Left Side Weakening and High-Field MRI Brain Scanning of Angiocentric Glioma: A Case Report

Abstract

This case report details the history, diagnosis, and follow-up of a 16-year-old male of South Asian descent who presented to the emergency room with left side weakening and numbness, decreased vision, and headaches. Radiologic evaluation with computed tomography (CT) and magnetic resonance imaging (MRI) results and findings are discussed. In addition, a comparison between low-field and high-field MRI is given with some benefits of intraoperative MRI. Possible advantages of using high-field MRI are given. The patient’s treatment regimen and follow-up care are presented to better educate the radiologic technology community.

Introduction

The brain is the most complex part of the human body, controlling movement, behavior, senses, and all other functions of the body. The cerebral cortex or gray matter in the brain is where most of this information is processed. The cerebral lobe is the source of intellectual activities such as planning, thinking, reading books, playing games, and holding memories. The nerve fibers of the two hemispheres of the cerebral lobe cross over causing the right side of the cerebrum to control the left side of the body and the left side of the cerebrum to control the right side of the body. Therefore, when problems occur within the brain, the results can be devastating.¹

This case study reviews the history, diagnosis, radiologic evaluation using CT and MRI, and treatment options of a patient with angiocentric glioma (AG). Radiologic evaluation is key in determining resectability, treatment effectiveness, and observation of recurrent disease. The goal is to inform the radiologic science community of high-field magnetic resonance imaging’s role in the diagnosis, surgical targeting, and management of brain tumors, specifically AG.²

Anatomy and Physiology

“A glioma is a primary brain tumor that originates from the supportive cells of the brain, called glial cells. Glial cells are the most common cellular component of the brain. There are five
to 10 times more glial cells than neurons.\textsuperscript{4}\textsuperscript{(p.1)} Gliomas form when glial cells multiply and divide too quickly and rapidly.\textsuperscript{4}

Because gliomas cover a wide range of tumor types and grades, benign or malignant, treatments and expected outcomes vary greatly from patient depending upon tumor type and location. Different types of gliomas are formed from different types of glial cells. Of the different tumor types, astrocytomas make up two-thirds of gliomas. One rare subtype of astrocytoma is (AG). AGs refer to lesions that originate in blood vessels. Consequently, classification and diagnosis of this type of tumor can be very challenging. Because the brain controls so many functions of the body, symptoms can vary widely from tumor to tumor and make diagnosis of AG difficult.\textsuperscript{4}

**Signs and Symptoms of Angiocentric Glioma**

“Angiocentric gliomas (AGs) are a rare, slow-growing neoplasm occurring predominantly in the pediatric population and in young adults without a strong gender bias, and most commonly presents with intractable seizures.”\textsuperscript{2}\textsuperscript{(p.4)} These seizures are typically the first recognizable symptom.\textsuperscript{2,6} AGs are usually found in any cerebral lobe in the cortex or subcortical white matter of the brain, therefore, symptoms of AG can vary greatly. Depending upon the location of the tumor, symptoms will change. This occurs because different sections of the brain control different functions throughout the body.\textsuperscript{2} A brain tumor within the skull can cause pressure on the brain or can cause the brain to shift. It can also damage nerves and other healthy brain tissue. For example, a tumor infringing upon the Broca’s area section of the frontal lobe of the brain, which controls the motor movements necessary to perform speech, would cause changes to a patient’s speech patterns.\textsuperscript{6}

Since being described and recently classified in 2007 by the *World Health Organization Classification of Tumours of the Central Nervous System*, only seven reports of this type of tumor have been described in literature. AGs are of uncertain etiology and histogenesis, and have been reclassified as a neuroepithelial central nervous system tumor. There have been so few cases reported that understanding of the symptoms is somewhat lacking. However, with the information available, some patients reported symptoms of headaches, decreased vision, ataxia, and otalgia. Symptoms such as dizziness, slurred speech, and weakening or numbness of extremities on one side of the body have also been reported.\textsuperscript{2,6}
Risk Factors

When a patient is informed that they have a brain tumor, many questions may arise concerning the risk factors associated with that disease. If something affects the patient’s risk of having a medical issue, it is considered to be a risk factor. Although many studies have been performed testing various environment and genetic risk factors, the cause of brain tumors is unclear. Exposure to ionizing radiation is the only risk factor that has clearly shown an increased risk in developing brain cancer. Some genetic factors such as inherited chromosomal abnormalities may also be risk factors for brain tumors, but this is extremely uncommon. Also, because AG is so rare, many of the risk factors for developing this type of lesion are simply unknown.

Histopathology

The pathological features of AGs are similar to other types of brain tumors such as astrocytomas and ependymomas, and their rare occurrence make accurate diagnosis difficult. AGs, in general, are “composed of diffusely infiltrating, monomorphic, bipolar spindle cells arranged around blood vessels in concentric sleeves and pseudorosettes, demonstrating an angiocentric pattern. Immunohistochemical staining results are typically positive for glial fibrillary acidic protein, S-100, and vimentin and are consistent with a dotlike pattern for epithelial membrane antigen6(p12-13). The primary histologic features are elongated tumor cells that do not test positively for neuronal antigens.

Case Report

A 15-year-old South Asian male presented to the emergency department with indications including a four-month history of progressively worsening numbness of the left side of his body and increased weakness, which began with his left hand and arm and eventually involved his left leg. In addition to these indications, the patient complained of left-sided facial weakness, blurred vision, intermittent headaches with photophobia, and drooling. His past medical and family history did not contribute to his condition. Several neurological findings such as bilateral papilledema, left-sided facial droop, right-sided cranial nerve VI palsy, sluggish pupil responses
to light, and reduced strength in lower and upper left extremities were seen in a physical examination, while routine laboratory studies were normal. To begin diagnosis, radiologic evaluations of the brain were recommend.²

**Diagnosis and Detection**

Radiologic evaluation is essential in diagnosing the type of brain tumor, resectability, surgical targeting, treatment effectiveness, and detecting recurrent disease. Computed tomography (CT) is often the first radiologic diagnostic procedure taken. One specific modality, however, magnetic resonance imaging (MRI), plays the greatest role in the diagnosis and treatment of brain tumors, and some advances have recently been shown in this process using a high field magnet.

**Computed Tomography**

Diagnostic imaging for this patient began with an unenhanced head CT. Findings from this CT showed a heterogeneous, intraaxial ovoid mass measuring 6.7 cm in maximal diameter centered on the right frontal lobe (see Figure 1a). “The lesion produced both local mass effect with subfalcine herniation and effacement of the anterior horn of the lateral ventricle, as well as global mass effect with approximately 6 mm of right-to-left midline shift. No hemorrhage or calcification of the lesion was demonstrated, and there was no significant white matter edema.”²(p1) The early diagnosis for this mass in the right frontal lobe included a dysembryoplastic neuroepithelial tumor, ganglioglioma or gangliocytoma. From these findings, urgent MRI and neurosurgical consultation were recommended.²

**Magnetic Resonance Imaging**

Because AGs have pathological features similar to other types of brain tumors such as astrocytomas and ependymomas, their rare occurrence make accurate diagnosis using MRI challenging.² MR images of AGs generally show a supratentorial, non-enhancing, T1-hypointense and a T2-hyperintense tumor.⁸ The patient chose to continue diagnostic imaging using MRI of the brain and spine which “confirmed an ovoid T1 heterogeneously hypointense, T2 heterogeneously hyperintense intraaxial mass in the right anterior frontal lobe extending from the
periventricular region up to the vertex” (see Figure 1b, c and d).\(^2\) Compression of the anterior horn of the right lateral ventricle was shown causing a shift in the midline. Sagittal and axial T1-weighted, 3D gradient echo T1, axial T2-weighted, axial diffusion-weighted, and axial diffusion tensor tractography imaging were used to diagnose this angiocentric glioma. MR spectroscopy was also performed followed by gadolinium administration. Post-gadolinium, mild, heterogeneous, internal enhancement with several pial feeder vessels were demonstrated in the mass. Images of the spinal cord were unremarkable.\(^2\) Although the tumor in this patient was visualized well using a low-field, 1.5T magnet, some vasculature, particularly in malignant brain tumors can be better visualized using a high-field magnet. This can aid in providing higher quality treatment planning, diagnosing, and surgical targeting for a patient with a brain tumor.

**High-field vs. Low-field MRI**

Some advancements have been made technologically concerning MRI that may aid in the diagnosis, and especially in the surgical targeting of AG. Magnet field strength of MRI has increased since its first introduction clinically in the 1980s. Although many pilot studies have been done using the ultrahigh-field strength MRIs at 7.0T and higher, there has been some concern about imaging artifacts and safety in imaging brain tumors with the 7.0T along with its comparison to the diagnostic ability of 1.5T MRI when using contrast. All side effects reported after being scanned by the 7.0T MRI were minor including headache, back pain, neck stiffness, skeletal muscle contraction, and most commonly, transient vertigo in a study done from August 2009 to August 2010 by Seung et al. A clearer delineation of the tumor was revealed on the margins of the brain tumors examined with the 7.0T MRI. Figure 2 shows images of the brain that have been acquired in T2-weighted axial or T1-weighted coronal or sagittal images with the 7.0T MRI then compared with 1.5T brain MRIs in recent studies.\(^3\)

High-field MRI compared to low-field MRI may aid in the treatment of patients with brain tumors, especially those with more vascularity seen in many malignant or high grade brain tumors. Vascular proliferation, necrosis, and mitotic figures provide evidence in the identification of high grade gliomas. Vascular proliferation is one of the most significant findings in predicting survival. To facilitate appropriate diagnosis and determine the grade of tumor, “the improved signal-to-noise ratio, possible with ultrahigh-field-strength magnetic resonance (MR) imaging, allows for the acquisition of the high-spatial-resolution images of the central nervous
Intraoperative surgical targeting with high-field MRI is another way a patient with a brain tumor can benefit from MRI.

**Surgical Targeting with MRI**

Although very high in cost, high-field intraoperative MRI (iMRI) scanners provide the “highest resolution for detection of even small tumor remnants and have thus proven to be a sufficient tool providing extended tumor volume resections and higher percentages of gross total resections (GTRs) in glioma surgery.” Being able to visualize fiber bundles, localization of eloquent cortical sites, and metabolic function is also a major benefit of iMRI. Another important advantage of using iMRI during tumor resection is that it allows the surgeon to have updated navigation when intraoperative brain deformations occur, such as brain shift caused by tumor mass resection itself, brain swelling, use of retractors, or loss of cerebrospinal fluid. When resection is done with the iMRI guidance there is also less damage done to the nerves. One of the most significant findings in a study done by Kuhnt et al is that the extent of resection (EOR) was >98.5%. With the help of iMRI patient survival increases because gross total resection is done without the risk of brain shift. Furthermore, iMRI helps to ensure that the entire tumor is removed including small remnants not visualized without the use of iMRI.

**Treatment**

There are only a few different treatment options available for patients diagnosed with AG, partially because the occurrence of this type of tumor is so rare. However, the treatment options that are available seem to produce very favorable outcomes. Treatment options available are gross total resection, partial resection, and radiation therapy. Of the treatment options available, resection followed by radiation therapy are fairly effective in helping a patient with AG reduce symptoms such as seizures, vision or speech impairment, and return to a more normal quality of life.

**Resection**

Either gross total resection or subtotal resection of the tumor can be performed. Because AGs behave like a low-grade neoplasm, gross total resection has been curative in most cases that
have been documented with no recurrence of seizures. Subtotal resection has a higher risk of recurrence than gross total resection, and prognosis is not as good for the patient. However, the prognosis for gross total resection is very good and is usually curative of the seizures associated with it and other symptoms can often be suppressed by medications. Radiation therapy in addition to resection is another option.

**Radiotherapy**

Adjuvant radiotherapy is an additional treatment option to resection. Malignant gliomas like the AG in this patient can have a relapse rate up to 90%. Sometimes, re-irradiation is required using conventional radiotherapy, fractionated stereotactic radiotherapy, and LINAC-based stereotactic radiosurgery. Post-resection, biopsy of the this patient’s tumor was done. After the patient in this case had a successful gross total resection of the AG, fractionated radiation therapy was given to ensure the tumor was completely gone.

**Histological Findings**

After gross total resection of the tumor, histological findings were consistent with those of malignant glioma with anaplastic features. Some characteristics found histologically corresponded to high-grade angiocentric glioma including:

- Cellular elongation.
- An infiltrating growth pattern with numerous entrapped neurofilament protein-immunoreactive axons.
- Diffuse immunoreactivity for glial fibrillary acidic protein (GFAP).
- Perivascular formations linearly and radially as classic perivascular pseudorosettes
- Absence of subpial palisading.
- Ependymal differentiation.
- Numerous mitoses.
- Vascular proliferation.
- Focal necroses.

With specimens sent for pathology, the patient had very high levels of choline content and the choline/NAA ratio was also elevated. When this occurs, it indicates “the presence of rapid tumor growth and necrotic tissue, characteristics of higher-grade malignancies, including
primitive neuroectodermal tumors. The histological results from the biopsy showed features of malignant glioma with anaplastic features.

Post-Surgery

After gross total resection of the tumor, the patient suffered from more vision loss, and was experiencing 20/400 vision in both eyes. The patient’s hemiparesis improved. Although the patient did not experience seizures prior to gross total resection, a seizure disorder developed postoperatively but was able to be controlled well by a medication called Tegretol. The patient also underwent radiotherapy. Six-month follow-up imaging showed that the patient had a thickened and nodular appearance on the tumor bed. A repeat right frontal craniotomy for resection was then required. Histologic findings from the second resection showed recurrence of AG. The second radiotherapy session consisted of dose-intense temozolomide. Since then subsequent MR imaging has remained stable. The patient has experienced problems with balance and gait, lower limb and left facial weakness, and expressive aphasia, but these symptoms have improved with medication adjustments. No other surgeries have been required.

Conclusion

A 15-year old South Asian male presented to the emergency department with symptoms including progressively worsening numbness and weakness on the left side of his body, left-sided facial weakness, blurred vision, intermittent headaches with photophobia, and drooling. These symptoms had been occurring for four months. A CT of the patient’s head revealed a heterogeneous, intraaxial ovoid mass centered on the right frontal lobe. Continued diagnostic imaging using MRI confirmed an ovoid intraaxial mass containing several small hyperintense cavitary regions within the mass and a shift in the midline. Many pial feeder vessels were also visualized. Several advances in MRI have enabled surgical targeting and better treatment of AG including iMRI using a high-field magnet.

The patient underwent gross total resection of the tumor followed by fractionated radiation therapy. Unfortunately, six-month follow-up MR imaging showed a thickened and nodular appearance of the tumor bed and a second resection was done. This was followed by more radiation therapy and adjustments to medication to ease other symptoms occurring such as left lower limb and left facial weakness, gait and balance problems, and aphasia. Treatment
options for AG are limited because of the rarity of the disease, but mortality rates are favorable with gross total resection and radiation therapy.
References


Figure 2. 1.5T and 7.0T MRI for a central neurocytoma. A shows T1-weighted coronal images from 1.5T brain MRI, and B shows T2-weighted coronal images from 1.5T brain MRI. C and D show images with 7.0T MRI. 7.0T MRI show images with a clearer tumor margin, better contrast between gray and white matter, and more detailed vascularity compared with 1.5T brain MRI. Image courtesy of: Paek L, Chung Y, Paek S, et al. Early experience of pre- and post-contrast 7.0T MRI in brain tumors. J Korean Med Sci, 2013;28(9):1362-1372. doi: http://dx.doi.org/10.3346/jkms.2013.28.9.1362.