.

CHAPTER THREE

METHODOLOGY

CHAPTER THREE

METHODOLOGY

This study was designed to determine if speech-language pathologists (SLPs) who evaluate children following treatment for brain stem glioma tumors or medulloblastoma tumors confirm the presence of speech, language, and/or swallowing disorders. The study also was designed to determine, in the SLP's professional opinion, if motor speech was more affected than swallowing in this clinical population. Specifically the research hypotheses were:

1. There were no diagnosed disorders of speech, language, and/or swallowing in a child with a brain stem glioma tumor.
2. There were no diagnosed disorders of speech, language, and/or swallowing in a child with a medulloblastoma tumor.
3. Swallowing disorders were the primary communication disorder identified and treated by the SLP in children with brain stem glioma tumors.
4. Swallowing disorders were the primary communication disorder identified and treated by the SLP in children with medulloblastoma tumors.

Subjects

The subjects for this research project were SLPs who work in pediatric hospitals where children diagnosed with brain tumors are treated. A minimum of two pediatric hospitals from each state in the United States was selected, but the number of surveys sent per state varied. This number varied due to the number of hospitals found per state that had a pediatric wing or floor and had speech-language pathology services. The list of hospitals can be found in Appendix C. There was no discrimination based on gender, race, or age of the subjects in this study.

Procedure

A list of pediatric hospitals in the United States of America, including at least two pediatric hospitals from each of the 50 states plus one hospital in the District of Columbia was compiled. A survey containing specific questions about speech, language, hearing, and swallowing complications in children post medical treatment for brain stem glioma tumors and/or medulloblastoma tumors was mailed to the attention of the SLPs at the pediatric hospitals (see Appendix D for a copy of the survey). A cover letter was included explaining in detail the research project, goals, and purposes, as well as instructions for completing and returning the questionnaire. The cover letter can be found in Appendix A and the IRB approval can be found in Appendix B. To maintain confidentiality during this research project the surveys were to be anonymously returned (no names or identifying information was to be included on the surveys). The SLPs were also asked not to include personal information about themselves or specific children in their answers. Envelopes were coded to keep track of the hospitals from which the SLPs returned the surveys.

Follow up letters containing a second copy of the survey were sent if a response was not received by the requested deadline.

Once the surveys were returned, the data was analyzed. Following completion of data analysis, surveys were placed in a locked file cabinet in the Communication Sciences and Disorders Department to assure that no one would have access to them without permission.

Data

The data were also analyzed, using descriptive data, to determine the frequency of speech, language, and swallowing disorders, as well as the following:

- Length of time the SLPs had practiced in the field of Communication Sciences and Disorders
- Length of time SLPs had worked with the pediatric brain tumor population
- Types of pediatric brain tumors SLPs evaluated and treated
- Types of medical treatment the children with brain tumors had received
- Types of communication and swallowing disorders that occurred in children with brain tumors
- Percentage of the SLPs' patients referred for post medical treatment evaluation who exhibited speech, language, and/or swallowing disorders
- Length of time the speech, language, and/or swallowing problems persisted post medical treatment
- Frequency of SLP treatment with children with brain tumors

- Types of follow-up services provided by SLPs for children with communication and/or swallowing problems associated with medical treatment for brain stem glioma tumors and/or medulloblastoma tumors
- "Red flags" for SLPs to be aware of when working with children with brain tumors

CHAPTER FOUR

RESULTS

CHAPTER FOUR

RESULTS

This study was designed to determine if speech-language pathologists (SLPs), who work in pediatric hospitals, identified speech, language, and/or swallowing disorders in children with brain stem glioma tumors or medulloblastoma tumors. A second purpose in the design was to determine if motor speech or swallowing was more affected in a child with a brain stem glioma tumor and in a child with a medulloblastoma tumor. The third question in this study was to determine the incidence and treatment of speech, language, and/or swallowing disorders. As stated in the methodology, the research hypotheses were:

1. There were no diagnosed disorders of speech, language, and/or swallowing in a child with a brain stem glioma tumor.
2. There were no diagnosed disorders of speech, language, and/or swallowing in a child with a medulloblastoma tumor.
3. Swallowing disorders were the primary communication disorder identified and treated by the SLP in children with brain stem glioma tumors.
4. Swallowing disorders were the primary communication disorder identified and treated by the SLP in children with medulloblastoma tumors.

A survey of questions for SLPs, who work at pediatric hospitals, was compiled and sent to the selected SLPs. The questions were designed to survey the SLPs about speech, language, and swallowing disorders in children with brain stem gliomas and medulloblastomas following medical treatment. Surveys were mailed to the SLPs at the chosen hospitals (pediatric hospitals or hospitals with a pediatric floor). Surveys were initially sent to 72 pediatric hospitals or hospitals with a pediatric floor covering all 50 states in the United States. Sixteen surveys were returned initially. Follow-up letters were then sent to the remaining 56 identified sites. From these 56 hospitals, 29 surveys were returned. A second complete packet (letters and surveys) was then sent to 48 more hospitals and 12 surveys were returned. The third complete packet was sent to 25 hospitals and 8 were returned. At the end of the process, the author had sent 145 surveys and had a returned total of 65 surveys.

Results of the various survey questions are displayed in the following figures. Figures 1, 2, 3 and 7 show both absolute number of returns falling into each category and the percentage of survey returns that this number represents. Percentages were not included in Figures 5 and 8 because the SLPs had the opportunity to give multiple answers to the question.

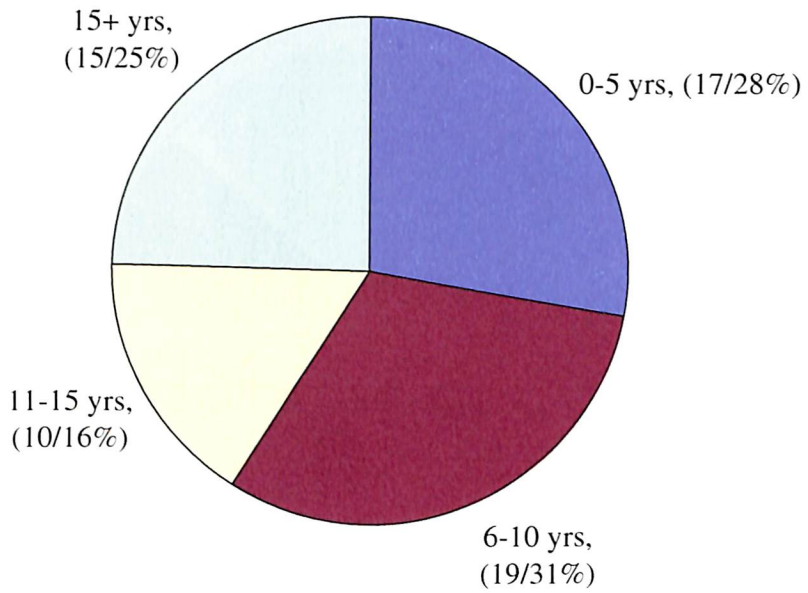

Figure 1. SLPs' Length of Time in Profession (n=60)

Figure 1 shows the length of time that responding SLPs have practiced in the field of communication sciences and disorders. Approximately 28%, 31%, 16%, and 25% of SLPs responding have practiced speech-language pathology for 0-5 years, 6-10 years, 11-15 years, and more than 15 years respectively. The majority of SLPs responding to the survey have practiced six to ten years. The percentage difference between SLPs who had practiced 0-5 years and 6-10 years (3%), 11-15 years (12%), and 15+ years (3%) was fairly equally distributed.

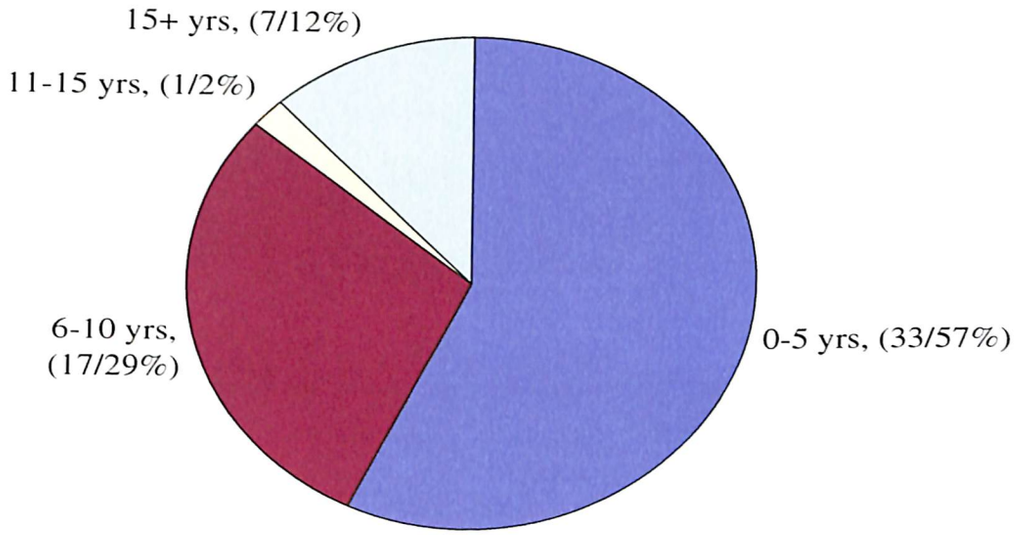

Figure 2. SLPs' Length of Time in Profession Working With Pediatric Brain Tumors (n=58)

Figure 2 depicts the length of time responding SLPs have worked with the pediatric brain tumor population. A majority of the SLPs responding have worked with children with brain tumors for 0-5 years (57%). The next highest was 6-10 years (29%) This was followed by a significant drop, down to 2% for the 11-15 years category, and up to 12% for the 15+ years category. These data could be a reflection of the increase in awareness and diagnosis of pediatric brain tumors during the past 10 years. As identification rates have increased, it can be expected that an awareness of the effects of the tumors and tumor treatment on communication and swallowing has also increased, resulting in the need for more SLPs to provide evaluation and treatment services.

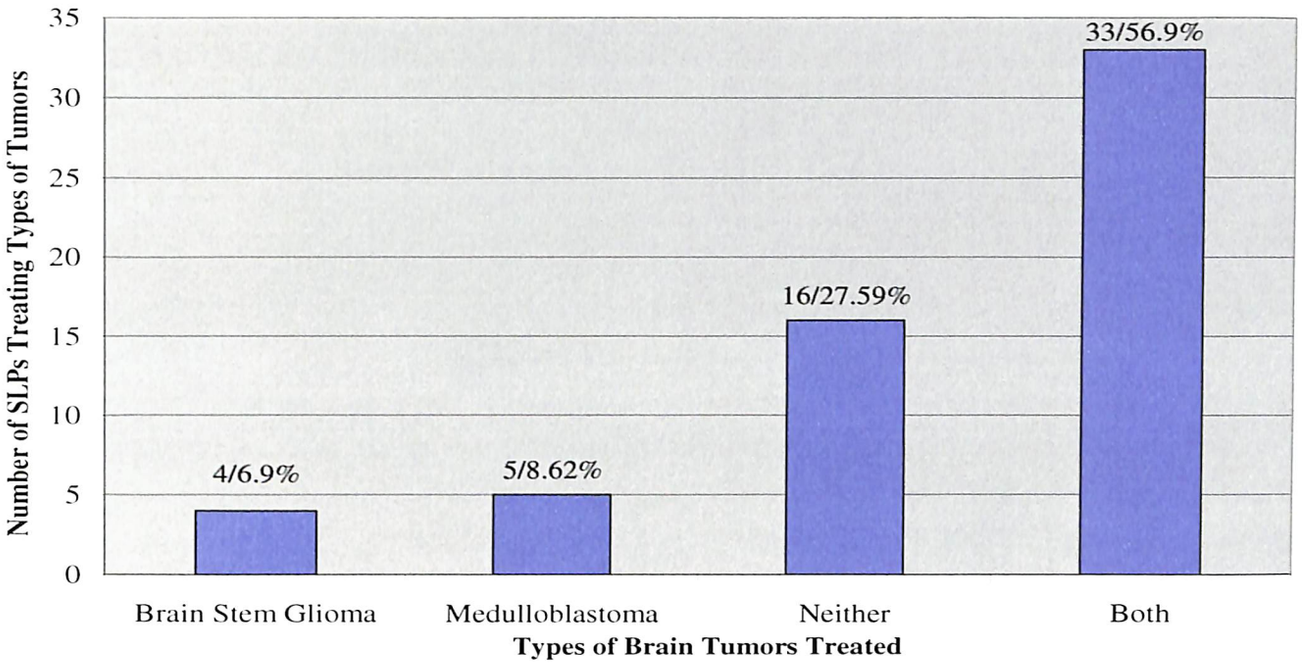

Figure 3. Number of SLPs Surveyed Who Worked With Communication Disorders in Children with Brain Stem Gliomas and Medulloblastomas (n=58)

According to Figure 3, of the 58 SLPs, who answered this survey question, 33 (56.9%) had treated communication disorders in children with brain stem glioma tumors and children with medulloblastoma tumors, while 16 (27.59%) had not treated children with either type tumor. Five (8.62%) had only treated medulloblastoma tumors and 4 (6.9%) of the 58 SLPs responding had treated only brain stem glioma tumors.

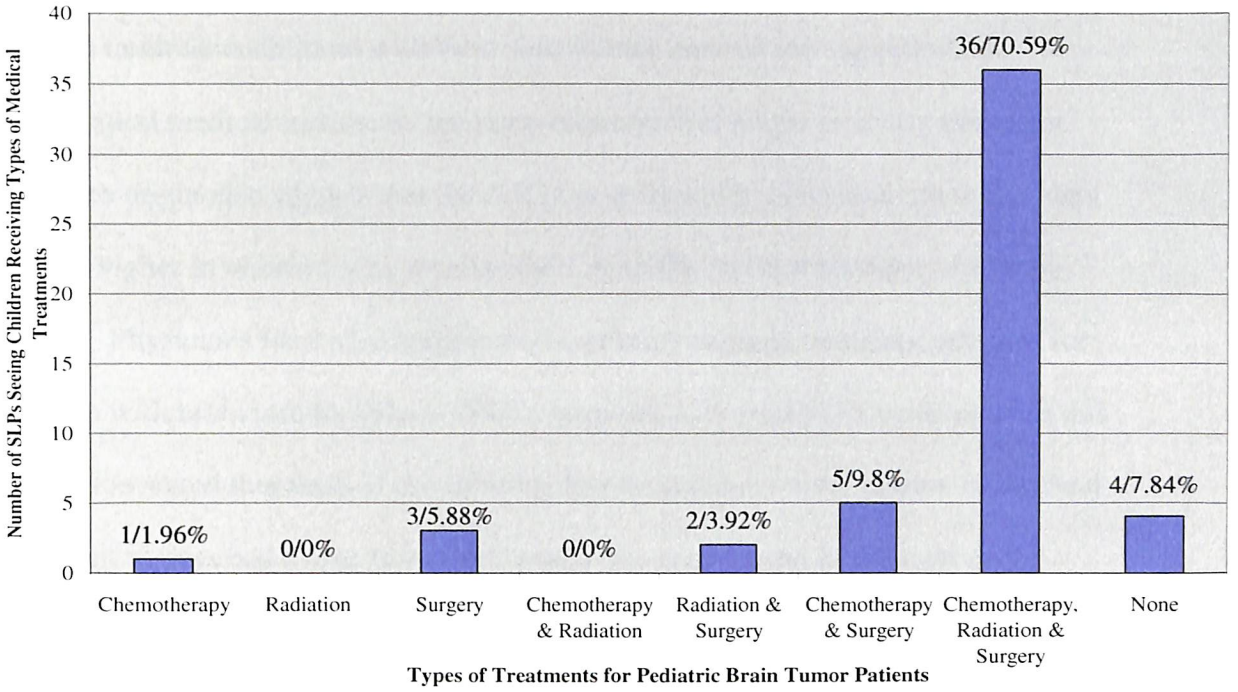

Figure 4. Number of Surveyed SLPs Seeing Children Receiving Various Medical Treatments for Tumors (n=51)

Figure 4 shows the distribution of various medical treatments which had been provided to the children with brain stem gliomas and medulloblastomas treated by the responding SLPs. Thirty-six (70.59%) of the SLPs responding had evaluated and treated communication disorders in children who had received some form of chemotherapy, radiation, and/or surgery. This percentage was high compared to the number of surveyed SLPs who had evaluated and treated children for communication disorders following only chemotherapy (1.96%), radiation (0%), surgery (5.88%), and combinations of chemotherapy and radiation (0%), combinations of radiation and surgery (3.92%), or combinations of chemotherapy and surgery (9.8%). Four (7.84%) of the SLPs responding had never treated children receiving chemotherapy, radiation, or surgery, but these four SLPs had also not treated any children with brain stem gliomas or medulloblastomas, even though they were employed in pediatric

hospitals or hospitals with pediatric floors or wings. These results show the variety of medical treatments children with these tumors may receive and suggests that combination medical treatments are more common than single modality treatment. This data might also suggest that the risk of post-treatment communication disorders may be higher in children who receive multi-modality medical treatment for brain tumors. Physicians identified surgery as the primary medical treatment protocol for children with brain tumors (Black, 2006); however, surveyed SLPs working with this population stated that most of the children they treated had a combination of medical treatment as opposed to one type. The reason this is important in the field of communication sciences and disorders is because of the amount and type of communication and swallowing disorders SLPs may need to treat as a result of combination treatments.

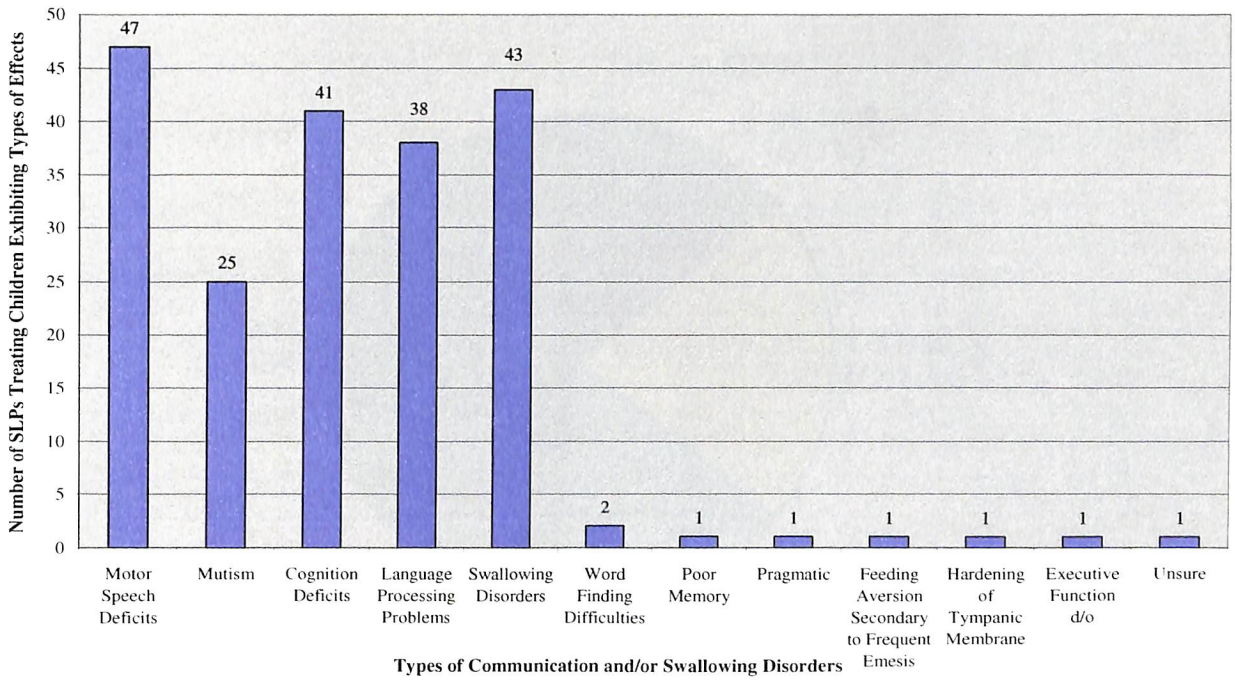

Figure 5. Types of Communication and Swallowing Disorders Occuring in Children with Brain Stem Gliomas and/or Medulloblastomas (n=51)

The data in Figure 5 show different types of communication disorders that SLPs identified in children with brain tumors. Forty-seven (47) SLPs who responded observed motor speech deficits and 43 observed swallowing disorders. Additional diagnoses reported include cognition deficits (observed by 41 SLPs), language processing problems (observed by 38 SLPs), and mutism (observed by 25 SLPs). The hypothesis, identified in the research questions, was that swallowing would be the primary communication disorder observed in children with either brain stem glioma tumors or medulloblastoma tumors, yet this research showed motor speech deficits to be slightly more prevalent , based on the responses of the SLPs surveyed. Some other communication disorders observed included word finding difficulties, memory deficits, pragmatic disorders, feeding complications, and executive functioning disorders.

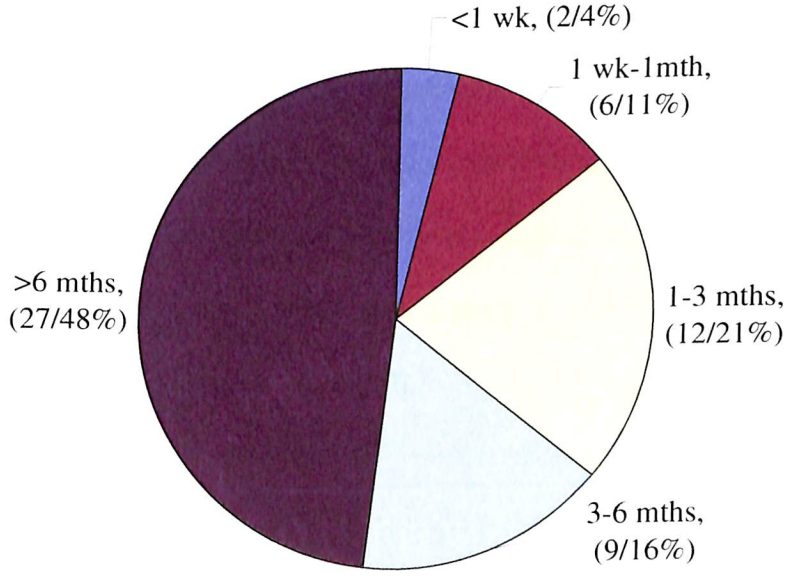

Figure 6. Length of Time Speech, Language, Hearing or Swallowing Disorders Persisted After Medical Management (n=56)

The next survey question (Figure 6) asked the SLPs how long the communication disorders, swallowing, and/or hearing disorders persisted after medical treatment (e. g. chemotherapy, radiation, and/or surgery). Twenty-seven (48%) of the SLPs responded that the children on their caseload exhibited communication, swallowing, or hearing disorders for more than 6 months following medical treatment. Twenty-one percent (21%) of SLPs reported these disorders persisting for 1 to 3 months after medical treatment, sixteen percent (16%) reported problems persisting for 3 to 6 months and eleven percent (11%) reported problems persisting for 7 days to 30 days. The question regarding length of time residual communication and swallowing disorders persisted was included in order to improve understanding of the role of speech-language pathology in the therapy regimen for children with these two types of brain tumors. It seems reasonable to assume that the longer the communication and swallowing disorders persist, the greater the impact on the child's life. Persistent communication problems might also have an impact on the child's educational progress. Additional allied health services could include physical therapy, occupational therapy, behavioral therapy or case management and social work intervention. When this occurs, the economic impact on families, school systems, and other social systems must be considered (B. Foley, L. P. Barakat, A. Herman-Liu, J. Radcliffe & P. Molloy, 2000).

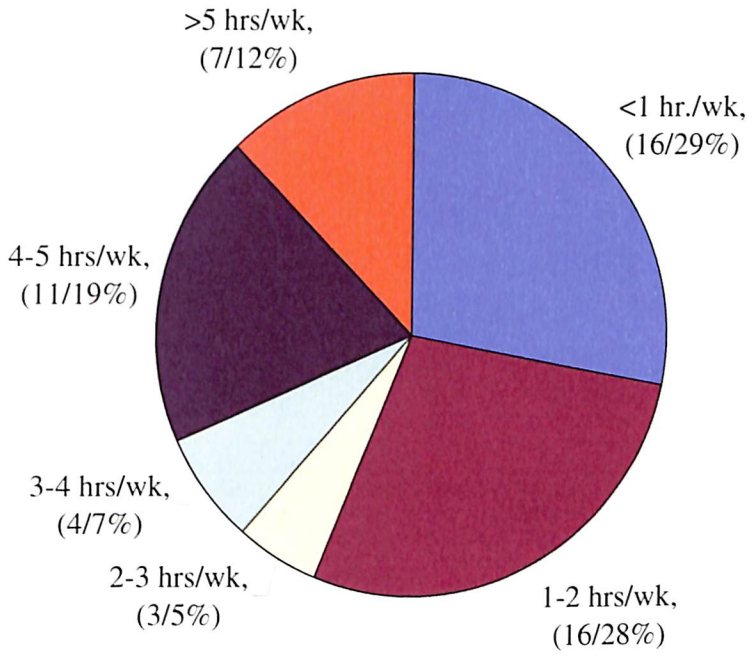

Figure 7. Frequency of Treatment for Children with Pediatric Brain Tumors (n=49)

The majority of children received treatment from an SLP less than one hour per week (29% according to Figure 7). However, a close second was the number of responding SLPs (28%) who treated the children on their caseload for 1 to 2 hours per week. Nineteen percent of responding SLPs (19%) treated children 4 to 5 hours per week, 12% treated children for more than 5 hours per week, 7% treated children for 3 to 4 hours per week, and 5% treated children 2 to 3 hours per week. The frequency of treatment depended on the type of communication disorder and the progress of the children as communication and swallowing therapy continued. Once again, these results represent a wide variation in the amount of services required for children with brain tumors, specifically brain stem gliomas and medulloblastomas.

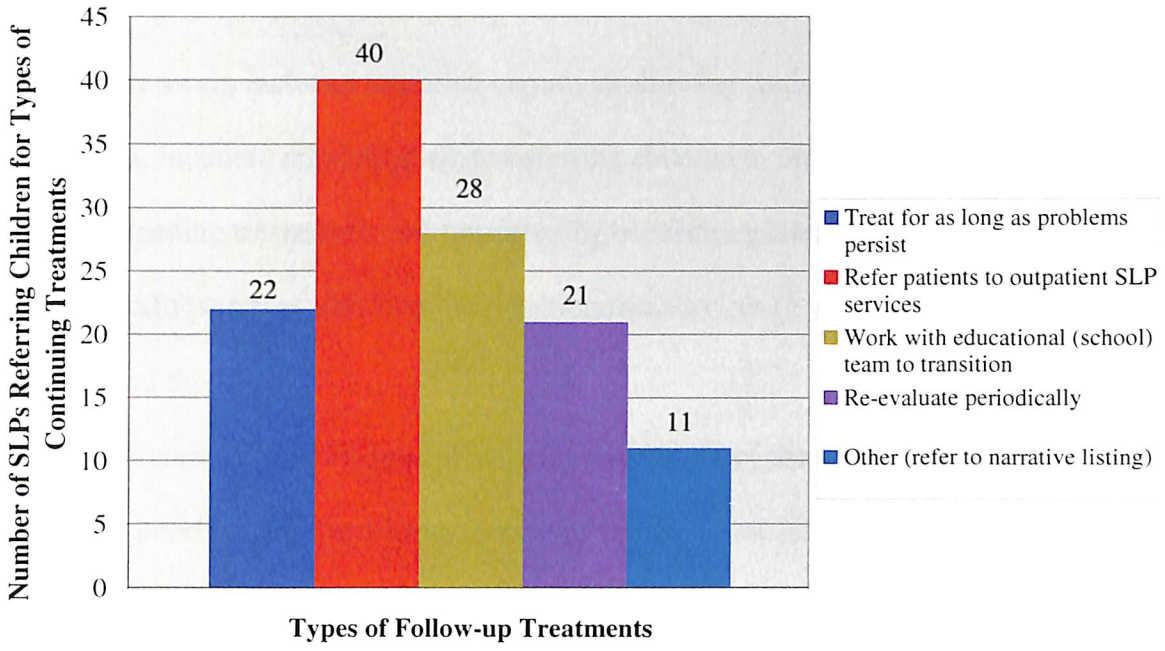

Figure 8. Types of Follow-up Treatments for Children with Brain Stem Gliomas and Medulloblastomas (n=50)

Responding SLPs were asked to discuss follow-up service provided for children with brain tumors after completion of SLP evaluations and treatments (Figure 8). The options included: a) treating children for as long as communication, swallowing, or hearing problems persisted, b) referring children to outpatient SLP services, c) working with the educational (school) team to transition children, d) re-evaluating children periodically, and e) other services (listed in the narratives Appendix E). Forty (40) of the responding SLPs referred the children to outpatient SLP services. The next most frequent form of follow-up service was working with an educational team to transition the children back into their school program (28 SLPs). Twenty two (22) SLPs responding stated they also treat the children as long as problems persist and 21 of the SLPs responding stated they re-evaluated the children periodically to check for changes in the communication, swallowing, or hearing

disorders. Some of the other follow-up services mentioned in the narrative portion of the SLPs' answers included modified barium swallowing studies, cognitive evaluations, inpatient rehabilitation, transferring children to inpatient rehabilitation hospitals, feeding treatments, and transitioning between inpatient SLP services, outpatient SLP services, and/or other rehabilitative services (e.g. occupational therapy and physical therapy).

The surveys also inquired about what percentage of the SLPs' caseloads exhibited speech and/or swallowing problems following medical treatment for pediatric brain tumors (question #6 from survey, Appendix D). The percentages ranged from 25% of the children to 100% of the children. Three SLPs stated that 25% of their children exhibited speech and/or swallowing issues, one estimated 30%, six estimated 50%, three estimated 70%, six estimated 75%, three estimated 80%, two estimated 85%, two estimated 90%, one estimated 95%, and nine estimated 100%. This showed the variation in the amount of children exhibiting speech and/or swallowing disorders post-medical treatment, according to the responding SLPs. Three SLPs also answered that the number of children they have treated in their experience depended on the location of the tumor, the treatment course selected, and whether or not children received speech-language pathology services before being referred to this specific SLP. Also one of the SLPs stated that they treated only children with cognitive or swallowing deficits, so all referrals to them would have one or both of these disorders.

In conclusion, the findings of this study indicate the following:

1. SLPs may have job opportunities in hospitals or units where children with tumors receive medical treatment and then need the clinical treatment of an SLP for the communication and/or swallowing complications that occur as a result of the tumors or the resection of the tumors. SLPs may have very little experience in the field of communication sciences and disorders, much less with the pediatric tumor population when they take these jobs. The lack of experience may be exacerbated by the lack of peer mentoring available to them, leaving them to "learn on the job" with this population. The study also shows that SLPs do remain or take these jobs later in their career, also, although prior experience to the pediatric hospitals and units is unclear at this time based on this study. This would be a question for the next step of the study.
2. The majority of responding SLPs (72.42%) had experience working with children recovering from brain stem gliomas and/or medulloblastomas. As the author previously stated, these two tumors are two of the most frequently identified tumors in the pediatric population. Thus this author is comfortable in stating that SLPs working in pediatric tumor centers will likely be called upon to treat children recovering from these type tumors. SLPs need to appreciate the differences and similarities among the various tumors commonly found in the pediatric population, as well as the resultant communication and swallowing problems associated with medical treatment of these tumors.

3. This study also confirms, albeit with a small sample size, that many children diagnosed with tumors will receive a combination of three medical interventions (chemotherapy, radiation, and surgery), rather than a single intervention or two interventions. Secondary clinical complications such as motor speech, language, and swallowing problems appear to occur more frequently when multi-modality medical interventions are required. .
4. The SLPs surveyed identified the five most common types of communication and swallowing disorders that occur in children who have either of these tumors. These include motor speech disorders, mutism, cognitive disorders, language processing disorders, and swallowing disorders.
5. The SLPs surveyed also confirmed that these communication and/or swallowing disorders persist for longer than six months, thus creating additional challenges in the areas of education, independent living, and community based activities. This fact also bears the question of whether the field has SLPs qualified in the outpatient and home health arenas to continue the treatment regime started in the pediatric hospitals and units for children with brain tumors.
6. The study confirms that the greatest number of these children is referred to outpatient facilities or into the local educational system for continued services following hospital discharge. This raises questions regarding the availability of local resources, adequately trained teacher and community services needed to provide the quality care required for these children to make maximum re-integration into society.

This study suggests that additional research is needed in this area in order to improve the general knowledge base of SLPs regarding brain tumors in the pediatric population, as well as to provide a second tier of specific training and mentoring for SLPs who work in these facilities. This is discussed further in Chapter Five.

CHAPTER FIVE

DISCUSSION

CHAPTER FIVE

DISCUSSION

Summary

Brain tumors are one of the two most common sites of childhood cancer. In 2007-2008 between 3,500 and 3,750 children were expected to be diagnosed with brain tumors annually (Central Brain Tumor Registry of the United States, 2007-2008). Pediatric brain tumors are classified according to location, size, and cell origin. These factors determine the course of medical treatment for the child. Medical treatment can include surgery, radiation, and/or chemotherapy and often results in post-treatment problems in the areas of motor speech, language, and/or swallowing.

This study was designed to determine if speech-language pathologists (SLPs), who work in pediatric hospitals, frequently identify and treat speech, language, and/or swallowing disorders in children following medical treatment for brain stem glioma tumors or medulloblastoma tumors. A second purpose in the design was to determine if motor speech or swallowing was more frequently affected. Specifically the research hypotheses were:

1. There were no diagnosed disorders of speech, language, and/or swallowing in a child with a brain stem glioma tumor.

2. There were no diagnosed disorders of speech, language, and/or swallowing in a child with a medulloblastoma tumor.

3. Swallowing disorders were the primary communication disorders identified and treated by the SLP in children with brain stem glioma tumors.

4. Swallowing disorders were the primary communication disorders identified and treated by the SLP in children with medulloblastoma tumors.

The subjects for this study were SLPs at pediatric hospitals across the United States of America. At least two hospitals in each of the 50 United States and one hospital in the District of Columbia were chosen from the American Hospital Directory website (http://www.ahd.com) and the U.S. News and World Report website (http://health.usnews.com/sections/health/best-childrens-hospitals/index.html). These hospitals either had a pediatric wing, where children were treated, or were pediatric hospitals, defined by the fact that they treated only children. A questionnaire survey was sent to the SLPs asking them to report, from their experience, the prevalence of speech, language, and swallowing disorders in children with brain stem glioma tumors or medulloblastoma tumors. One hundred forty-five (145) surveys were sent with 65 final responses received. From the western United States 11 surveys were returned, 26 from the Midwest, 19 from the South, and 8 from the Northeast (Appendix F).

General Discussion

After compiling the survey results, it was found that SLPs observed 11 different communication disorders, contrary to the first and second original hypotheses that no diagnosed disorders of speech, language, and/or swallowing were present in the children evaluated in their facilities who had the medical diagnosis of brain stem glioma or medulloblastoma. Surveys returned from 47 SLPs stated they observed motor speech disorders following medical treatment (chemotherapy, radiation, and/or surgery) while surveys returned from 43 SLPs confirmed they observed swallowing disorders. This difference may be an indicator of an increase in either the number of swallowing disorders related to these two types of tumors or an increase in the ability to identify swallowing disorders following medical intervention. The difference could also be an indicator of a decrease in identified motor speech disorders. If additional SLPs or SLPs in different types of facilities were questioned, it is possible the difference between these two disorders would be weighted in favor of motor speech disorders. In addition, other communication disorders were observed by the SLPs including mutism, cognition deficits, language processing problems, word finding difficulties, pragmatic issues, memory disorders, feeding aversions, hardening of the tympanic membrane, and executive function issues. The incidence of additional communication disorders beyond the most obvious motor speech and swallowing disorders suggests that SLPs need to evaluate all children treated for brain tumors

The literature also cites the presence of cognitive and psychological disorders including depression, withdrawal, and anxiety (Poggi, et. al., 2004), as well as motor

speech, language, and swallowing issues (Goncalves, et. al., 2006). In the literature cognitive disorders correlate with learning difficulties, indicated by lowered scores in the areas of reading, spelling, and mathematics (Poggi, et. al., 2004). The results of the current study confirm, according to the SLPs who responded, that cognitive and psychological disorders were observed in the pediatric brain tumor population. In future research more detailed information regarding these identified disorders should be obtained. In addition to the presence of cognitive and psychological disorders, an article by Levisohn, et. al., in 2000 cites the presence of executive functioning impairments in children with these particular brain tumors. One of the SLPs responding to the survey listed executive functioning impairments as a disorder found in children with brain tumors. The Levisohn article (2000) discussed memory deficits (a type of executive functioning impairment), which were also listed by one of the responding SLPs.

Mutism in children with brain tumors was reported by 25 of the 65 responding SLPs. Postoperative mutism is mentioned in the literature, specifically posterior fossa syndrome, as occurring in tumors in the brain stem and the cerebellum (Hudgins & Edwards, 1987). According to an article by Stargatt et al (2007), because posterior fossa tumors arise from the cerebellum and adjacent structures, the tumors and their subsequent surgical resection can damage the cerebellum and/or adjacent structures. The cerebellum controls motor function and cognitive function so the damage may affect these functions and lead to the development of posterior fossa syndrome. Both brain stem gliomas and medulloblastomas are posterior fossa tumors, therefore the correlation with mutism.

Overall, the results of this pilot study led to the rejection of the researcher's first and second hypotheses since communication and/or swallowing disorders were identified by SLPs, while the results failed to lead to the rejection of the third and fourth hypotheses since there was not enough of a difference in the number of identified motor speech disorders and swallowing disorders to be measured as significant. SLPs observed speech, language, and/or swallowing disorders in children diagnosed with brain tumors. A higher incidence of communication disorders identified in children with brain tumors in this study were motor speech disorders, although a variety of other communication disorders were identified by the SLPs as well.

Strengths and Limitations of Current Research

This current study was approached as a pilot study, but does, in the author's opinion, have several strong points. Information on the prevalence of communication disorders was collected from SLPs who evaluate and treat children diagnosed with brain tumors, specifically medulloblastoma tumors and brain stem glioma tumors. This improves our understanding of the role of speech-language pathology with this population. SLPs in a variety of geographic locations were surveyed in an attempt to eliminate geographic bias. This allowed for a broader range of SLP exposure and experiences. The SLPs who worked in hospitals in cities or states with larger populations would have more exposure due to the large population. SLPs in smaller hospitals or cities or states with smaller populations would have less exposure based on the population. Also, in smaller states children with brain tumors could be sent to hospitals in bigger states or to the nearest city in a different state (especially in the

Northeast United States) which would affect the caseloads of the SLPs. By focusing on two types of tumors, the response possibilities were narrowed, allowing a clearer understanding of the results. However, the information obtained was restricted to only two specific tumors. The two types of tumors chosen both originate in the posterior fossa region of the brain. This lends consistency to attempts to relate site of tumor origin and secondary damage/complications.

The study was limited in the following ways: a) the varying number of facilities identified as providing SLP services for children with brain tumors per state, b) the types of residual communication disorders observed by SLPs was not correlated with a specific type of tumor and c) information gathered about type of communication disorders was not tumor specific.

The number of surveys sent to each state could have been the same in order to improve the consistency of the study. The fact that a different number of surveys was sent to different geographic regions accounts for the higher number of returns in one geographic area over another.

To gain a better understanding of each tumor, it would have been helpful to ask about the communication problems associated with each tumor individually. Another limitation was the difficulty associated with analyzing the narrative responses of the SLPs. Two of the questions on the survey allowed a narrative answer, but the answers provided were so general that accurately interpreting the responses was difficult. Since there is no generally agreed upon standard of care for children with different types of tumors, evaluation and treatment protocols vary greatly, and therefore SLPs' responses to the questions varied greatly.

Although this study could have been more specific in some areas, it did answer the original research questions posed and provided information which should be useful in planning for additional research on the treatment of communication and swallowing disorders in children with brain tumors. The author is in the process of preparing the information for publication.

Suggestions for Future Research

The study should be expanded to include additional types of brain tumors and to investigate in more detail the etiology and treatment of communication deficits occurring post medical treatment.

In order to expand this study, tumors that originate in other portions of the brain besides the posterior fossa should be included. The differences between residual communication deficits appearing in posterior fossa tumors and in other tumors could then be further explored.

Another way to extend the study would be to ask more specific questions about the types of treatments SLPs perform. The correlation between the type of clinical and medical treatment performed and the type of tumor could be investigated. Also, the rationale underlying the SLP's treatment plan could be explored. A comprehensive understanding of the treatment plan could assist individuals planning to practice in the field.

Finally, the etiology of the communication and swallowing disorders could continue to be researched. If the etiology can be found, then there may be a way to prevent the communication and swallowing disorders from occurring. The SLP could then work with the oncology team to form a treatment plan that would hopefully

prevent any disorders after clinical and medical treatment. Ideally, this would reduce the residual communication and swallowing disorders from chemotherapy, radiation, surgery, and/or the brain tumor itself. The field of communication sciences and disorders is constantly changing, as is research about pediatric brain tumors. The combinations of medical research and clinical research on communication and swallowing disorders may eventually lead to a standard protocol or best practice for treatment of children with brain tumors which would apply across various practice settings.

Summary

This student research project set out to investigate the role of speech-language pathology in the management of children with brain tumors. More specifically, the research questions addressed whether or not speech, language, and/or swallowing disorders were present in children with brain stem glioma tumors and/or medulloblastoma tumors. The research questions also examined whether motor speech or swallowing disorders were the most prevalent in children with brain stem gliomas and/or medulloblastomas. SLPs in pediatric hospitals or hospitals with pediatric wings answered surveys containing questions about issues such as the length of time the SLPs had worked in the field, the length of time the SLPs had worked with children diagnosed with brain tumors, the types of tumors the SLPs had evaluated and treated, how often clinical treatment was provided, which types of communication deficits, if any, the SLPs saw, and what types of treatment the SLPs provided.

The results of this experiment confirmed that speech, language, and/or swallowing problems were present in 100% of the children seen by the responding SLPs after medical treatment for a pediatric brain tumor. The results also showed that the SLPs surveyed observed motor speech deficits more often than swallowing problems. Additional problems that SLPs observed frequently included mutism, cognitive deficits, and language processing problems. This survey shows that the prevalence of residual communication disorders will depend on the location, size, and cell origin of the tumor, but can also be related to the type of medical treatment prescribed. The fact that 72.42% of respondents had experience working with children diagnosed with brain stem glioma tumors and/or medulloblastoma tumors supports the need for SLP services in this population of children.

The strengths of this research project included the wide range of geographic locations sampled, the homogenous nature of the sites (all were pediatric hospitals or hospitals with a pediatric floor), the limited range of tumors types researched, and the fact that both of the tumors chosen originated from the posterior fossa region of the brain. The limitations of this research project were the variations in the number of surveys sent to each state, the lack of specificity in some of the survey questions, and the difficulty in analyzing the narrative answers due to the wide variety of answers received.

Future research should address these limitations and address the etiology of the residual communication disorders. Once the etiology of the brain tumors is better understood, then a better clinical and medical treatment regimen for the child can be implemented. Future research will help SLPs better understand the etiology of the

communication deficits that result because of the type of tumor, and medical treatment received by the child. This will allow the SLPs to develop a clinical treatment plan earlier and one that will better serve the needs of the individual child. Every child is such a valuable human being and children with brain tumors deserve every scientific advancement possible on their behalf.

LIST OF REFERENCES

LIST OF REFERENCES

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APPENDICES

APPENDIX A

LETTER TO SPEECH-LANGUAGE PATHOLOGISTS

APPENDIX A

LETTER TO SPEECH-LANGUAGE PATHOLOGIST

Date

Name

Address

Dear....,

Brain tumors are the second most common form of pediatric cancer, affecting between 1,500 and 2,000 children annually. Patients undergo extensive rehabilitation after treatment including speech therapy, physical therapy, and occupational therapy. In this research project, the main tumors researched are medulloblastoma tumors and brain stem glioma tumors. A medulloblastoma tumor is one type of malignant brain tumor that arises in the fourth ventricle and cerebellar vermis or the posterior fossa region of the brain. Brain stem glioma tumors are tumors that arise along the midbrain, pons, or medulla which are deep in the posterior portion of the brain.

My name is Emily Chambers and I am currently a senior at the University of Mississippi studying Communicative Disorders. I am conducting this research project to fulfill the graduation requirements for the Sally McDonnell-Barksdale Honors College. I have chosen to research the role of speech-language pathology in the treatment of pediatric brain stem glioma tumors and medulloblastoma tumors. This project will also examine the incidence of speech/language disorders and swallowing disorders, in order to see which type of disorder is more prevalent following treatment of a pediatric brain tumor.

Attached to this letter is a survey that I would appreciate if you could take the time to complete. This survey will not take more than ten minutes of your time and your

answers will be kept confidential. When you finish the questionnaire, please mail it back to the return address above in the enclosed self-addressed envelope. If you would like a copy of the results, please indicate at the bottom of the questionnaire and I will send them to you at the given contact information.

This experiment has been read by The University of Mississippi's Institutional Review Board (IRB). The IRB has determined that this experiment follows the obligations required by federal law and University policies. If you have any questions, concerns or reports regarding your rights as a research subject, please contact the IRB at (662) 915-3929. Protected Health Information means any personal health information that may identify you. The data in this experiment will include your experiences in treating children with brain stem glioma tumors and medulloblastoma tumors. A decision to take part in this research study means that you agree to the use of your occupational information. This information will be used as described in this form. This information will not be released for any reasons that do not concern this experiment. The information collected will be kept until the experiment is finished. While this experiment is ongoing you may not have access to the research information, but you may request it after the research is finished.

Research on the speech, language, and swallowing disorders that may follow pediatric brain tumors is very important and can help professionals gain a better understanding of how to treat these patients. Thank you once again for taking time to complete this survey.

Sincerely,

Dr. Carolyn Wiles Higdon
Ph. D, CCC-SLP, F-ASHA
Advisor

Emily Chambers
Undergraduate Honors Student
The University of Mississippi

APPENDIX B

IRB APPROVAL

The University of Mississippi
Oxford • Jackson • Tupelo • Southaven

Office of Research and
Sponsored Programs
100 Barr Hall
Post Office Box 907
University, MS 38677
(662) 915-7482
Fax: (662) 915-7577

May 9, 2008

Ms. Emily Chambers
2000 Lexington Pointe Drive, Apt. 13 C
Oxford, MS 38655

Dr. Carolyn Higdon
Communication Sciences and Disorders
University, MS 38677

Dear Ms. Chambers and Dr. Higdon:

This is to inform you that your application to conduct research with human participants, ***Pediatric Brain Tumors and Subsequent Motor Speech/Swallowing Disorders*** **(Protocol No. 08-150)** has been approved as Exempt under 45 CFR 46.101(b)(2).

Please remember that all of The University of Mississippi's human participant research activities, regardless of whether the research is subject to federal regulations, must be guided by the ethical principles in *The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research*.

It is especially important for you to keep these points in mind:

- You must protect the rights and welfare of human research participants.
- Any changes to your approved protocol must be reviewed and approved before initiating those changes.
- You must report promptly to the IRB any injuries or other unanticipated problems involving risks to participants or others.

If you have any questions, please feel free to call me at (662) 915-7482.

Sincerely,

Diane W. Lindley
Coordinator, Institutional Review Board

APPENDIX C

ADDRESSES FOR SPEECH-LANGUAGE PATHOLOGISTS

APPENDIX C

ADDRESSES FOR SPEECH-LANGUAGE PATHOLOGISTS

*Indicates Follow-up Letters
**Indicates 2nd mailing
***Indicates 3rd mailing
# Indicates Response Received

1. ALABAMA
   A. University of South Alabama Children's and Women's Hospital *#
      Karen Walker-Director of Therapy Services;
      1700 Center St.
      Mobile, AL 36604-3391
   B. Children's Hospital of Alabama #
      Dept. of Pediatric Rehabilitation Medicine,
      1600 7th Avenue South, ACC Suite 406,
      Birmingham, AL 35233

2. ALASKA
   A. Children's Hospital at Providence *#
      3200 Providence Drive
      Anchorage, AK 99508
   B. Alaska Regional Hospital ***#
      2801 DeBarr Road
      Anchorage, AK 99508

3. ARIZONA
   A. Phoenix Children's Hospital *#
      1919 East Thomas Road
      Phoenix, AZ 85016
   B. Banner Children's Hospital at Banner Desert Medical Center ***
      1400 South Dobson Road
      Mesa, AZ 85202

4. ARKANSAS
   A. Arkansas Children's Hospital *
      800 Marshall Street
      Little Rock, AR 72202
   B. University of Arkansas for Medical Sciences Medical Center ***#
      4301 West Markham Street
      Little Rock, AR 72205

5. CALIFORNIA
   A. Children's Hospital Central California #
      9300 Valley Children's Place
      Madera, CA 93636-8762
   B. Children's Hospital Los Angeles ***
      4650 Sunset Boulevard
      Los Angeles, CA 90027
   C. Alta Bates Summit Medical Center- Alta Bates Campus ***
      2450 Ashby Avenue
      Berkeley, CA 94705

6. COLORADO
   A. Memorial Hospital for Children *
      1400 E. Boulder St.
      Colorado Springs, CO 80909
   B. University of Colorado Hospital ***
      12605 East 16th Avenue
      Aurora, CO 80045

7. CONNECTICUT
   A. Connecticut Children's Medical Center #
      Speech and Audiology
      282 Washington Street
      Suite 2F
      Hartford, CT 06106
   B. Yale-New Haven Children's Hospital #
      20 York Street
      New Haven, CT 06510-3202

8. DELAWARE
   A. The Alfred I. DuPont Hospital for Children *#
      1600 Rockland Road
      P.O. Box 269
      Wilmington, DE 19899
   B. Christiana Hospital ***#
      4755 Ogletown-Stanton Road
      Newark, DE 19718

9. FLORIDA
   A. St. Joseph's Children's Hospital of Tampa #
      3001 W. Dr. Martin Luther King Jr. Blvd.
      Tampa, FL 33607
   B. All Children's Hospital ***
      801 6th Street South
      St. Petersburg, FL 33701

10. GEORGIA
    A. Children's Healthcare of Atlanta at Scottish Rite #
       1001 Johnson Ferry Road NE
       Atlanta, GA 30342-1600
    B. Athens Regional Medical Center ***#
       1199 Prince Avenue
       Athens, GA 30606

11. HAWAII
    A. Shriners Hospital for Children (Honolulu) *
       1310 Punahou St.
       Honolulu, HI 96826-1099
    B. Kapi'olani Medical Center for Women & Children ***#
       1319 Punahou St.
       Honolulu, HI 96826

12. IDAHO
    A. St. Luke's Children's Hospital *##
       190 E. Bannock St.
       Boise, ID 83712
    B. Eastern Idaho Regional Medical Center ***#
       3100 Channing Way
       Idaho Falls, ID 83404

13. ILLINOIS
    A. Children's Memorial Hospital *#
       2300 Children's Plaza
       Chicago, IL 60614-3363
    B. Shriners Hospitals for Children (Chicago) #
       2211 N. Oak Park Ave.
       Chicago, IL 60707
    C. Advocate Christ Medical Center/Advocate Hope Children's Hosp. **
       4440 West 95th Street
       Oak Lawn, IL 60453
    D. Loyola Univ. Med. Center/Ronald McDonald Children's Hospital **#
       2160 South First Avenue
       Maywood, IL 60153
    E. Mercy Hospital **
       2525 South Michigan Avenue
       Chicago, IL 60616-2477
    F. Michael Reese Hospital and Medical Center **
       2929 S. Ellis Avenue
       Chicago, IL 60616
    G. Sinai's Children's Hospital **
       California Avenue at 15th Street
       Chicago, IL 60608

14. INDIANA
    A. Peyton Manning Children's Hospital at St. Vincent *#
       2001 West 86th Street
       Indianapolis, IN 46260
    B. Community Hospital **
       901 MacArthur Boulevard
       Munster, IN 46321
    C. Dupont Hospital **#
       2520 East Dupont Road
       Fort Wayne, IN 46825
    D. Home Hospital **
       1116 N. 16th Street
       Lafayette, IN 47904
    E. Lutheran Hospital of Indiana **
       7950 West Jefferson Boulevard
       Fort Wayne, IN 46804

15. IOWA
    A. Blank Children's Hospital *#
       1200 Pleasant Street
       Des Moines, IA 50309
    B. Allen Hospital **
       1825 Logan Avenue
       Waterloo, IA 50703
       Attn: Dept. of Speech-Language Pathology Carey Degroote
    C. Genesis Medical Center, Davenport **
       1227 East Rusholme Street
       Davenport, IA 52803
       Attn: Ron Bear
    D. Mercy Medical Center **#
       701 Tenth Street Southeast
       Cedar Rapids, IA 52403
    E. Mercy Medical Center- Des Moines **#
       1111 Sixth Avenue
       Des Moines, IA 50314
       Attn: Director of Rehabilitation, Lynne Garner

16. KANSAS
    A. University of Kansas Medical Center *#
       3901 Rainbow Boulevard
       Kansas City, KS 66160
    B. Overland Park Regional Medical Center **
       10500 Quivira Road
       Overland Park, KS 66215
       Attn: Director of Rehabilitation, Janice Harp

C. Via Christi Regional Medical Center- St. Francis Campus **
929 North Saint Francis
Wichita, KS 67214
Attn: Director of Rehabilitation, Sue Willey

17. KENTUCKY
A. Kentucky Children's Hospital *
800 Rose St.
Lexington, KY 40536-0293
B. Jennie Stuart Medical Center **
320 West 18th Street
Hopkinsville, KY 42240-2400
C. King's Daughters Medical Center **
2201 Lexington Avenue
Ashland, KY 41101
Attn: Dept. of Speech-Language Pathology, Kaci Norris
D. Pikeville Medical Center **
911 Bypass Road
Pikeville, KY 41501

18. LOUISIANA
A. Children's Hospital (New Orleans) *#
200 Henry Clay Avenue
New Orleans, LA 70118
B. Baton Rouge General- Mid City **
3600 Florida Boulevard
Baton Rouge, LA 70806
C. CHRISTUS Schumpert Saint Mary Place **
One Saint Mary Place
Shreveport, LA 71101
Attn: Dept. of Speech-Language Pathology, Stephanie Lynn
D. East Jefferson General Hospital **
4200 Houma Boulevard
Metairie, LA 70006

19. MAINE
A. Barbara Bush Children's Hospital *#
22 Bramhall Street
Portland, ME
B. Eastern Maine Medical Center **
489 State Street
Bangor, ME 04401
C. Central Maine Medical Center **
300 Main Street
Lewiston, ME 04240

20. MARYLAND
    A. Johns Hopkins Children's Center *
       600 North Wolfe Street
       Baltimore, MD 21287
    B. Anne Arundel Medical Center **
       2001 Medical Parkway
       Annapolis, MD 21401
       Attn: Dept. of Speech-Language Pathology, Heather Langford
    C. Franklin Square Hospital Center **
       9000 Franklin Square Drive
       Baltimore, MD 21237
    D. Frederick Memorial Hospital **
       400 West Seventh St.
       Frederick, MD 21701
    E. Johns Hopkins Bayview Medical Center **
       4940 Eastern Avenue
       Baltimore, MD 21224
    F. St. Joseph Medical Center **#
       7601 Osler Drive
       Towson, MD 21204

21. MASSACHUSETTS
    A. Children's Hospital Boston *
       300 Longwood Avenue
       Boston, MA 02115
    B. Beth Israel Deaconess Medical Center **#
       330 Brookline Avenue
       Boston, MA 02215
    C. Caritas Saint Elizabeth's Medical Center **
       736 Cambridge St.
       Boston, MA 02135
    D. Charlton Memorial Hospital **
       363 Highland Avenue
       Fall River, MA 02720
    E. Massachusetts General Hospital- Mass General Hospital for Children **#
       55 Fruit Street
       Boston, MA 02114

22. MICHIGAN
    A. C.S. Mott Children's Hospital #
       1500 E. Medical Center Drive
       Ann Arbor, MI 48109
    B. Beaumont Hospital, Royal Oak **#
       3601 West Thirteen Mile Rd.
       Royal Oak, MI 48073

C. Harper University Hospital **
3990 John R
Detroit, MI 48201

D. Hurley Medical Center **#
One Hurley Plaza
Flint, MI 48503

E. Marquette General Hospital **#
580 West College Ave.
Marquette, MI 49855

F. Beaumont Health Center **
Children's Speech-Language Pathology
4949 Coolidge Hwy
Royal Oak, MI 48073
Attn: Dept. of Speech-Language Pathology, Kristine Rutkowski

23. MINNESOTA

A. Mayo Eugenio Litta Children's Hospital *
1216 Second St. S.W.
Rochester, MN 55902

B. Abbott Northwestern Hospital **
800 East 28th St.
Minneapolis, MN 55407

C. Hennepin County Medical Center **#
701 Park Avenue
Minneapolis, MN 55415
Attn: Dept. of Speech-Language Pathology, Maxine Slobof

D. North Memorial Medical Center **
3300 Oakdale Avenue North
Robbinsdale, MN 55422
Attn: Dept. of Speech-Language Pathology, Amanda Myers-Kuitu

E. Saint Cloud Hospital **#
1406 Sixth Avenue North
Saint Cloud, MN 56303

24. MISSISSIPPI

A. Blair E. Batson Children's Hospital *
2500 North State St.
Jackson, MS 39216

B. Baptist Medical Center **
1225 North State Street
Jackson, MS 39202

C. North Mississippi Medical Center **
830 South Gloster St.
Tupelo, MS 38801

D. Forrest General Hospital **
6051 U.S. Highway 49
Hattiesburg, MS 39404

25. MISSOURI
A. Children's Mercy Hospital *#
2401 Gilham Road
Kansas City, MO 64108
B. St. Louis Children's Hospital *#
One Children's Place
St. Louis, MO 63110
C. Ranken Jordan *#
11365 Dorsett Road
Maryland Heights, MO 63043
D. Saint Francis Medical Center **
211 Saint Francis Dr.
Cape Girardeau, MO 63703
E. Columbia Regional Hospital **
404 Keene St.
Columbia, MO 65201
F. SSM Saint Mary's Health Center **
6420 Clayton Road
Richmond Heights, MO 63117
G. St. Luke's Hospital **
4401 Wornall Road
Kansas City, MO 64111

26. MONTANA
A. Shodair Children's Hospital *
2755 Colonial Drive
PO Box 5539
Helena, MT 59604
B. Billings Clinic Hospital ***
2800 10th Avenue North
PO Box 37000
Billings, MT 59107-7000

27. NEBRASKA
A. Children's Hospital Omaha *#
8200 Dodge St
Omaha, NE 68114
B. Bryan LGH Health System ***
1600 South 48th Street
Lincoln, NE 68506-1299

28. NEVADA
    A. Sunrise Children's Hospital *
       3186 South Maryland Pkway
       Las Vegas, NV 89109
    B. North Vista Hospital ***
       1409 E. Lake Mead Blvd.
       North Las Vegas, NV 89030

29. NEW HAMPSHIRE
    A. Children's Hospital at Dartmouth *
       789 Central Avenue
       Dover, NH 03820
    B. Exeter Hospital ***
       5 Alumni Drive
       Exeter, NH 03833

30. NEW JERSEY
    A. The Joseph M. Sanzari Children's Hospital *
       30 Prospect Ave
       Hackensack, NJ 07601
    B. Children's Hospital of New Jersey at Newark Beth Israel Med. Center ***
       201 Lyons Ave., Suite L5
       Newark, NJ 07112

31. NEW MEXICO
    A. University of New Mexico Children's Hospital *
       2211 Lomas Blvd. N.E.
       3rd Floor of UNM Hospital
       Albuquerque, NM 87131

32. NEW YORK
    A. Elizabeth Seton Pediatric Center *#
       590 Avenue of the Americas
       New York, NY 10011
    B. Morgan Stanley Children's Hospital of New York (Presbyterian) *
       3959 Broadway
       New York, NY 10032

33. NORTH CAROLINA
    A. Levine Children's Hospital *
       1000 Blythe Blvd
       Charlotte, NC 28203

B. Pitt County Memorial Hospital ***#
2100 Stantonsburg Rd.
Greenville, NC 27835

34. NORTH DAKOTA
A. MeritCare Children's Hospital *##
P.O. Box M.C.
Fargo, ND 58122
B. Linton Hospital ***
518 North Broadway
Linton, ND 58552

35. OHIO
A. Children's Hospital Medical Center of Akron *#
1 Perkins Square
Akron, OH 44308
B. Cincinnati Children's Hospital Medical Center #
3333 Burnet Avenue,
Cincinnati, OH 45229-3039
C. Cleveland Clinic Children's Hospital for Rehabilitation *#
2801 Martin Luther King Jr Dr
Cleveland, OH 44104
D. Nationwide Children's Hospital #
700 Children's Drive
Columbus, OH 43205

36. OKLAHOMA
A. Children's Hospital at OU Medical Center *#
1200 Everett Drive
Oklahoma City, OK 73104
B. The Children's Hospital at Saint Francis ***#
6161 South Yale Avenue
Tulsa, OK 74136

37. OREGON
A. Doernbecher Children's Hospital *
15220 NW Laidlaw, Suite 100
Portland, OR 97229
B. Legacy Emanuel Children's Hospital *#
2801 N Gantenbein Avenue
Portland, OR 97227

38. PENNSYLVANIA
    A. Lehigh Valley Hospital *#
       P.O. Box 689
       Allentown, PA 18105-1556
    B. St. Christopher's Hospital for Children *
       3601 A Street
       Philadelphia, PA, 19134
    C. Children's Hospital of Philadelphia *
       34th Street and Civic Center Boulevard
       Philadelphia, PA 19104-4399

39. RHODE ISLAND
    A. Hasbro Children's Hospital at Rhode Island Hospital *#
       167 Point Street
       Providence, RI 02903
    B. Kent Hospital ***
       455 Toll Gate Rd.
       Warwick, RI 02886

40. SOUTH CAROLINA
    A. MUSC Children's Hospital *
       171 Ashley Ave.
       Charleston, SC 29425
    B. Shriners Hospital for Children *
       950 W Faris Rd
       Greenville, SC 29605

41. SOUTH DAKOTA
    A. Sanford Children's Hospital *#
       1305 West 18th Street
       Sioux Falls, SD 57117-5039
    B. St. Michael's Hospital ***
       410 West 16th Ave.
       Tyndall, SD 57066

42. TENNESSEE
    A. Le Bonheur Children's Medical Center #
       50 N. Dunlap Street,
       Memphis, TN 38103
    B. St. Jude Children's Research Hospital *#
       262 Danny Thomas Place
       Memphis, TN 38105

43. TEXAS
    A. Children's Medical Center of Dallas *
       1935 Medical District Dr
       Dallas, TX 75235
    B. Children's Memorial Hermann Hospital *
       7737 Southwest Freeway, Suite 200
       Houston, TX 77074
    C. Methodist Children's Hospital of South Texas *
       7700 Floyd Curl Drive
       San Antonio , TX 78229

44. UTAH
    A. Primary Children's Medical Center *#
       100 North Medical Drive
       Salt Lake City, UT 84113
    B. Shriners Hospital for Children (Salt Lake City) *
       1275 Fairfax Rd
       Salt Lake City, UT 84103

45. VERMONT
    A. Vermont Children's Hospital *
       111 Colchester Ave
       Burlington, VT 05401
    B. Mt. Ascutney Hospital ***
       289 County Road
       Windsor, VT 05089

46. VIRGINIA
    A. Children's Hospital of the King's Daughters #
       601 Children's Lane
       Norfolk, VA 23507
    B. VCU Health System Children's Medical Center *
       1250 East Marshall Street,
       Richmond, VA 23298
    C. Children's Hospital Richmond *
       2924 Brook Road
       Richmond, VA 23220-1298
    D. University of Virginia Children's Hospital #
       Pediatrics
       PO Box 800386
       Charlottesville, VA 22908

47. WASHINGTON
    A. Mary Bridge Children's Hospital and Health Center *
       311 S L St
       Tacoma, WA 98405

B. Children's Hospital and Regional Medical Center ***
4800 Sand Point Way NE
Seattle, WA 98105

48. WASHINGTON D.C.
A. Children's National Medical Center #
111 Michigan Avenue,
NW Washington, DC 20010

49. WEST VIRGINIA
A. WVU Children's Hospital #
PO Box 8200
6th Floor, Ruby
Morgantown , WV 26506
B. Cabell Huntington Hospital ***
1340 Hal Greer Blvd.
Huntington, WV 25701

50. WISCONSIN
A. Children's Hospital of Wisconsin #
PO Box 1997
Milwaukee, WI 53201-1997
B. University of Wisconsin Hospital ***
600 Highland Avenue
Madison, WI 53792

51. WYOMING
A. Memorial Hospital of Carbon County *
2221 W. Elm Street
Rawlins, WY 82301
B. North Big Horn Hospital *#
1115 Lane 12
Lovell, WY 82431

*Indicates Follow-up Letters
**Indicates 2nd mailing
***Indicates 3rd mailing
# Indicates Response Received

APPENDIX D

SURVEY

APPENDIX D

SURVEY

1. How long have you been practicing in the field of speech-language pathology?
    a. 0-5 years ____
    b. 6-10 years ____
    c. 11-15 years ____
    d. 15 + years ____
2. How many years have you worked as a speech-language pathologist (SLP) with children with brain tumors?
    a. 0-5 years ____
    b. 6-10 years ____
    c. 11-15 years ____
    d. 15 + years ____
3. What type of pediatric brain tumors have you evaluated and/or treated? Please specify by each type whether you have evaluated, treated, or both.
    a. Brain Stem Glioma ____
    b. Medulloblastoma ____
    c. Neither ____
    d. Both ____
4. In your experiences with these patients, what types of treatments have the children received?
    a. Chemotherapy ____
    b. Radiation ____
    c. Surgery ____
    d. Both a. and b. ____
    e. Both b. and c. ____
    f. Both a. and c. ____
    g. All of the above ____
    h. None of the above ____
5. What types of residual communication effects occur in children with brain tumors?
    a. Motor Speech Deficits ____
    b. Mutism ____
    c. Cognition Deficits ____
    d. Language Processing Problems ____
    e. Swallowing Disorders ____
    f. Other (please specify) ____
6. How many of your patients exhibit speech or swallowing problems after treatment of their brain tumors? (An estimate is fine.) _____
7. How long do these problems persist?
    a. Less than one week after treatment ____
    b. 1 week-1 month ____
    c. 1 month-3 months ____
    d. 3-6 months ____

e. > than 6 months _____

8. How often do you treat patients with pediatric brain tumors?
    a. < than 1 hour a week _____
    b. 1-2 hours a week _____
    c. 2-3 hours a week _____
    d. 3-4 hours a week _____
    e. 4-5 hours a week _____
    f. > than 5 hours a week _____
9. What types of follow up treatment do you perform for patients with pediatric brain tumors?
    a. Treat for as long as problems persist _____
    b. Refer patients to Outpatient SLP services _____
    c. Work with educational (school) team to transition _____
    d. Re-evaluation periodically _____
    e. Other (please explain)

    _____

    _____

    ___

10. What is the one most important point for SLPs to realize in working with children with tumors?

    _____

    _____

    ___

APPENDIX E

SURVEY NARRATIVES

APPENDIX E

SURVEY NARRATIVES

Question 6

1A) 50%

1B) 85%

2A) 80% of patients

2B) NA (we do not treat pediatrics)

3A) ~75%

5A) 75%

7A) Difficult question to answer because there may be patients admitted with these tumors that do not need all services. Therefore we do not know they exist. Therefore any patient that is referred to us usually has a speech or swallowing problem, which is why they are referred.

7B) Most

8A) 100%

9A) As I am inpatient, I don't see kids after their treatment but more so during treatment but, I would say at least 90%

10A) 100%

10B) All that have been here

11B) ~50-60%

12A) 50%

12Ab) 100% The doctors would not order speech therapy unless there was a problem in these areas.

13A) I may not get consulted on all, but 95-100% of the ones for whom I receive a consult for

13D) 75%

14A) 1/1

15A) 50%

15E) 0

16A) ~25%

18A) 75-80%

19A) 1 year

22A) 25%

22B) NA (we do not see many children with brain tumors at this site)

22D) Unable to give estimate, most have treatment before coming to speech

23C) Of the small number, all have exhibited speech and swallowing problems. My experience is most pediatric patients are treated at another facility where follow-up services are provided.

25A) All, that's why speech consulted

25B) ~85-95%

25C) 1

27A) 80% speech/language

33B) 1/1

34A) 30%

34Ab) 25%

35A) 70%

35B) Depends on location of tumor/treatment course selected

35C) 50%

35D) 75%

36A) 100% (otherwise I would not receive a consult)

36B) 100%

37B) 100% The severity of the problem varies mild-severe

39A) With posterior fossa tumors ~80% swallowing ~50% mutism

41A) NA (we do not treat these pts.)

42A) 50%

42B) ~70-75%

44A) 70-85% (we only get referrals on those pts who exhibit cognitive or swallow deficits)

46A) 75%

46D) ~80%

48A) 100% (this is why we are referred)

49A) ~80%

50A) 90%

Question 9e

5A) MBSS as needed

8A) I work in a rehab setting so we treat the patient as long as problem persists as well as transition the child back to school if possible.

9A) Cognitive evaluations

10A) Inpatient rehabilitation

12Ab) Several patients have received outpatient Modified Barium Swallow studies post d/c

13A) If residual deficits, typically transfer to rehab hospital

15E) Unknown

33B) Feeding/speech issues

34Ab) We have a Coordinated Treatment Center that conducts a Peds Acquired B1 Clinic monthly.

42A) We are an acute facility. We do a pre and post-operative cognitive and communication evaluation. If any post-op deficits are identified we treat until discharged to outpatient therapy or St. Jude.

48A) Transition from inpatient to outpatient. Tx if I have an opening

Question 10

1A) These children have sensory issues secondary to needles and tubes inserted into their bodies.

2A) Deficits are individualized and will vary greatly from child to child.

3A) Swallowing Problems are very severe due to location of brain injury.

4B) We don't have the experience to comment on this.

5A) Thorough medical chart review and safety first, with respect to eating and drinking. Ongoing family education.

7A) Every patient with a brain tumor is different.

7B) Prognosis and appropriate level of intervention.

8A) It is important to realize that we are treating speech-language deficits and swallowing dysfunction; however, "quality of life" is an integral piece. We need to help our families cope at times secondary to the difficult/devastation recommendations we are making at times.

10A) Brainstem tumors have high risk of aspiration- need swallowing checked out by SLP.

10B) The interpersonal (emotional journey) of possibly losing these kids. Knowing what you can fix and what you can't.

11B) Allow rest periods and avoid over-stimulation.

12A) Teach the parents.

12Ab) Decreasing environmental stimulation as needed particularly immediately post op. Treat mutism like apraxia and associated motor dysfunction. I personally think that craniosacral therapy has been helpful in treating the apraxic-like symptoms post posterior fossa tumors unfortunately our medically staff does not recognize its value.

13A) Deficits can be affected by where they are in treatment.

13D) Families need to be involved in the entire process. Depending on where the child is with treatment, they can have varying degrees of dysphagia and cognitive deficits day to day.

14A) Treat each patient with an individualized treatment plan because each child will present differently at different points of the "recovery" process.

14C) We do not see children with brain tumors at our hospital. So sorry!

15A) That the size, location, and types of medical treatment make EACH one different!

16A) Neuroplasticity

19A) Patient/Family education and making appropriate discharge plans from hospital to outpatient or home health.

22A) Can't assume outcome based on tumor location/type like in adults and you must compare functional status to premorbid function rather than just look at standard scores.

22D) Have seen slow, steady progress.

22E) I believe it would be target functional skills with direct application to a child's daily living skills and environment, school performance, social-communication and peer relationships etc. Ask- what skills make the biggest impact or cause the most problems or consequences? Start there.

23C) Sequelae of radiation treatment, anticipate exacerbation of symptoms or recurrence of tumor. Treatment for compensatory approaches.

23E) Psychological/mental health of these children.

25A) It's a family/team approach.

25B) Treat the issues that arise, not what you think the deficit (tumor type or placement) might be. That is good knowledge to start your assessment, but treat what you see.

27A) The child's awareness of their deficits. Recognition of deficits in word finding, processing and memory.

32A) Limited experience precludes an opinion at this time.

33B) I have only had 1 patient with brain tumor at this facility in 4 years that was referred with feeding/speech issues. She was 13 m and didn't survive 3 months s/p dx.

34A) Each child will present differently regardless of the type of tumor. Education for future difficulties is so important, especially in the really little kids.

34Ab) Outcomes can vary and we need to focus on the patient's current functional needs knowing they will chg. as pt. grows and develops. Adaptations need to be made to respond to these changes.

35A) A thorough assessment in all parameters is imperative, as a multitude of manifestations can potentially be expected.

35B) often children with brain tumor dx have a poor prognosis however you can work to improve their quality of life while they are completing their treatment protocol.

35C) They may have difficulty tolerating acute rehab, irritability and need to focus of function initially/family education.

35D) Understanding different symptoms that can be observed pre or post-surgery (e.g. posterior fossa syndrome)

36A) These children have been through a lot. Keep it fun and let them have fun and be kids!

36B) Sometimes treatment/therapy can be more for family benefit than actual patient progress and is palliative in nature.

37B) After a tumor resection, remember to think about what these kids have been through- there is a high level of frustration when these kids can't communicate verbally- reassure them you'll be working together to find a way.

42A) The children can be quite resilient and in a majority of cases, the children do not need speech services. Patients with brainstem gliomas typically demonstrate issues with oral dysphagia early on demonstrating both oropharyngeal dysphagia as the patient progresses. Posterior fossa syndrome seen with medulloblastoma patients affecting both PO feeding skills and communication skills. Cases can last as long as 6 months with a few documented cases up to 1 year. Patients have poor interaction with their environment, but will recall events once posterior fossa syndrome has resolved.

42B) Radiation has long-term effects that can result in changes in language/cognition for many years after treatment has been completed. Therefore, all children who

receive radiation should be closely monitored as they are at high risk for language/cognitive deficits.

44A) The patient continually changes and requires reassessment.

46A) They need constant reassessment and reevaluation because their needs, skills, and abilities are constantly changing.

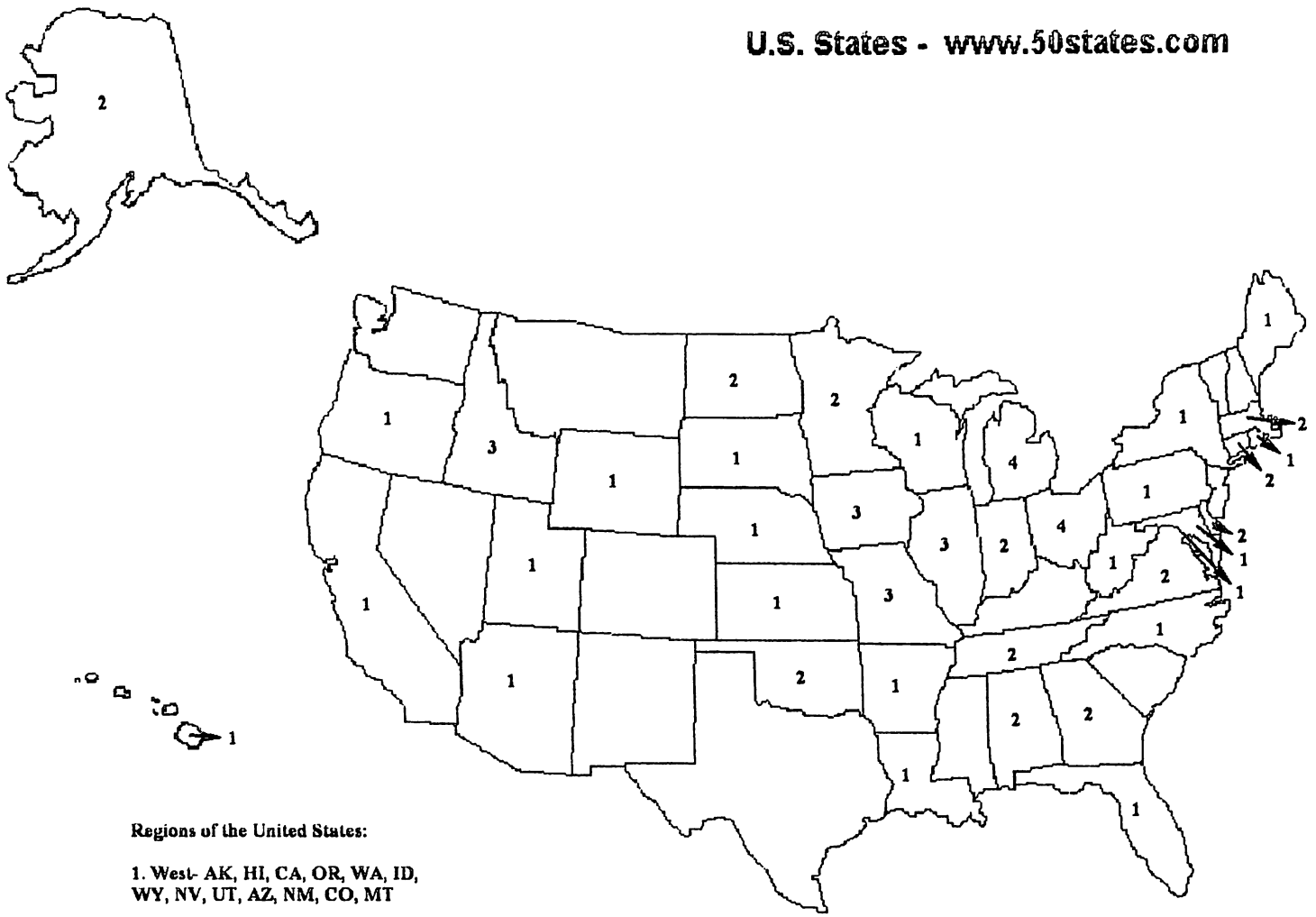
46D) Their deficits can be very different from those patients with acquired brain injuries such as TBI, CHI, stroke, etc. There is also a very different grieving process for parents, as these tumors may return.

48A) Each child presents differently and family input is vital!

50A) Each child is VERY different, even if their tumor is in the same place.

APPENDIX F

MAP OF SLPS' RESPONSES BY STATE



Regions of the United States:

1. West- AK, HI, CA, OR, WA, ID, WY, NV, UT, AZ, NM, CO, MT

2. Midwest- ND, SD, NE, KS, MN, IA, MO, WI, IL, IN, MI, OH

3. South- TX, OK, LA, MS, AL, FL, GA, SC, NC, VA, WV, MD, DC, DE, KY, TN, AR

4. Northeast- NJ, PA, NY, CT, RI, MA, NH, VT, ME

APPENDIX F

MAP OF SLPS' RESPONSES BY STATE

This map shows the number of SLP responses per state. The regions are divided according to the U. S. Census

APPENDIX G

LIST OF ABBREVIATIONS

APPENDIX G

LIST OF ABBREVIATIONS

CNS	central nervous system
ADL	activities of daily living
CT	computed tomography
CSF	cerebrospinal fluid
MRI	magnetic resonance imaging
MRA	magnetic resonance angiography
MRS	magnetic resonance spectroscopy
EBRT	external beam radiation therapy
IRT	internal radiation therapy
IQ	intelligence quotient
CBTRUS	Central Brain Tumor Registry of the United States
CBCL	Child Behavior Check List
CMS	cerebellar mutism syndrome
WPPSI-R	*Wechsler Preschool and Primary Scales of Intelligence*
DAS	*Differential Abilities Scale*
VMI	*Beery Visual Motor Integration*
EOWPVT-R	*Gardner Expressive One-Word Picture Vocabulary Test*
CELF-3	*Clinical Evaluation of Language Fundamentals-3rd Ed.*
CELF-P	*Clinical Evaluation of Language Fundamentals-*

	Preschool
PPVT-III	*Peabody Picture Vocabulary Test-Third Edition*
HPNT	*Hundred Pictures Naming Test*
TOPS-Elementary	*Test of Problem Solving-Elementary, Revised*
TOPS-Adolescent	*Test of Problem Solving-Adolescent*
TOWK	*Test of Word Knowledge*
TLC-E	*Test of Language Competence-Expanded Edition*
QUIL	*Queensland University Inventory of Literacy*
TOPA	*Test of Phonological Awareness*
VABS	*Vineland Adaptive Behavior Scales*
RAVLT	*Rey Auditory Verbal Learning Test*

APPENDIX H

LIST OF DEFINITIONS

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LIST OF DEFINITIONS

Abducens Nerve- a small motor nerve supplying the lateral rectus muscle of the eye (*Stedman's Medical Dictionary*)

Apathy- Indifference; absence of interest in the environment. Often one of the earliest signs of cerebral disease. (*Stedman's Medical Dictionary*)

Apraxia- 1. A disorder of voluntary movement, consisting of impairment in the performance of skilled or purposeful movements, notwithstanding the preservation of comprehension, muscular power, sensibility, and coordination in general; due to acquired cerebral disease. 2. A psychomotor defect in which the proper use of an object cannot be carried out although the object can be named and its uses described. (*Stedman's Medical Dictionary*)

Astrocyte- cells found between blood vessels and neurons (Greenberg, 1997)

Astrocytoma- central nervous system tumors derived from astrocytes (Greenberg, 1997)

Ataxia- An inability to coordinate muscle activity during voluntary movement; most often due to disorders of the cerebellum or the posterior columns of the spinal cord; may involve the limbs, head, or trunk. (*Stedman's Medical Dictionary*)

Basal Forebrain- The anterior primitive cerebral vesicle and the most rostral of the three primary brain vesicles of the embryonic neural tube; it subdivides to form the diencephalon and telencephalon. (*Stedman's Medical Dictionary*)

Brain edema- brain swelling due to increased volume of the extravascular compartment from the uptake of water in the neuropile and white matter. (*Stedman's Medical Dictionary*)

Brain Stem- Originally, the entire unpaired subdivision of the brain, composed of (in anterior sequence) the rhombencephalon, mesencephalon, and diecephalon as distinguished from the brain's only paired subdivision, the telencephalon. More recently, the term's connotation has undergone several arbitrary modifications: some use it to denote no more than rhombencephalon plus mesencephalon, distinguishing that complex from the prosencephalon (diencephalon plus telencephalon); others restrict it even further to refer exclusively to the rhombencephalon. From both developmental and architectural viewpoints, the original interpretation seems preferable. (*Stedman's Medical Dictionary*)

Calcification- 1. Deposition of lime or other insoluble calcium salts. 2. A process in which tissue or noncellular material in the body becomes hardened as the result of

precipitates or larger deposits of insoluble salts of calcium (and also magnesium), especially calcium carbonate and phosphate (hydroxyapatite) normally occurring only in the formation of bone and teeth. (*Stedman's Medical Dictionary*)

Cerebellar Mutism- transient and not uncommon complication following surgical resection of posterior fossa tumors. (Rekate et al., 1985)

Cerebellar Vermis- the narrow middle zone between the two hemispheres of the cerebellum; the portion projecting above the level of the hemispheres on the upper surface is called the superior vermis; the lower portion, sunken between the two hemispheres and forming the floor of the vallecula, is the inferior vermis. (*Stedman's Medical Dictionary*)

Cyst- An abnormal sac containing gas, fluid, or a semisolid material, with a membranous lining. (*Stedman's Medical Dictionary*)

Diencephalon- The caudal part of the prosencephalon composed of the epithalamus, thalamus, and hypothalamus. (*Stedman's Medical Dictionary*)

Diffuse Intrinsic Brain Stem Glioma- a brain stem glioma spread out entirely in one part of the brain. (*Stedman's Medical Dictionary*)

Dysarthria- A disturbance of speech due to emotional stress, to brain injury, or to paralysis, incoordination, or spasticity of the muscles used for speaking. (*Stedman's Medical Dictionary*)

Dysphonia- phonation disorder characterized by hypernasal and/or breathy voice quality (Goncalves et. al., 2006)

Ependymal cells- cells that line the ventricles within the brain and center of the spinal cord (Capodano, 2001)

Ependymoma- type of glioma tumor derived from ependymal cells (Capodano, 2001)

Executive function issues- including planning and sequencing (Levisohn et. al, 2000)

Facial Nerve Palsy- paralysis of facial nerve (*Stedman's Medical Dictionary*)

Focal Lesion- pathologic change in tissue relating to a localized area. (*Stedman's Medical Dictionary*)

Fornix- The compact, white fiber bundle by which the hippocampus of each cerebral hemisphere projects to the contralateral hippocampus and to the septum, anterior nucleus of the thalamus, and mamillary body. (*Stedman's Medical Dictionary*)

Hemiparesis- Weakness affecting one side of the body. (*Stedman's Medical Dictionary*)

High-grade tumors- grow rapidly and can easily spread through the brain, require very intensive therapy (Disease Information, Astrocytoma/Glioma, n. d.)

Histology- The science concerned with the minute structure of cells, tissues, and organs in relation to their function. (*Stedman's Medical Dictionary*)

Hydrocephalus- A condition marked by an excessive accumulation of cerebrospinal fluid resulting in dilation of the cerebral ventricles and raised intracranial pressure; may also result in enlargement of the cranium and atrophy of the brain. (*Stedman's Medical Dictionary*)

Hypokinesis- Diminished or slow movement. (*Stedman's Medical Dictionary*)

Hypothalamus- The ventral and medial region of the diencephalon forming the walls of the ventral half of the third ventricle prominently involved in the functions of the autonomic (visceral motor) nervous system and, through its vascular link with the anterior lobe of the hypophysis, in endocrine mechanisms; it also appears to play a role in neural mechanisms underlying moods and motivational states. (*Stedman's Medical Dictionary*)

Language processing problems- primarily in the areas of expressive and receptive syntax, vocabulary, word fluency and literacy (Hudson and Murdoch, 1992)

Low-grade tumors- more localized tumors that grow slowly over a long period of time (Disease Information, Astrocytoma/Glioma, n. d.)

Medulla- the most caudal subdivision of the brainstem, immediately continuous with the spinal cord, extending from the lower border of the decussation of the pyramid to the pons. (*Stedman's Medical Dictionary*)

Medulloblastoma- tumor found in the cerebellum (Bailey and Cushing, 1925)

Memory Disorder- ability to recall information (Spiegler, et. al., 2004)

Motor Speech Disorder- A disorder due to an inability to accurately produce speech sound or phonemes due to muscle weakness/incoordination or difficulty in voluntary muscle movement. (*Stedman's Medical Dictionary*)

Mutism- the state of being silent and the organic or functional absence of the faculty of speech (*Stedman's Medical Dictionary*)

Neuroblastoma- A malignant neoplasm characterized by immature, only slightly differentiated nerve cells of embryonic type, *i.e.*, neuroblasts. (*Stedman's Medical Dictionary*)

Optic Chiasm- a flattened quadrangular body in front of the tuber cinereum and infundibulum, the point of crossing or decussation of the axons of the optic nerves; axons from the nasal retina cross to the opposite side while axons from the temporal retina run directly caudal without crossing, some pass transversely on the posterior surface between the two optic tracts and others pass transversely on the anterior surface between the two optic nerves. (*Stedman's Medical Dictionary*)

Osteosarcoma- the most common and malignant of bone sarcomas, which arises from bone-forming cells and affects chiefly the ends of long bones. (*Stedman's Medical Dictionary*)

Pons- that part of the brainstem between the medulla oblongata caudally and the mesencephalon rostrally, composed of the basilar part of pons and the tegmentum of pons. (*Stedman's Medical Dictionary*)

Pragmatic issues- rules of language governing how language is used for social purposes (K. L. Pence & L. M. Justice, 2008)

Radiochemotherapy- radiation given during the first cycle of induction chemotherapy with high-energy photon beams either by lateral opposed fields with the child in the supine position or by two lateral and a posterior field with the child in the prone position (Benesch et al, 2001)

Thalamus- large, ovoid mass of gray matter that forms the larger dorsal subdivision of the diencephalon. (*Stedman's Medical Dictionary*)

Word finding difficulties- vocabulary (Docking et al, 2005)

Velum- 1. Any serous membrane or membranous envelope or covering 2. Any structure resembling a veil or curtain (*Stedman's Medical Dictionary*)

APPENDIX I

DIAGRAMS OF THE BRAIN

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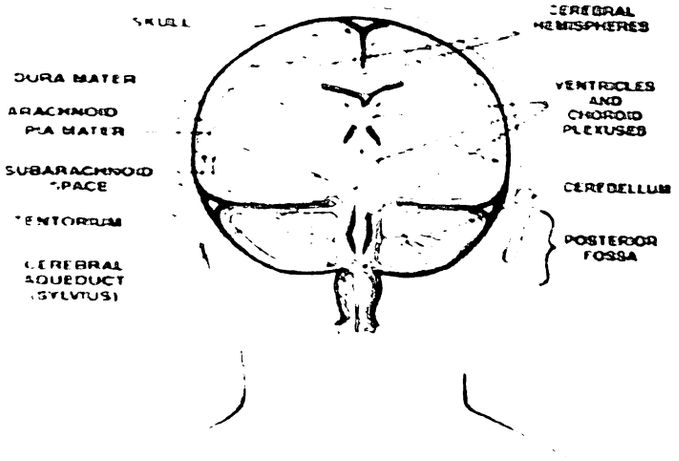

Figure 9. Meninges and Ventricles of the Brain

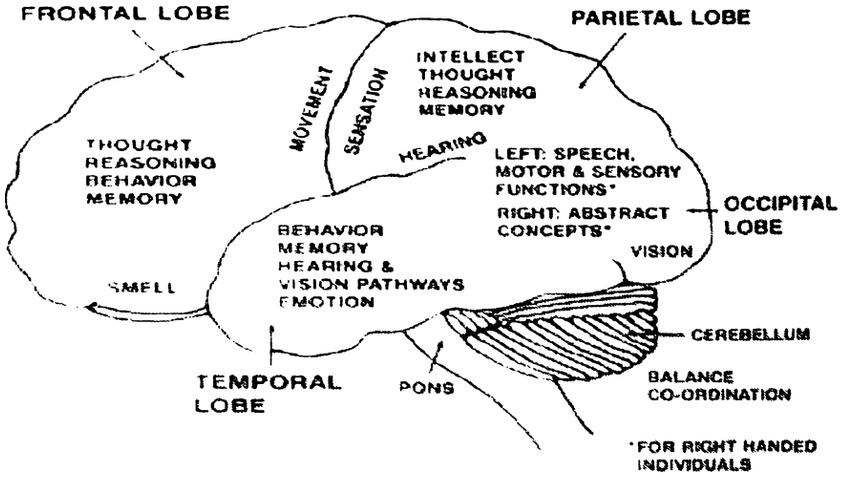

Figure 10. Functions of the Cerebral Hemispheres

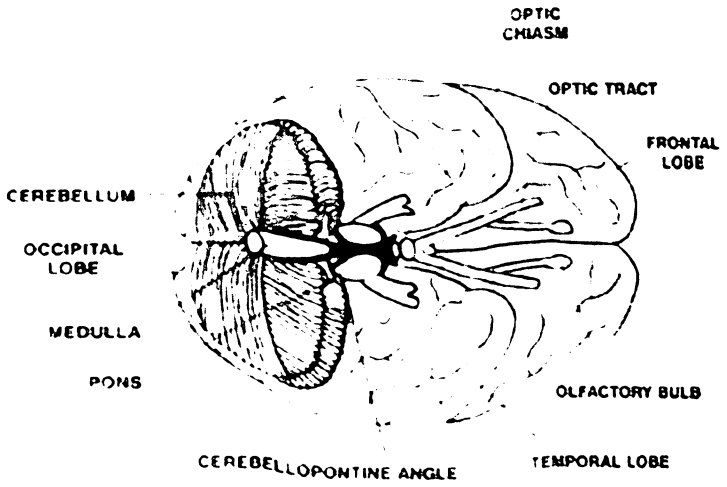

Figure 11. View from the Bottom of the Brain

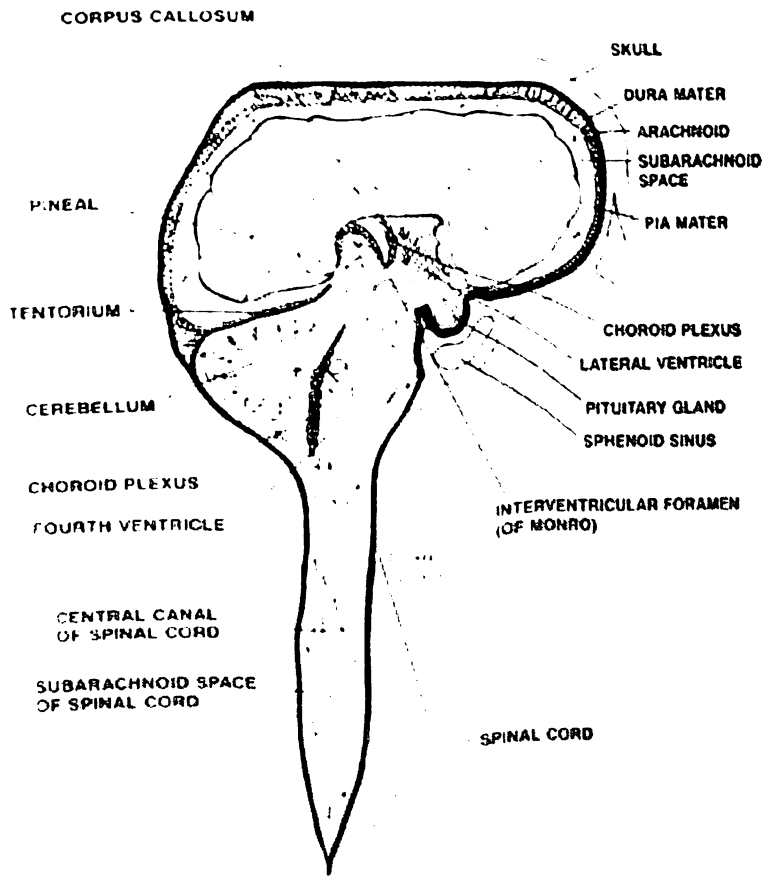

Figure 12. Lateral View of the Brain and Spinal Cord

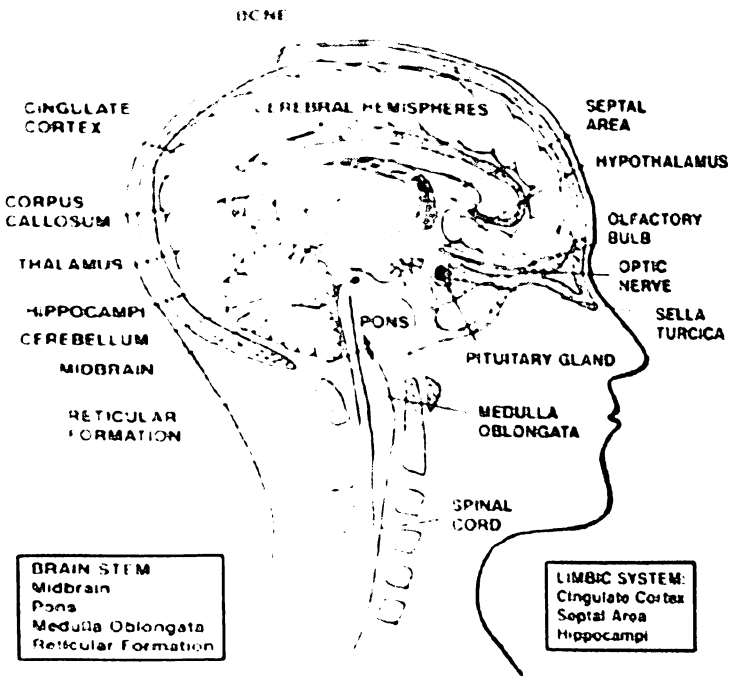

Figure 13. Cross-section of the Head

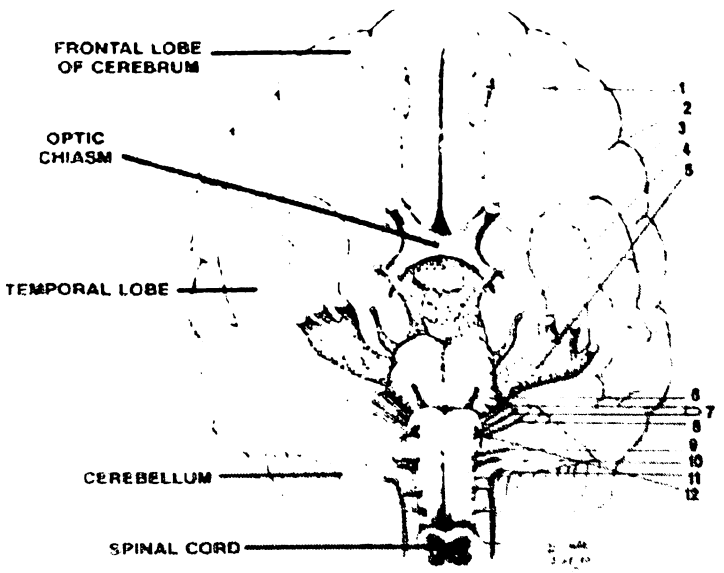

Figure 14. Cranial Nerves

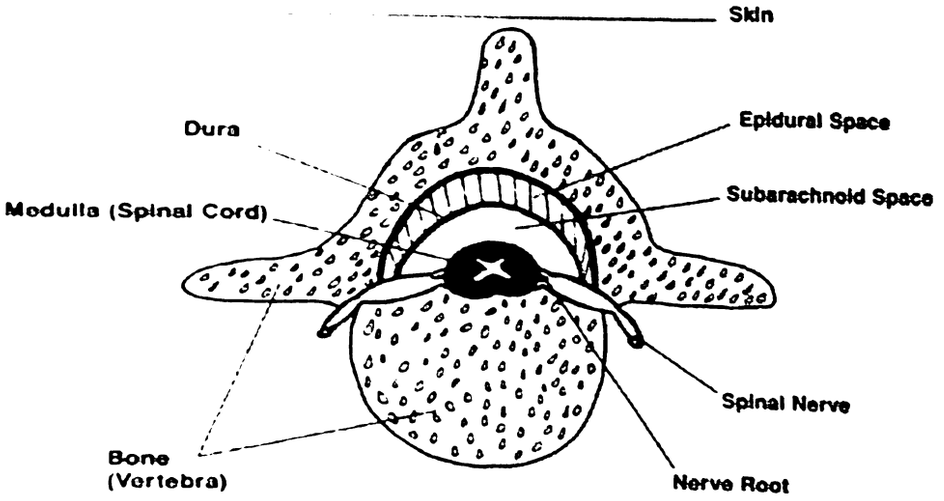

Figure 15. Cross-section of Vertebra and Spinal Cord

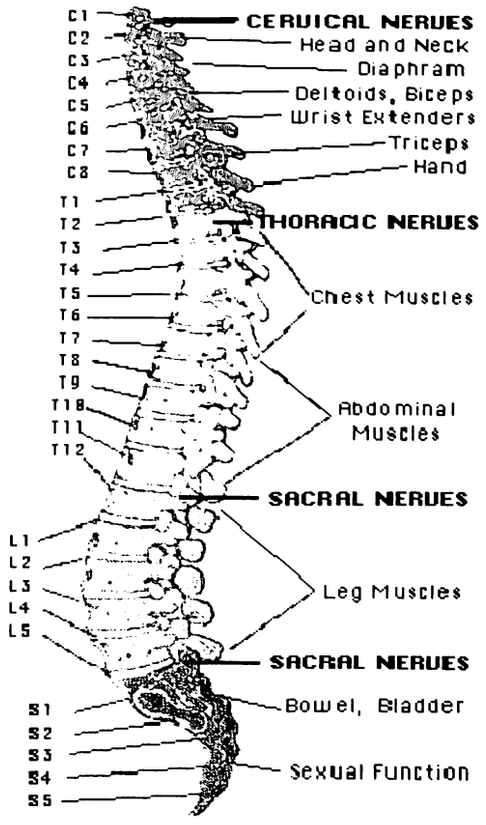

Figure 16. Spinal Cord and Nerve Roots

VITA

Emily Kathryn Chambers is a senior in the Department of Communication Sciences and Disorders at the University of Mississippi. She will receive a Bachelor of Arts degree in Communication Sciences and Disorders from the University of Mississippi in May 2009 and graduate Magna Cum Laude. Emily is a member of Phi Kappa Phi, Gamma Beta Phi, Eta Sigma Phi, Sigma Alpha Lambda, Alpha Lambda Delta, and serves as membership chair of Mortar Board. She has been on either the Chancellor's Honor Roll or the Dean's List each of her semesters at the University of Mississippi. This project was presented in poster format at the 2008 American Speech Language Hearing Association (ASHA) Convention in Chicago, Illinois. This project was also accepted to the 2009 International Otolaryngology Conference in Brazil.