

Brain Tumors

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ABSTRACT

Brain tumors are a result of uncontrolled growth of cells in the brain. This growth can be cancerous or noncancerous and cause damage to brain tissue which leads to loss of certain functions. Brain cancer is the 10th leading cause of death. There are 4 grades of brain tumors classified by the World Health Organization based on specific components of each type of tumor. Several factors seem to affect whether an individual is diagnosed with brain tumors: age, exposure to radiation, ethnicity and race, family history, weak immune system, and gender. There are various symptoms of brain tumors that are general as well as specific to the location of the tumor. Many types of treatments are available for brain tumors today such as surgery, radiation therapy, chemotherapy, and targeted therapy. This article works to provide an overview of brain tumors discussing the types, risk factors, symptoms, diagnosis, treatments, and preventions.

Introduction

In 2020, approximately 308,102 people worldwide were diagnosed with brain or central nervous system tumors and approximately 251,329 people died from primary cancerous brain and central nervous system tumors (Brain Tumor - statistics, 2023). Brain tumors are the result of abnormal cellular growth in the brain. These tumors can occur either in brain tissue or near the brain tissue. Brain tumors can be either noncancerous (benign) or cancerous (malignant). Benign brain tumors tend to grow gradually and rarely spread to surrounding areas while malignant brain tumors grow rapidly and tend to spread to surrounding areas. However, both types of brain tumors can be dangerous as they can cause damage to the brain by increasing pressure on healthy parts of the brain which results in dysfunction (Brain tumor and brain cancer, n.d.).

Grades of Brain Tumors

Brain tumors can primarily be classified as primary or metastatic based on whether the tumor was formed in the brain tissue itself or migrated to the brain. Primary tumors are tumors that start in the brain (Brain tumor and brain cancer, n.d.). Primary tumors are classified into glial and non-glial based on the type of cell that it is formed and can be further classified as benign or malignant. Metastatic tumors are malignant tumors that start somewhere else in the body and spread to the brain. These tumors are 4 times more common than primary tumors (Brain tumors, n.d.).

The World Health Organization (WHO) has created a classification system that shows a tumor's benignity or malignancy into 4 grade levels. This grading is based on the histological features of the tumor, its growth and whether it is cancerous. Although there are distinct levels, some tumors have various types that can fall into other levels and some tumors can even change grade levels if they get worse.

Grade 1

Tumors that fall under grade 1 are benign and slow-growing. These tumors do not spread and there is a chance of long-term survival. They have distinct edges and will most likely not return if completely removed. With grade 1 tumors, they can mostly be fixed through surgery (Brain tumors, n.d.). The cells affected by these tumors look like normal cells under a microscope (Grades of brain tumours, 2023). Types of grade 1 tumors include pilocytic astrocytoma, craniopharyngioma, gangliocytoma, and ganglioglioma (Brain tumors, n.d.).

Grade 2

Tumors that fall under grade 2 are also benign and relatively slow-growing. However, they can spread into nearby brain tissue. There is a chance that these types of tumors may recur at a higher grade level (How brain tumours are graded, 2023). The grade 2 cells look less like normal cells (Grades of brain tumours, 2023). Although grade 2 tumors are considered low grade, they can still be dangerous and cause serious harm in parts of the brain. Examples of grade 2 tumors include diffuse astrocytoma, pineocytoma, and pure oligodendroglioma (Brain tumors, n.d.).

Grade 3

Grade 3 tumors are malignant and grow fairly fast. These tumors tend to spread to other parts of the brain and sometimes to the spinal cord. They tend to recur even if greatly treated. The cells of grade 3 tumors look abnormal under a microscope (Grades of brain tumours, 2023). These tumors cannot be treated by just surgery, they require other treatments such as chemotherapy or radiotherapy. Some examples of grade 3 tumors include anaplastic astrocytoma, anaplastic ependymoma, and anaplastic oligodendroglioma (Brain tumors, n.d.).

Grade 4

Grade 4 tumors are the most malignant type of brain tumor. They grow rapidly and are very aggressive. These tumors also spread widely to other parts of the brain and rarely the spinal cord. There's a high chance that these tumors will reoccur even if treated intensely (How brain tumours are graded, 2023). The grade 4 tumor cells look very abnormal (Grades of brain tumours, 2023). These tumors cannot be treated with only surgery, they need various types of treatments such as radiotherapy and/or chemotherapy. A few examples of grade 4 tumor types include glioblastoma multiforme, pineoblastoma, medulloblastoma and ependymblastoma (Brain tumors, n.d.).

Common Types of Brain Tumors

Meningioma

Meningioma is a type of brain tumor that occurs in the meninges, layers of tissue that surround the brain as well as the spinal cord. Therefore, meningiomas can start in either the brain or the spinal cord (Brain Tumor, 2023). This type of tumor is usually slow-growing and benign due to its slow-growing characteristic, symptoms tend to develop gradually over time. However, there are instances where this type of tumor can be malignant which also means that meningiomas can be classified as grade 1, 2, or 3 depending on the aggressiveness of the specific tumor (Meningioma, 2023). More women are diagnosed with this type of brain tumor than men. Making up about 30% of all brain tumors, meningioma is the most common type of benign tumor seen in individuals (Brain tumor types, 2021).

Gliomas

Gliomas are tumors that originate from glial cells. Glial cells support as well as surround nerve cells in brain tissue (Brain Tumor, 2023). The type of glial cell forming the glioma affects the aggressiveness of the tumor. These tumors originate in the brain but can also originate in the spinal cord. Making up 78% of malignant brain tumors, gliomas are the most common cancerous brain tumors (Brain Tumors, n.d.). However, some types of gliomas are benign. Based on the 2021 WHO classification of CNS tumors there are 18 different types of gliomas. For instance, glioblastoma and astrocytoma are common types of gliomas (Glioma, 2024).

Glioblastoma

Glioblastoma is the third most common type of brain tumor (What Are the Most Common Types of Brain Tumors?, 2018). These tumors are a type of gliomas that develop from either astrocytes or oligodendrocytes glial cells. Glioblastoma originates in the brain or the spinal cord. They tend to occur more in adults and males. This tumor is the most invasive type of glioma as well as the most aggressive. All glioblastoma tumors are grade 4. There is no indefinite cure for this type of tumor, only treatments that may slow cancer or help symptoms (Glioma, 2023).

Astrocytoma

Astrocytoma is a common type of glioma brain tumor that affects both adults as well as children. These tumors develop from astrocytes which are star-shaped cells that support the neurons in the brain. They can occur in any part of the brain and occasionally start in the spinal cord but frequently occur in the cerebrum (Brain tumors, n.d.). The grade of astrocytoma tumors can vary from grade 2, 3, or 4.

Metastatic

Metastatic brain tumors are a secondary type of tumors and the most common type of brain tumors among adults. They affect nearly 150,000 people a year (Brain tumors, n.d.). These tumors do not originate in the brain but instead spread to the brain from other areas of the body that are affected by cancer. Common types of cancer that can become metastatic tumors include breast cancer, colon cancer, kidney cancer, lung cancer, and skin cancer (melanoma). Metastatic tumors are malignant and can create one or more tumors in the brain. They are rapidly growing and invasive to nearby brain tissue. As they grow, they can create pressure on the brain which leads to changes in the function of surrounding brain tissue (Brain metastases, 2022).

Risk Factors and Causes

Age

Brain tumors occur often in older adults and children but those of any age can develop it. Specific types of brain tumors can affect more children or adults (Brain Tumor - risk factors, 2023). For example, astrocytomas tend to be more common in children while gliomas occur the most in adults (Brain tumors, n.d.). The risk of brain tumors is the greatest at the age of 85 to 89 (Risks and causes of brain tumours, 2023).

Radiation

Radiation exposure can increase the risk of developing brain tumors. Although rare, most radiation-induced brain tumors are typically caused by radiation given to treat other types of cancers. (Risk factors for brain and

spinal cord tumors, 2020). Strong types of radiation increase the risk of developing brain tumors, low-grade radiation from radio waves or cell phones does not cause brain tumors (Brain Tumor, 2023). However, x-rays, as well as CT scans, can increase the risk of these tumors (Risks and causes of brain tumours, 2023).

Ethnicity and Demographics

Although any race can develop brain tumors, some types of these tumors are more common in certain demographics. For instance, gliomas tend to be more common in Caucasian people. Meningiomas tend to be more common in those of African American ethnicity (Brain Tumor, 2023).

Family History

About 5% of brain tumors can be linked to hereditary genetic conditions or factors such as Li-Fraumeni syndrome, tuberous sclerosis, neurofibromatosis type 1, neurofibromatosis type 2, Turcot syndrome, nevoid basal cell carcinoma syndrome, and von Hippel-Lindau disease. The risk of developing brain tumors is higher if a close relative has been diagnosed with a brain tumor (Brain Tumor - risk factors, 2023).

Weak Immune System

A weak immune system can increase the risk of developing brain tumors as a weakened immune system can lead to a higher chance of developing lymphomas in the brain or spinal cord. Weak immune systems can be from various things such as cancer treatment, diseases like AIDS, or congenital (Risk factors for brain and spinal cord tumors, 2020).

Gender

Men are more likely to develop brain tumors than women. However, some types of brain tumors such as meningiomas are more common in women (Brain Tumor - risk factors, 2023).

Signs and Symptoms

Signs and symptoms of brain tumors can differ based on the type, size, and location of the tumor (Brain tumor - symptoms and signs, 2023). Slow-growing benign brain tumors sometimes go unnoticed. Generally, symptoms get worse over months or years. For malignant tumors, symptoms get worse quickly, over a matter of days or weeks (Brain Tumor, 2023). Common signs include headaches or pressure in the head, nausea or vomiting, feeling very tired or weak, confusion about everyday things, dizziness, or vertigo. Other types of symptoms are specific to a part of the brain affected by the tumor which includes eye problems such as blurry vision, seeing double or losing sight on the sides of your vision, numbness in an arm or leg, trouble with balance, trouble with speech, having trouble following simple commands, personality or behavior changes, seizures especially if there is no history of it, hearing issues, feeling hungry and gaining weight. Based on the function of the structure of the brain affected, symptoms may vary (Signs & symptoms, 2022). For example, a tumor in the frontal lobe could lead to issues with memory while a tumor in the parietal lobe can lead to issues regarding sensations.

Diagnosis

When signs and symptoms of a brain tumor are shown, healthcare professionals work to perform various tests that can help diagnose the tumor. Diagnosing a brain tumor can help physicians determine the best treatment plan to treat the tumor. There are a variety of procedures that can be done to determine the size, location, and type of brain tumor an individual has which include the following.

Neurological Exams

Neurological exams are physical exams that test various parts of the brain to determine the proper functioning. This can include checking hearing, balance, vision, strength, coordination, and reflexes. Although these types of exams do not detect brain tumors, they can help a healthcare professional understand where the tumor might be located (Brain tumor, 2023b).

MRI Scans

MRI scans are magnetic resonance imaging scans. These scans are the best way to look for tumors in the brain (Tests for brain and spinal cord tumors in adults, 2020). As these scans are very detailed, they can help show the size of the tumor and the area of the brain that it is located in. With MRIs, a dye is injected into a vein to create a clear picture of the brain and the tumor. If a more detailed scan is required, various types of MRIs can be used such as functional MRI, magnetic resonance spectroscopy, and magnetic resonance perfusion. Functional MRIs show what part of the brain is controlling your various functions such as movement and speaking. Magnetic resonance spectroscopy helps in measuring the levels of certain chemicals in the tumor cells. Magnetic resonance perfusion measures the amount of blood in parts of the tumor which helps highlight the active parts. The various types of MRIs are all used by healthcare professionals to determine a treatment plan for the tumor (Brain tumor, 2023b).

CT Scans

CTs are computed tomography scans. CT scans take a series of X-rays to create a picture of the brain. These pictures show in detail not only the tumor but also the bone structures surrounding the tumor. This can help detect issues in and around the brain (Brain tumor, 2023b). CT scans can be used to determine the size of the tumor (Brain tumor - diagnosis, 2023). Although CTs are not used as much as MRIs for brain tumors, they can be a good alternative for those unable to receive an MRI (Tests for brain and spinal cord tumors in adults, 2020).

PET Scans

PET (Positron Emission Tomography) scans inject a radioactive substance into a vein to create a picture of the brain and brain tumor. The substance collects in the cells of the tumor which makes these cells stand out in the scan. The cells of the brain that are dividing and multiplying fast take up more of the tracker substance which

helps in determining the location of brain tumors (Brain tumor, 2023b). Although CT and MRI are more detailed, PET scans help determine the presence of abnormal cells especially that of fast-growing tumors. (Tests for brain and spinal cord tumors in adults, 2020).

Biopsy

A biopsy can be performed to diagnose brain tumors. A biopsy takes a sample of the cells of the tumor to help determine the type of tumor and whether it is benign or malignant (Brain tumor: Symptoms, signs & causes, 2022). Two types of biopsies can be done, surgical biopsy and stereotactic needle biopsy. Surgical biopsy requires surgeons to perform surgery to get a sample of the cells of the tumor. Stereotactic needle biopsy is mostly done with surgery is not an option. In this procedure, a small hole is drilled into the skull in which a needle is inserted to take a sample of the tumor cells (Brain tumor, 2023b). The acquired sample is then observed under a microscope to determine not only the type of tumor but also if it is cancerous (Tests for brain and spinal cord tumors in adults, 2020). However, complications can arise with using a biopsy to diagnose a tumor, such as bleeding in the brain or damage to the brain tissue (Brain tumor, 2023b).

Lumbar Puncture

A lumbar puncture, also referred to as a spinal tap, is a procedure where a small needle is placed between the spinal bones to take a sample of cerebrospinal fluid. This procedure is usually performed to look for cancer cells in cerebrospinal fluid, the liquid around the brain and spinal cord. Even though they are generally safe, healthcare professionals do not prefer lumbar punctures as, if fluid pressure in the skull drops too much as a result of this procedure, it could lead to serious complications. Although lumbar punctures are not used as frequently as scans, they are helpful if the tumor is suspected to have invaded the tissue that covers the brain (Tests for brain and spinal cord tumors in adults, 2020b).

Treatments

Treatments are decided based on various factors such as the type, grade, size, and location of the brain tumor. Healthcare professionals consider all treatment options available to determine what will work best for a specific individual and their tumor. Treatments are mostly not needed if the tumor is small as well as benign and does not cause problems. However, if the tumor grows fast or symptoms are developed then treatment may be necessary (Brain tumor, 2023b).

Surgery

Surgery is the most common type of treatment for brain tumors (Brain tumors and brain cancer, n.d.). The goal of surgery is to remove all tumor cells as best as possible without affecting the functions of the brain. However, sometimes not all tumor cells can be removed completely especially if the tumor is too close to an important part of the brain or it becomes too risky to entirely remove the tumor (Brain Tumor, 2023b). Partial removal is still helpful as it reduces pressure on the brain and lowers the amount of tumor that needs to be treated with other treatment types such as chemotherapy or radiation (Brain Tumor, n.d.). Removing part of the brain tumor can also aid in reducing symptoms caused by the tumor (Brain Tumor, 2023b). Surgery is a type of treatment that works for both benign and malignant brain tumors and is the only type of treatment needed for low-grade tumors. Many types of surgery can be performed to treat a brain tumor, such as craniotomy, endoscopic brain surgery, and laser interstitial thermal therapy. However, all types of surgery come with risks such as bleeding, infection, and damage to the brain, spinal cord, or other nearby structures.

Craniotomy

A craniotomy is a type of brain surgery in which a neurosurgeon removes a part of the skull to access the brain tumor and remove it. This type of surgery is how most brain tumor removal operations are done. During a craniotomy, the patient is given medication to numb the area the tumor is located so that no pain is felt during the surgery (Brain Tumor, 2023b). Sometimes patients are awake during this surgery for the neurosurgeon to ensure that damage is not created to the functional parts of the brain (Brain tumor: Symptoms, signs & causes, 2022).

Endoscopic Brain Surgery

Endoscopic brain surgery is a type of surgery that involves inserting an endoscope, a long thin tube, into the brain. The endoscope takes pictures of the tumor that it transmits to the surgeon through a small camera. Surgical tools are then inserted into the endoscope to remove the tumor (Brain Tumor, 2023b). This type of surgery can be used for tumors that are near the base of the brain or skull and for tumors near the top of the spine. It allows surgeons to reach areas of the brain without having to remove parts of the skull or make large incisions. Endoscopic brain surgery frequently makes recovery quicker as well as less painful (Endoscopic endonasal surgery, 2021).

Laser Interstitial Thermal Therapy (LITT)

Laser interstitial thermal therapy (LITT) is a minimally invasive surgical procedure performed to remove brain tumors (Laser interstitial thermal therapy, 2023). LITT is a newer technique that is used to treat small tumors that are hard to reach with open surgery (Brain tumors, n.d.). This type of surgery can be a sufficient alternative to a craniotomy. In this procedure, a probe with special fibers is inserted into the brain through a small hole in the skull. This procedure is performed with the assistance of an MRI scan that shows the surgeon pictures of the brain as a laser is placed through the probe in order to heat the tip and damage nearby abnormal tissue. Compared to a craniotomy, LITT causes less pain after surgery and has a shorter recovery time (Laser interstitial thermal therapy, 2023). However, since this is a newer technique to treat brain tumors, long-term effects, and efficiency are yet to be determined (Brain tumors, n.d.).

Radiation Therapy

Radiation therapy uses high-energy X-rays to destroy tumor cells in the brain. These high-energy X-rays usually come from a machine outside the body, this is called external beam radiation. This is the most common type of radiation treatment for brain tumors. However, occasionally radiation is placed inside the body which is called brachytherapy (Brain Tumor, 2023b). Radiation therapy assists in slowing down tumor growth, shrinking tumors, and preventing tumors from returning (Brain tumors and brain cancer, n.d.). This type of treatment can be used on both cancerous and noncancerous tumor cells. Radiation is typically given after surgery if surgery does not completely remove the tumor cells (Brain tumor - types of treatments, 2023). However, it can also be given as an alternative to surgery (Brain Tumor, n.d.). Physicians choose a type of radiation based on factors such as tumor size and location. Types of standard external beam radiation used for brain tumors include stereotactic radiosurgery and proton therapy. However, all these types of radiation have side effects such as fatigue, skin reactions, hair loss, neurological symptoms, and stomach aches (Brain tumor - types of treatments, 2023).

Stereotactic Radiosurgery

Stereotactic radiosurgery is a precise form of radiation that is used to treat brain tumors (Stereotactic Radiosurgery, 2019). In this type of radiation, a high dose of radiation is given directly to the tumor from various angles (External beam radiation, 2023). It can be given as a single dose or various doses over a matter of days (Brain Tumors: Radiation Therapy, 2021). The X-rays used in this radiation aid in shrinking and destroying tumor cells. Since this targets the tumor specifically, the radiation damages the tumor but does not damage nearby brain tissue (Brain Tumor, n.d.). It can be used to treat both benign and malignant brain tumors (Brain Tumor, 2023b). It is especially useful with small difficult-to-reach tumors (Stereotactic Radiosurgery, 2019).

Proton Therapy

Proton therapy is a type of external beam radiation that utilizes protons instead of X-rays (Brain tumor - types of treatments, 2023). It allows physicians to target radiation based on the shape or size of the tumor which means that the tumor cells are destroyed but the surrounding tissue is still healthy (Proton therapy, 2022). Since protons only travel a specific distance, the tumor as well as surrounding tissue are only exposed to a small amount of radiation (External beam radiation, 2023). Although proton therapy is usually used to treat malignant tumors, it can be used to treat benign tumors as well (Proton therapy, 2022).

Chemotherapy

Chemotherapy uses medication to kill cancerous tumor cells. It is usually given as a combination with surgery and/or radiation, it is not given by itself (Brain tumor treatment, 2024). The goal of chemotherapy is to destroy tumor cells, slow tumor growth, or reduce symptoms (Brain tumor - types of treatment, 2023). Chemotherapy can be received as an injection into a vein or as a pill (Brain tumor: Symptoms, signs & causes, 2022). This type of treatment is given in cycles, a treatment period is followed by a recovery period which is repeated (Brain Tumor, n.d.). Chemotherapy is proven to improve survival in patients, and it does so in about 20% of patients (Brain tumors, n.d.). Although the side effects of chemotherapy depend on dose and the type of drugs given, it can include nausea, vomiting, and hair loss (Brain Tumor, 2023b).

Targeted Therapy

Targeted therapy uses medications to attack specific chemicals in tumor cells (Brain Tumor, 2023b). Usually used to treat metastatic brain tumors and is paired with other treatments like radiation or surgery (Brain tumor treatment, 2024). However, it can be used to treat certain types of benign tumors as well as malignant tumors (Brain Tumor, 2023b). Targeted therapy blocks the growth and spread of tumor cells as well as limits damage to healthy cells in the brain (Brain tumor - types of treatment, 2023). This type of treatment can be an alternative to chemotherapy if an individual can't tolerate the side effects of chemotherapy (Brain tumor: Symptoms, signs & causes, 2022).

Prevention

Brain tumors cannot be prevented. However, an individual can lower their risk of brain tumors by avoiding environmental factors such as smoking and excessive radiation (Brain tumor: Symptoms, signs & causes, 2022). There is no other known lifestyle or environmental risk that may cause brain tumors (Can brain and spinal cord tumors in adults be prevented?, 2020).

Conclusion

Around 1 million Americans are living with a brain tumor (Brain tumor facts, 2023). Brain tumors can be dangerous leading to issues like vision loss or memory loss. By being informed on brain tumors, early detection is made more possible. Knowing the signs and risk factors of brain tumors can help an individual visit a physician earlier in order to get assistance with their condition. This earlier visit can allow the physician to start a treatment plan quickly before the tumor damages more of the brain. This could ultimately prevent a tumor from getting to a point where it causes serious dysfunction in an individual.

Acknowledgments

I would like to thank my advisor Dr. Rajapriya Manickam who supported me through this article. I would also like to thank Mr. Anthony Calandro for proofreading it.

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