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A Review of the Current State of Care :The Impact on Brain Tumors on Patients and Families

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Abstract: *Brain tumors are a complex and heterogeneous group of neoplasms that pose significant challenges in diagnosis and treatment. This systematic review aims to provide a comprehensive overview of the current state of knowledge on brain tumors, including their types, symptoms, treatment options, causes, and diagnostic approaches. A thorough literature search was conducted across multiple databases, and relevant studies were selected based on predefined inclusion and exclusion criteria. The review highlights the various types of brain tumors, including gliomas, meningiomas, and medulloblastomas, and discusses their distinct characteristics and clinical presentations. The symptoms of brain tumors, such as headaches, seizures, and cognitive impairment, are also discussed. The review provides an in-depth analysis of current treatment options, including surgery, radiation therapy, and chemotherapy, as well as emerging therapies and ongoing clinical trials. Additionally, the review explores the potential causes of brain tumors, including genetic mutations and environmental factors, and discusses the diagnostic approaches used to detect and monitor brain tumors, including imaging modalities and biomarkers. This systematic review aims to provide a comprehensive and up- to-date summary of the current state of knowledge on brain tumors, which will be valuable for clinicians, researchers, and patients.*

Keywords: Brain tumor, glioma, meningioma, medulloblastoma, symptoms, treatment, causes, diagnosis, systematic review

I. INTRODUCTION

A tumor also referred to as a neoplasm or lesion, is an abnormal mass of tissue resulting from uncontrolled cell division. Unlike normal cells, which grow in a regulated wayto replace old or damaged cells, tumor cells divide without the usual checks and balances.A brain tumor specifically forms within any of the tissues enclosed in the cranium. This includes the brain itself, cranial nerves, meninges, skull, pituitary gland, and pineal gland. Brain tumors are classified according to the type of cells they originate from and can be categorized as primary, meaning they start in the brain, or secondary, which indicates they have spread to the brain from other areas.

Treatment options for brain tumors depend on several factors, including the type, size, and location of the tumor, whether it has metastasized, and the individual's age and overall health. These treatments may aim for a complete cure or focus on alleviating symptoms. Of the over 120 distinct types of brain tumors, many have viable treatment options that can significantly enhance both life expectancy and quality of life for affected individuals. Advances in therapies continue to improve outcomes for many patients.Primary brain tumors remain confined to the brain and can either be malignant or benign. In contrast, secondary brain tumors are always malignant. Both types pose significant risks, as they can lead to serious health complications and be life-threatening.[1]Boundaries are rarely exceeded, and the tumor does not spread. While its cells are non-malignant, this tumor, which consists of benign cells and is situated in critical regions, may pose a threat to life. A malignant brain tumor is characterized by rapid growth, irregular edges, and the ability to invade surrounding areas of the brain. While they are often referred to as brain cancer, these tumors don't fit the traditional definition since they typically don't spread to organs outside of the brain and spinal cord. Malignant brain tumors encompass various types, including gliomas, medulloblastomas, primary central nervous system (CNS)

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lymphomas, and brain metastases. Within the brain, there are several distinct forms of tumors, and treatment options and outcomes can differ significantly based on specific pathological and histological assessments. It's also important to note that brain tumors may remain localized, and can either be malignant or benign. On the other hand, secondary brain tumors are always classified as malignant. Both forms can have serious impacts, making them potentially disabling and life-threatening.Researchers are discovering novel therapies grounded in an enhanced understanding of cellular and molecular biology.

Metastatic (secondary) brain tumors originate from cancer that starts in other parts of the body and subsequently spreads to the brain. These tumors develop when cancer cells travel through the bloodstream to reach the brain. The most frequently encountered cancers that metastasize to the brain are those originating from the lungs and breast.[3]

A brain tumor refers to a cluster (or mass) of abnormal cells located in the brain. Such a tumor can potentially lead to cancer, which is a significant contributor to mortality, accounting for approximately 13% of all deaths globally. The rate of cancer incidence is increasing at a concerning pace worldwide. Therefore, early detection of tumors is crucial. A comprehensive understanding and expertise in radiology are essential for precise tumor detection through medical imaging. MRI stands out as the most versatile among our diagnostic imaging techniques, as it can characterize a broad spectrum of parameters in living subjects and offers exceptional spatial resolution. The process of identifying brain tumors using magnetic resonance imaging (MRI) involves several stages. Segmentation is recognized as a critical yet challenging phase in the classification and analysis of medical imaging. Consequently, it is imperative that the segmentation of MRI images is performed accurately before relying on the computer for precise diagnosis. This review provides an overview of medical image analysis based on magnetic resonance imaging (MRI) for brain tumor research.[4]

1.1 Brain:

Together, the brain and spinal cord, which together form the central nervous system (CNS), regulate both the physiological and psychological functions of our body. Generally, the brain is divided into three primary components:

Cerebrum. This part is responsible for thinking, learning, problem-solving, emotions, speech, reading, writing, and voluntary movements.

Cerebellum. This section manages movement, balance, and posture.

Brain stem. It serves as a connection between the brain and spinal cord, overseeing essential functions in the human body, including motor and sensory pathways, cardiac functions, respiration, and reflexes [5].

The brain is made up of two types of tissue: gray matter (GM) and white matter (WM). Gray matter consists of neuronal and glial cells, also referred to as neuroglia or glia, which regulate brain activity, along with the basal nuclei that are gray matter nuclei situated deep within white matter. The basal nuclei comprise the caudate nucleus, putamen, pallidum, and claustrum. White matter fibers are composed of numerous myelinated axons that link the cerebral cortex to other regions of the brain. The left and right hemispheres of the brain are interconnected by the corpus callosum, a substantial band of white matter fibers. Both the cerebellum and cerebrum feature a very thin outer cortex of gray matter, internal white matter, and small yet deeply located masses of gray matter. The spinal cord is positioned at the lower end of the brain and consists of three structures: the midbrain, pons, and medulla oblongata [6]. Additionally, the brain contains cerebrospinal fluid (CSF), which is composed of glucose, salts, enzymes, and white blood cells. This fluid circulates through channels (ventricles) surrounding the brain and spinal cord, providing protection against injury. There is also a tissue known as meninges, which serves as the membrane covering the brain and spinal cord.[6]Figure 1 [7] illustrates the structure of the brain. It consists of the cerebrum and the brain stem.

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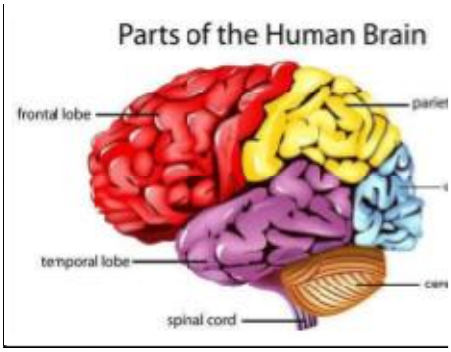

Fig 1: Human brain

The cerebrum occupies the the largest section of the brain is associated with conscious thought, movement, and sensory experiences. It is further divided into two halves, known as the right and left hemispheres. Each hemisphere governs the opposite side of the body.

Additionally, each hemisphere is segmented into four lobes: the frontal, temporal, parietal[7]

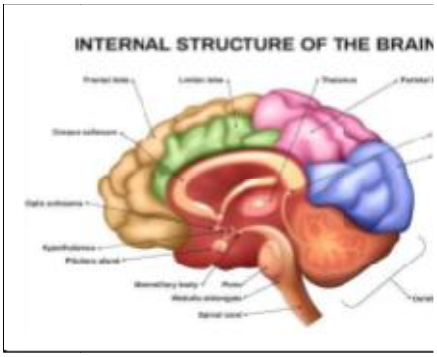

Fig 2: Structure of Brain

Functions of lobes :

Frontal Lobe. This lobe is section of the cerebral cortex located just behind the forehead. It plays a role in speech, muscle movements, and the formulation of plans and judgments.

Occipital Lobe. This lobe is a section of the cerebral cortex situated at the back of the head. It encompasses regions that process information from the visual fields.

Parietal Lobe. This lobe is a section of the cerebral cortex found at the top of the head and towards the rear. It is responsible for receiving sensory input related to touch and body positioning.

Temporal Lobe. This lobe is a section of the cerebral cortex located approximately
above the ears. It contains the auditory areas, which primarily receive information from the opposite ear [7].

1.2 Brain Tumor:

A brain tumor refers to an unusual proliferation of tissue within the brain or central spine, which can interfere with normal brain function and lead to heightened pressure within the cranial cavity. This increased pressure can cause certain brain tissues to be displaced, pressed against the skull, or may result in damage to the nerves of surrounding healthy brain tissues [8]. Tumors of the brain and spinal cord vary from person to person. They can arise in various locations and progress differently.

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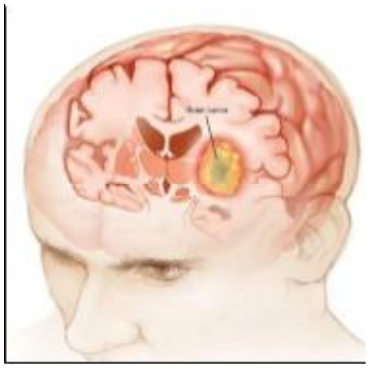

Fig 3: Brain tumor

Brain tumors can originate from various cell types and may present different
treatment options. Researchers have categorized brain tumors based on the following criteria:
The type and grade (indicating their aggressiveness),
Whether they are primary or secondary tumors
3.Their cancerous (malignant) status or non-cancerous (benign) nature, and the specific location of the tumor within the brain .[9]

The least aggressive form of brain tumor is typically referred to as a benign brain tumor. These tumors arise from cells within or adjacent to the brain, lack cancer cells, grow at a slow pace, and usually have well-defined borders that do not invade surrounding tissues. They can grow significantly large before any symptoms manifest. If completely excised, these tumors generally do not recur. However, they can lead to considerable neurological symptoms depending on their size and proximity to other brain structures. Some benign tumors have the potential to progress into malignant forms.

Malignant brain tumors, on the other hand, contain cancer cells and often lack clear borders. They are deemed life-threatening due to their rapid growth and ability to infiltrate surrounding brain tissue. While malignant brain tumors seldom metastasize to other body parts, they can spread within the brain or to the spinal cord. Treatment options for these tumors include surgery, chemotherapy, and radiation therapy, although they may reappear following treatment.

Regardless of being cancerous or benign, tumors that originate from brain cells are classified as primary brain tumors. Primary brain tumors can spread to other regions of the brain or the spinal cord, but rarely to other organs. In contrast, metastatic or secondary brain tumors originate in a different part of the body and subsequently spread to the brain. These tumors are more prevalent than primary brain tumors and are named according to their site of origin. Treatment is determined by the original location, such as the lung, breast, colon, or skin. Each of these tumors exhibits distinct clinical, radiographic, and biological features [8].

1.3 Brain Tumor Grading:

Tumors are classified based on the type of cells from which they originate, and are assigned a grade ranging from 1 to 4, typically denoted by Roman numerals I-IV. This grading system, referred to as the 'grade', indicates the rate of cell growth and the likelihood of metastasis. This information is vital for treatment planning and outcome prediction.

Tumors with lower grades (grades I & II) exhibit less aggressive behavior and are generally linked to prolonged survival. Under microscopic examination, these tumors appear nearly normal and may be amenable to surgical intervention for potential cure. However, a grade II tumor has the capacity to infiltrate surrounding healthy tissue and may recur as a higher grade tumor. In contrast, higher grade tumors (grades III & IV) exhibit rapid growth, can inflict greater damage, and are often more challenging to treat. These tumors are classified as malignant or cancerous and display abnormal characteristics under microscopic scrutiny. Tumors may also present areas of necrosis, where dead cells are found; within these regions, various grades of cells may exist, but the most malignant cell type dictates the overall grade of the tumor, even if the majority of the tumor consists of lower grade cells. Additionally, certain tumors may alter their growth patterns and potentially become malignant over time [9].

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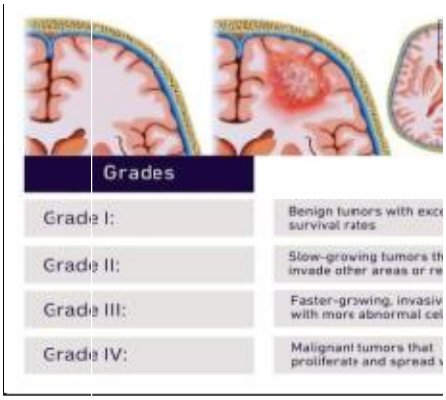

Fig 4: Grades of Brain tumors

Grade 1:

Tumors classified as grade 1 are characterized as benign and exhibit slow growth. These tumors do not metastasize, and there is a possibility of long-term survival. They possess well- defined borders and are unlikely to recur if they are entirely excised. Grade 1 tumors can generally be treated effectively through surgical intervention (Brain tumors, n.d.). Under microscopic examination, the cells involved in these tumors resemble normal cells (Grades of brain tumours, 2023). Examples of grade 1 tumors include pilocytic astrocytoma, craniopharyngioma, gangliocytoma, and ganglioglioma (Brain tumors, n.d.)[31] **Grade2**:

Tumors classified as grade 2 are also benign and tend to grow at a relatively slow pace. Nevertheless, they have the potential to infiltrate adjacent brain tissue. There exists a possibility that these tumors may reappear at a higher grade (How brain tumours are graded, 2023). The cells associated with grade 2 tumors exhibit a lesser resemblance to normal cells (Grades of brain tumours, 2023). While grade 2 tumors are deemed low grade, they can still pose significant risks and inflict serious damage to various regions of the brain. Instances of grade

2 tumors include diffuse astrocytoma, pineocytoma, and pure oligodendroglioma (Brain tumors, n.d.).[32]

Grade 3:

Grade 3 tumors are cancerous and exhibit rapid growth. These tumors often metastasize to different regions of the brain and occasionally to the spinal cord. They have a tendency to recur despite aggressive treatment. Under microscopic examination, the cells of grade 3 tumors appear abnormal (Grades of brain tumours, 2023). Treatment for these tumors cannot rely solely on surgical intervention; they necessitate additional therapies such as chemotherapy or radiotherapy. Examples of grade 3 tumors include anaplastic astrocytoma, anaplastic ependymoma, and anaplastic oligodendroglioma (Brain tumors, n.d.).

Grade 4:

Grade 4 tumors represent the most aggressive form of brain tumor. They exhibit rapid growth and are highly invasive. These tumors also disseminate extensively to other regions of the brain and, in rare cases, to the spinal cord. There is a significant likelihood of recurrence even after intensive treatment (How brain tumours are graded, 2023). The cells of grade 4 tumors appear markedly abnormal (Grades of brain tumours, 2023). Treatment for these tumors cannot rely solely on surgical intervention; they require a combination of therapies, including radiotherapy and/or chemotherapy. Examples of grade 4 tumor types include glioblastoma multiforme, pineoblastoma, medulloblastoma, and ependymoblastoma (Brain tumors, n.d.).[33]

Type of Brain Tumor:

There are several classifications for brain tumors, which include cell type, location, behavior, and grade. This classification highlights several key aspects, including tumors located in the brain.

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These tumors arise from glial cells, which protect and support neurons. A particularly aggressive and malignant form of glioma is known as Glioblastoma Multiform (GBM). The severity of astrocytes can range from low grade (less aggressive) to high grade (more aggressive).

Oligodendroglioma:

This type consists of glial cells referred to as oligodendrocytes. Ependymomas originate from ependymal cells found in the spinal cord's root canal or the brain's ventricles. Meningiomas are

tumors that develop from the protective covering of the brain and spinal cord. Benign pituitary adenomas may influence hormone levels. Medulloblastoma, which primarily affects children, is most commonly found in the cerebellum. The condition is also known as Primitive Neuroectodermal Tumor (PNET).

Stages of brain tumors: [10-13]

Stage 1: At this stage, tumors are generally small and localized. They tend to grow slowly and may or may not produce symptoms. Possible treatment options include regular monitoring or, if safe and practical, suWhile most are benign, some may lead to symptoms depending on their location.

Pituitary gland :

The pituitary gland, responsible for hormone regulation, is where these tumors can occurneurological removal of the tumor.

Stage 2: This stage indicates a slight advancement of the tumor. They may increase in size or extend to adjacent tissues, although their growth remains slow. Typically, efforts are made to remove as much of the tumor as possible.Surgically removed tumors, along with other treatments such as radiation therapy or chemotherapy, which target various tumors, are subsequently administered.

Stage 3: At this point, the tumor is classified as malignant or cancerous. It has the potential to metastasize and affect structures related to the brain. To decrease the size of the tumor and inhibit its progression, treatment generally involves a combination of radiation therapy, chemotherapy, and surgical intervention.

Stage 4: This phase of cancer is characterized as the most aggressive and advanced, commonly known as brain cancer or glioblastoma. These tumors often metastasize to other regions of the brain and even to different organs in the body due to their rapid proliferation. As most cases are not curable, treatment fo cuses on symptom management and improving the quality of life. At this stage, palliative care, which aims to alleviate pain and discomfort, becomes essential.

Common Types of Brain Tumors:

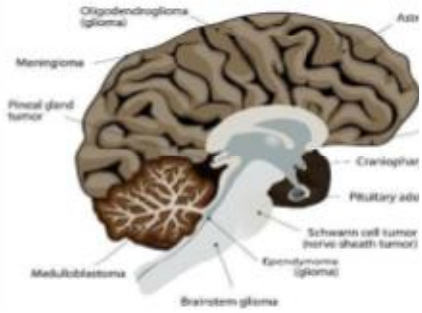

Fig 5: Common type of Brain tumors

Meningioma:

Meningioma is a form of brain tumor that arises in the meninges, the protective layers of tissue encasing the brain and spinal cord. Consequently, meningiomas can originate in either the brain or the spinal cord (Brain Tumor, 2023). Typically, this tumor type is slow-growing and benign; as a result of its gradual growth, symptoms often manifest

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slowly over time. Nevertheless, there are cases where this tumor can be malignant, which means that meningiomas can be categorized as grade 1, 2, or 3 based on the aggressiveness of the particular tumor (Meningioma, 2023). A higher number of women are diagnosed with this brain tumor compared to men. Comprising approximately 30% of all brain tumors, meningioma is recognized as the most prevalent type of benign tumor found in individuals (Brain tumor types, 2021).

Gliomas:

Gliomas are tumors that arise from glial cells. Glial cells provide support and surround nerve cells within brain tissue (Brain Tumor, 2023). The specific type of glial cell that forms the glioma influences the tumor's aggressiveness. These tumors primarily develop in the brain, although they can also occur in the spinal cord. Comprising 78% of malignant brain tumors, gliomas represent the most prevalent form of cancerous brain tumors (Brain Tumors, n.d.). Nevertheless, certain types of gliomas can be benign. According to the 2021 WHO classification of CNS tumors, there are 18 distinct types of gliomas. For example, glioblastoma and astrocytoma are well-known types of gliomas (Glioma, 2024).

3 Glioblastoma

It ranks as the third most prevalent form of brain tumor (What Are the Most Common Types of Brain Tumors?, 2018). These tumors are classified as gliomas, arising from either astrocytes or oligodendrocytes, which are types of glial cells. Glioblastoma can develop in the brain or spinal cord. It is more frequently observed in adults, particularly males. This tumor is recognized as the most invasive and aggressive variant of glioma. All glioblastoma tumors are classified as grade 4. Currently, there is no definitive cure for this tumor; however, there are treatments available that may slow the progression of cancer or alleviate symptoms (Glioma, 2023).[19]

Astrocytoma:

Astrocytoma is a prevalent form of glioma brain tumor that impacts both adults and children. These tumors arise from astrocytes, which are star-shaped cells that provide support to the neurons in the brain. They can manifest in any region of the brain and, on occasion, may originate in the spinal cord, although they are most commonly found in the cerebrum (Brain tumors, n.d.). The grading of astrocytoma tumors can range from grade 2 to grade 4.

Metastatic:

Metastatic brain tumors represent a secondary category of tumors and are the most prevalent type of brain tumors found in adults. Annually, they impact nearly 150,000 individuals (Brain tumors, n.d.). These tumors do not originate within the brain; rather, they spread to the brain from other parts of the body that are affected by cancer. Common cancers that may lead to metastatic tumors include breast cancer, colon cancer, kidney cancer, lung cancer, and skin cancer (melanoma). Metastatic tumors are malignant and can form one or more tumors within the brain. They exhibit rapid growth and invade adjacent brain tissue. As they expand, they can exert pressure on the brain, resulting in alterations in the functionality of the surrounding brain tissue (Brain metastases, 2022).[23-25]

TNM CLASSIFICATION OF BRAIN TUMOR

T1: Tumor is visible, T2: Tumor is enlarged,
T3: Tumor is near blood vessels,
T4: Tumor is near lymph nodes,
NX: Cancer is near lymph nodes,
No: No lymph nodes are visible,
N1: Nearby lymph nodes are present, N2: Many lymph nodes are involved,
N3: Almost all lymph nodes in the affected region,
MX: Metastasis cannot be assessed,
MO: Not observed,
M1: Metastasis is present.[13]

Causes:

The primary causes of tumors, including brain tumors, remain largely unidentified. Various studies have indicated that individuals at the highest risk for developing brain tumors typically include those who have:

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cancer in other parts of the body
extended exposure to pesticides, industrial solvents, and other forms of ionizing radiation.
genetic disorders, such as neurofibromatosis. ● environmental factors also play a significant role.[14]

Sign and symptoms:

The signs and symptoms associated with brain tumors can vary depending on the tumor's type, size, and location (Brain tumor - symptoms and signs, 2023). Benign brain tumors that grow slowly may often go undetected. Typically, symptoms tend to worsen over a span of months or years. In contrast, malignant tumors exhibit a rapid decline in symptoms, occurring within days or weeks (Brain Tumor, 2023). Common indicators include headaches or a sensation of pressure in the head, nausea or vomiting, extreme fatigue or weakness, confusion regarding everyday tasks, dizziness, or vertigo. Additionally, certain symptoms are specific to the area of the brain impacted by the tumor, which may involve visual disturbances such as blurred vision, double vision, or loss of peripheral sight, numbness in an arm or leg, difficulties with balance, challenges in speech, issues with following simple instructions, alterations in personality or behavior, seizures, particularly if there is no prior history, auditory problems, increased hunger, and weight gain. Symptoms may differ based on the function of the brain structure that is affected (Signs & symptoms, 2022). For instance, a tumor located in the frontal
lobe may result in memory-related issues, whereas a tumor in the parietal lobe could cause problems with sensory perception.

The most frequently observed symptoms at the time of diagnosis consist of headache, nausea, and vomiting, along with cognitive impairment. Headaches are likely the most prevalent symptom. Patterns that may be associated with brain tumors include:

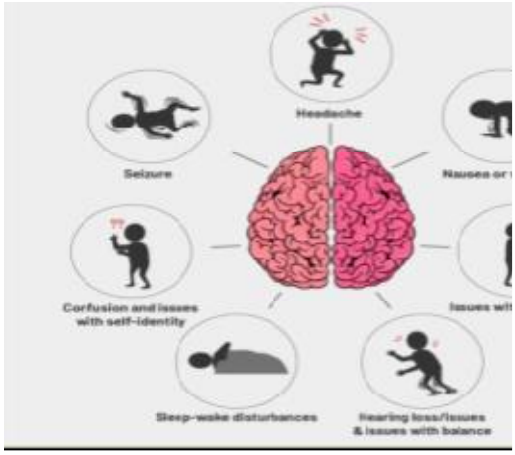

Fig 6: Common symptoms of Brain tumors

Headaches that intensify upon waking in the morning and subsequently diminish within a few hours1167
Headaches that intensify with coughingor physical activity, or with a shift in body
position
Headaches that manifest during sleep and
accompanied by at least one additional symptom (such as
vomiting or confusion)
Patients diagnosed with brain tumors may experience a seizure.
This could be the initial symptom or indication. ● Occasionally, the sole symptoms of brain tumors are ● cognitive changes, which may encompass:
Alterations in personality and behavior
Diminished concentration

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Increased sleep duration
Memory impairment
Difficulties with reasoning
Other potential symptoms include:
Gradual decline in movement or sensation in an
arm or leg
Hearing impairment, with or without dizziness
Challenges with speech
Unforeseen vision issues, including
vision loss in one or both eyes, or double
vision
Lack of steadiness and balance issues
Weakness or numbness
The symptoms associated with a brain tumor are influenced by
various factors, including the tumor's size, its location within the brain, and the rate at which it is growing.

According to tumor location:

Frontal lobe Mental disorder / mild personality disorders: depression, confusion, bizarre behavior, it is difficult to give an argument / judge true or not, hemiparesis, ataxia, and slurred speech.
Presentalis posterior cortical Weakness / paralysis of the facial muscles, tongue and fingers
Lobes parasentralis Weakness in the lower extremities
Occipital lobe Seizures, impaired vision
Temporal lobe Tinnitus, auditory hallucinations, sensory aphasia, paralysis of facial muscles
Parietal lobe Lost sensory function, kortikalis, localization sensory disturbances, visual disturbances
Cerebulum Papil edema, headache, motor disorders, hypotonia, joint hiperekstremite.[15] **Risk Factors:**

The exact cause of brain cancer remains largely unidentified. While certain genetic disorders and environmental influences may play a role in the onset of brain cancer, the risk factors are significantly less understood compared to other types of cancer in the body.Moreover, the likelihood of developing primary brain cancer is exceedingly low. The American Cancer Society projects that the risk throughout a lifetime is below one percent. It is
crucial to note that a risk factor for brain cancer influences only the probability of contracting brain cancer over a lifetime. [46]

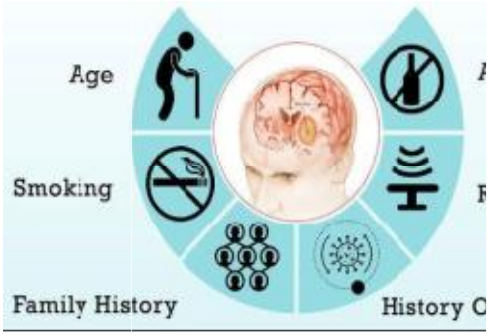

fig 7 : Risk factors

Gender:

There is no universal guideline that applies to all brain cancers. Certain types, such as meningiomas, are twice as likely to occur in women. Medulloblastomas are more commonly diagnosed in males.

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Age:

Compromised immune system: Individuals with weakened immune systems may have an elevated risk of developing brain lymphomas.

Genetic:

Genetic links: A family history may influence the chances of developing specific diseases. Von Hippel-Lindau disease, Li-Fraumeni syndrome, and neurofibromatosis (NF1 and NF2) are inherited disorders identified in families with a history of rare brain tumors.

Otherwise, there is minimal evidence indicating that brain cancer is hereditary.

Exposure:

Chemical exposure: Contact with certain industrial chemicals or solvents has been associated with a heightened risk of developing brain cancer. Although not definitive, there is evidence that there isAn increased occurrence of specific types of brain tumors has been observed in individuals employed in oil refining, rubber manufacturing, and drug manufacturing.[16]

Family History:

Approximately 5% of brain tumors are associated with hereditary genetic conditions or factors, including Li-Fraumeni syndrome, tuberous sclerosis, neurofibromatosis type 1, neurofibromatosis type 2, Turcot syndrome, nevoid basal cell carcinoma syndrome, and von Hippel-Lindau disease. The likelihood of developing brain tumors increases if a close family member has been diagnosed with a brain tumor (Brain Tumor - risk factors, 2023)

Compromised Immune System

A compromised immune system may elevate the likelihood of brain tumor development, as a weakened immune response can result in a greater risk of lymphomas occurring in the brain or spinal cord. Factors contributing to a weakened immune system can include cancer therapies, illnesses such as AIDS, or congenital conditions (Risk factors for brain and spinal cord tumors, 2020).

How Can a Healthy Person Develop a Brain Tumor?

While it's not possible to pinpoint a single cause, several factors may contribute to the development of brain tumors in healthy individuals:

Genetic mutations: Random genetic mutations can occur in brain cells, leading to tumor growth.

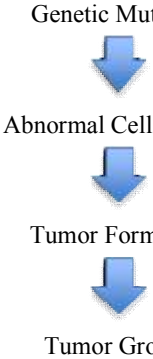
Environmental exposures: Exposure to radiation, certain chemicals, and other environmental toxins may increase the risk.

Infections: Certain viral infections, such as human papillomavirus (HPV), may contribute to brain tumor development.

Hormonal changes: Hormonal fluctuations during pregnancy, menopause, or other conditions may stimulate tumor growth.[50]

Brain Tumor Development

Here is a simplified diagram illustrating the development of a brain tumor:



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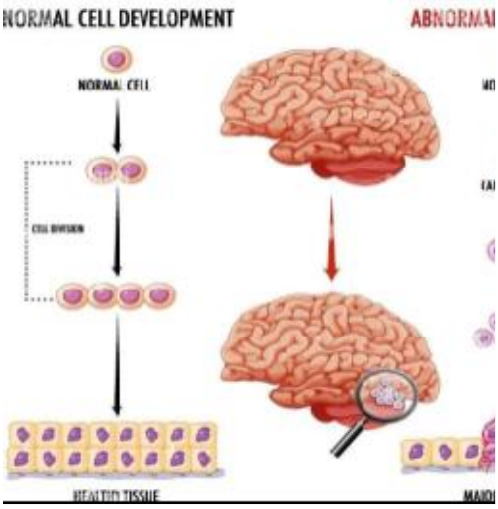

Fig 8 : Development of Brain tumor

Pathophysiology [26]

Due to causes like chemicals and radiation exposure
Irritation and damage to cell structure
As adaptive mechanism, changes in cell morphology occurs
As radiation exposure continue, the changes become irreversible causing gene mutations in DNA
Inactivation of tumor supressor genes and activation of oncogenes
Uncontrolled cell division and decreased apoptosis
Hyperplasia of brain cells

Brain tumors

More recent research has concentrated on the molecular pathobiology and pathophysiology that are fundamental to these lesions, distinguishing them from normal tissue. Brain tumors can lead to neurological disorders, with symptoms manifesting in a sequential manner.

Neurological symptoms associated with brain tumors are generally attributed to two primary factors: focal disruption caused by the tumor itself and increased intracranial pressure. Alterations in blood supply due to the pressure exerted by growing tumors can lead to necrosis of brain tissue. Seizures may occur as a result of neuro-sensitivity changes linked to tumor invasion and compression, which also affect blood supply to the brain tissue. Additionally, some cysts can develop into tumors that suppress the surrounding brain parenchyma, thereby exacerbating focal neurological disorders. [20]

Increased intracranial pressure can arise from various factors, including the mass increase within the skull, edema formation surrounding the tumor, and alterations in cerebrospinal fluid circulation. The mass effect results from tumor growth, as tumors occupy space within the relatively rigid confines of the skull.

Malignant tumors induce edema in brain tissue. The exact mechanisms are not fully understood, but it is believed that osmotic differences may lead to bleeding. Venous obstruction and edema resulting from damage to the blood-brain barrier contribute to an increase in intracranial volume.

The compensatory mechanisms may take several days or months to become effective, and they may prove ineffective if intracranial pressure rises rapidly. This compensatory mechanism works, among other things, to reduce intracranial blood volume, cerebrospinal fluid volume, intracellular fluid content, and the number of parenchymal cells. An increase in pressure can lead to untreated ulcers or cerebellar herniation. Herniation occurs when the medial temporal lobe gyrus shifts inferiorly through the tentorial notch due to a mass in the brain hemispheres. This herniation exerts pressure on

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the encephalon, resulting in loss of consciousness and neurological deficits. In the case of cerebellar herniation, the tonsils may be displaced. [21]

Case Study: Radiation-Induced Brain Tumor

Patient Profile:

Age/Sex: 32-year-old male.
History: Received cranial radiotherapy (RT) for acute lymphoblastic leukemia (ALL) at age 8.
Treatment: 18 Gy whole-brain irradiation + intrathecal chemotherapy.
Current Diagnosis: Secondary glioblastoma multiforme (GBM) in the left frontal lobe.

Clinical Timeline:

Initial Cancer (2000): ALL treated with chemotherapy + RT.
Latency Period: 24 years post-RT.
Symptoms (2024): Headaches, seizures, right-sided weakness.
MRI: Contrast-enhancing left frontal mass.
Biopsy: GBM, IDH-wildtype.
Management: Surgical resection + temozolomide + radiotherapy. Prognosis: Poor (median survival ~12–18 months).

Key Points

Risk Factors:

Radiation dose: >10 Gy increases risk (relative risk: 2–10×).
Age at exposure: Younger patients ↑ risk.
Genetic susceptibility: TP53, NF1 mutations.
Latency: 10–30 years (median: 20).
Incidence: <1% of RT patients, but higher in pediatric cases.

Mechanism:

DNA double-strand breaks → oncogenic mutations.
Disrupted blood–brain barrier → inflammation.

Prevention:

Proton therapy (reduced scatter).
Lower RT doses (if clinically feasible).
Long-term MRI surveillance.

Challenges:

Aggressive tumors, radioresistance.
Surgical risks (prior RT fibrosis).[52]

Diagnosis of brain tumor:

A.Physical exam and family history

During a physical examination, the overall indicators of illness, such as the presence of lumps, are examined. Additionally, the general habits of the patients, including smoking and exercise, along with their family medical history, are documented.[27]

Neurological exam:

A specimen of blood, urine, or tissue is analyzed to assess the concentrations of substances associated with specific types of cancer.

Gene test:

Cells or tissue samples extracted from the tumor are examined in the laboratory for alterations in genes or chromosomes, which may suggest abnormal growth. These alterations may serve as an indication that an individual has or is at risk of developing a specific disease or condition.

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X- ray:

Utilize electromagnetic radiation to visualize the skull and its constituent bones in order to identify tumors located within the brain or the nasal sinuses. X-ray imaging encompasses both conventional non-invasive techniques and cerebral arteriograms or angiograms, which involve the injection of a contrast medium into the patient's veins.[29]

Conventional invasive X-ray methods consist of:

Pneumoencephalography, where a lumbar or suboccipital approach is employed to introduce air into the cerebral ventricles and subarachnoid spaces, subsequently traced using advanced X-ray procedures.Ventriculography involves the introduction of air into each lateral brain ventricle through a trepanation opening, following the collection of cerebrospinal fluid (CSF).[30]

Both pneumoencephalography and ventriculography have fallen out of favor and have been supplanted by more modern neuroimaging techniques that are less invasive and more sophisticated.Myelography involves the injection of a dye into the cerebrospinal fluid, which is then traced with X-ray (myelogram) to determine if there is any spread to other areas of the brain or spinal cord.

Computed tomography (CT):

The identification and characterization of brain tumors depend on conventional imaging techniques such as CT scans and magnetic resonance imaging (MRI).A CT scan is a sophisticated three-dimensional x-ray that provides a detailed view of internal tissues and organs with remarkable accuracy; this includes soft tissues, bones, and blood vessels. It can effectively identify any irregularities, such as alterations in the skull bones.

Additionally, it can detect fluid leaks, such as blood, or the enlargement of brain ventricles or tumors with ease.

Magnetic resonance imaging (MRI):

Typically, T1-weighted imaging is utilized, which includes spin echo, turbo spin echo gradient echo, dynamic reviews, and 3D echo, or T2-weighted imaging: fluid proton thickness and fluid-attenuated inversion recovery, along with other techniques.

MRI can also be applied in various forms.

MRI spectroscopy is employed to assess the levels of metabolites within the body. Perfusion MRI is used to identify blood flow.

Functional MRI (fMRI) is utilized to examine oxygen usage and blood flow during physical activities. fMRI can assist in surgical planning by pinpointing the motor, sensory, visual, and language centers of the brain .

CT scans are often favored for patients with pacemakers or metal implants who are unable to undergo an MRI examination.

CT scans are less time-consuming than MRI and are more effective in identifying calcifications or abnormalities in the skull. Conversely, MRI is more sensitive and thus more effective for soft tissue investigations. Figure 3 illustrates normalized (MRI) images of various tumor types in different planes .[18]

Treatment method of brain tumor

The guidelines for the treatment of brain tumorsrely on various factors including:

The classification (malignant or benign; primary or secondary,local or metastatic, etc.).

The dimensions, location, and impact, such as exerting pressure on critical areas of the brain.

The grade or stage of the tumor.

The potential side effects associated with the treatment.

The overall health and preferences of the patient;some individuals may decline certain therapies, such as

Chemotherapy:[24-25]

Active surveillance:

This term denotes the careful observation of patients with asymptomatic, slow-growing tumors without any medical intervention. Patients are regularly monitored to prevent the deterioration of conditions that could necessitate aggressive treatments, which may subsequently lead to significant side effects .

Surgery[36]

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This involves the removal of the entire tumor or a portion of it, along with some adjacent tissues, for both diagnostic and therapeutic reasons as previously stated. This procedure can alleviate the pressure exerted by the tumor on surrounding brain areas, thereby enhancing neurological symptoms. Surgery may suffice as the sole treatment if the tumor is low-grade and localized. However, a primary disadvantage of surgery is the potential to overlook tumors that are too small to detect, which could result in a recurrence of the disease.[37]

Radiation therapy:

This treatment employs megavoltage x-rays or charged particles, such as electrons, to eliminate or sterilize tumor cells . The most prevalent types of radiotherapy modalities utilized for brain tumors include:[33].

External-beam radiation therapy:

Which comprises Conventional radiation therapy: The patient undergoes imaging with a simulator, for instance, to identify the tumor's position, size, and nearby organs at risk. Following this, the entire brain is irradiated according to a treatment plan devised by an oncology team (medical physicist, dosimetrists, and oncologist).3-D conformal radiation therapy: A more accurate 3-D plan is known as 3-dimensional conformal radiation therapy. This method employs multiple thin beams of varying intensities directed from different angles and orientations to concentrate the radiation on the tumor while safeguarding the adjacent healthy organs [38]

Intensity modulated radiation therapy (IMRT):

IMRT techniques employ inverse planning methods in conjunction with biological complication models for organs at risk.

Beam intensities are modeled through computer-optimized planning to achieve highly conformal dose delivery. By substituting conformal beams with smaller beams of irregular fluence, utilizing maps derived from optimization processes, complex dose distributions with high precision are attained .[39]

Proton therapy:

Protons, which are relatively heavy and positively charged, are utilized because of
their high relative biological effectiveness. This characteristic enables them to effectively destroy tumor cells while causing minimal harm to adjacent healthy organs. This treatment modality is particularly beneficial for tumors located near bones, such as brain tumors situated close to the base of the skull or near the optic nerves .[40]

Alternating electric bed therapy:

A non-invasive modality that is performed using electric6ields produced by electrodes at the head. It is veryeffective in treatment of newly diagnosed or recurrentglioblastoma. The survival rate is longer and the side waseffects are fewer than chemotherapy for this disease.[41,42]

Medicinal treatment :

As stated in part 1, the symptoms of brain tumors can be severe and significantly impact the quality of life for both patients and their families. Various medications are utilized to manage these symptoms. Additionally, they can provide supportive care aimed at enhancing the quality of life; for instance, by controlling seizures and fluid accumulation or any other swelling in the brain. Among these medications is Dexamethasone, a corticosteroid that aids in reducing swelling, thereby alleviating pressure and pain. Other medications include anti- seizure drugs. Medicinal treatment may also be employed to eliminate tumor cells, referred to as systemic therapy. An example of systemic therapies is Chemotherapy. In this case, one or more drugs, preferably those capable of easily crossing the blood-brain barrier (the physical and chemical barrier that actively regulates the entry of blood-borne molecules, pathogens, and immune cells into the brain), are administered to patients either orally, intramuscularly, or intravenously to destroy tumor cells or to sterilize or slow the growth of the tumor [43-45].

Technical challenge:

The application of deep learning for diagnosing brain tumors through MRI scans faces numerous challenges that impact its precision, reliability, and practical implementation. These challenges stem from various factors including the data quality, the model employed, the specific domain, the computational processes involved, inconsistencies in evaluation standards, and clinical obstacles, as depicted in . The difficulties associated with AI-based MRI diagnosis of brain

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tumors are intricately linked. Variability in data diminishes the robustness of models, resulting in decreased performance across different datasets due to shifts in domain. Limitations in computational resources obstruct real-time application, while models designed to be lightweight compromise on detail. Furthermore, inconsistent benchmarking complicates comparisons across studies. Collectively, these challenges hinder clinical integration, perpetuating a cycle where inefficiencies in computation and data limitations postpone regulatory approvals. Each of these challenges will be examined in detail below.[27] **A. Data-related challenges:**

A significant issue is the lack of large, high-quality, accurately labeled brain tumor datasets. This situation arises from the rarity of certain tumor types, concerns regarding patient privacy, and the high costs associated with expert radiologist annotation . Additionally, the data frequently experiences class imbalance (with some tumor types being considerably more prevalent than others, leading to bias), data heterogeneity (differences in MRI scanners, protocols, resolutions, and image types such as T1, T2, FLAIR, and DWI) , and the existence of noise and artifacts in the scans , all of which can adversely affect model performance.

B. Model-related challenges:

The diverse characteristics of brain tumors, which frequently include areas with varying histological traits such as necrosis, edema, and regions that are either enhancing or non- enhancing, complicate the processes of segmentation and classification. Additionally, precisely delineating tumor boundaries, especially in the case of infiltrative gliomas, presents significant challenges and may be subjective, even for seasoned radiologists. **C. Evaluation and validation challenges:**

Additional obstacles in the diagnosis of brain tumors through deep learning (DL) encompass the absence of standardized benchmarks, which impedes the ability to compare various methodologies. Furthermore, models are required to exhibit resilience to fluctuations in tumor characteristics, patient demographics, and imaging conditions, a challenging task that necessitates thorough validation. Lastly, the integration of longitudinal analysis, which entails monitoring tumor development over time, adds further complexity, as models must adeptly manage temporal variations in MRI scans.[28-29] **D. Computational challenges:**

MRI data frequently necessitates comprehensive and labor-intensive preprocessing procedures (such as skull stripping, normalization, and registration) to guarantee uniformity, and these procedures may be susceptible to inaccuracies.Training deep learning models on three-dimensional MRI data requires significant computational power, including high-memory GPUs.Ultimately, effectively integrating information from various MRI modalities (including T1, T2, FLAIR, and DWI) to improve diagnostic precision is a challenging task.

Researchers are investigating techniques to minimize inference durations by utilizing hardware accelerators like FPGA-based systems, with the goal of incorporating deep learning models into clinical workflows for swift diagnosis. **E. Clinical and practical challenges:**

Variations in datasets, such as those related to hospitals, scanners, and demographics, lead to domain shift, which hinders the generalization of models. The absence of standardized MRI preprocessing pipelines complicates the ability to make comparisons across different studies. Clinician acceptance is contingent upon the provision of interpretable and reliable AI assistance, rather than solely relying on fully automated solutions.

Moreover, significant privacy concerns obstruct the clinical acceptance of solutions for brain MRI tumor diagnosis. The sensitive nature of the data, which may include identifiable facial features, raises serious re-identification issues despite efforts to anonymize the information. Instances of data breaches or unauthorized access could lead to the misuse, discrimination, or stigmatization of patient data. Additionally, the dependence on extensive datasets for AI training prompts inquiries regarding patient consent and the sufficiency of anonymization measures. A failure to guarantee data anonymity can erode patient trust in AI diagnostic tools.[17]

Future outlook:

-Personalized medicine: Developing personalized treatment plans based on individual patient characteristics and tumor biology.

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Targeted therapies: Investigating novel targeted therapies that can selectively kill brain tumor cells while sparing normal brain tissue.

Immunotherapy: Exploring the potential of immunotherapy to stimulate the immune system to attack brain tumor cells.

Advanced imaging techniques: Developing and refining advanced imaging techniques, such as MRI and PET scans, to improve diagnostic accuracy and monitor treatment response.

By continuing to advance our understanding of brain tumors and developing more effective treatments, we can improve patient outcomes and ultimately work towards a future where brain tumors are no longer a life-threatening diagnosis. Deep learning (DL) is transforming the diagnosis of brain tumors, greatly enhancing both accuracy and efficiency.

This advancement is fueled by innovations in optimized DL models, AI-driven tools, and Explainable AI, all designed to address challenges related to data, models, computation, and specific domains.

Continuous initiatives in benchmarking and standardization are enhancing evaluation, validation, and generalization.Moreover, clinical and practical challenges are being addressed through the incorporation of DL systems into clinical environments and the attainment of regulatory approvals.[30]

The following sections outline efforts in significant research directions.

Optimized DL models for early detection:

Deep learning (DL) has emerged as a widely used technique for the automatic detection and segmentation of brain tumors in MRI scans. Models such as U-Net, 3D U-Net, DeepMedic, and V-Net have demonstrated significant potential in the realm of 3D brain tumor segmentation The adaptation of these models to various image types (for instance, transitioning from CT to MRI) and the integration of data from multiple imaging sources have enhanced their utility. Moreover, the incorporation of imaging data (MRI, CT), genomic data (DNA/RNA sequencing), and clinical data (patient history, treatment responses) into artificial intelligence (AI) models provides a more comprehensive understanding of tumors. This multimodal strategy results in improved tumor classification and facilitates the development of personalized treatment plans . Recent research indicates that the combination of structural MRI sequences (including T1, T2, and FLAIR) with functional imaging and genomic biomarkers through advanced DL architectures significantly boosts diagnostic performance when compared to traditional methods . Multimodal brain MRI tumor models are designed to enhance diagnostic accuracy by utilizing complementary information from various imaging modalities, thereby addressing data heterogeneity and enriching feature representation. While these models can assist in alleviating certain benchmarking inconsistencies, they do not completely eliminate them and may even introduce new challenges.

Furthermore, although multimodal approaches can enhance interpretability in certain situations, they do not inherently resolve the overarching issue of model transparency; in fact, the increased complexity arising from multiple data streams can further obscure the decision- making process. The implementation of federated learning frameworks signifies a similarly revolutionary progress in neuro-oncology AI. This decentralized methodology enables models to be trained collaboratively across various institutions while safeguarding patient privacy. Large-scale initiatives such as the Global Neuroimaging Consortium have illustrated the practical feasibility of federated learning, with participating centers reporting consistent accuracy improvements of 15–20% . while fully maintaining data confidentiality. These distributed systems utilize advanced techniques to handle data heterogeneity, including automated quality control, standardized preprocessing workflows, and adaptive weighting algorithms that compensate for variations in scanner manufacturers and imaging protocols across different sites, thereby enhancing generalizability.

The growing utilization of foundation models trained on extensive and diverse datasets is anticipated to considerably enhance the accuracy of deep learning for brain tumor analysis. These models may enable researchers to investigate tumor types that werepreviously challenging to analyze due to insufficient training data

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AI-powered diagnostic and prognosis tools:

To tackle computational limitations, lightweight deep learning models have emerged as effective solutions for detecting brain tumors, particularly in environments with limited resources. These models facilitate real-time diagnosis and monitoring on edge devices, thereby supporting timely clinical interventions.

AI-assisted tools are also being developed for use during operations, assisting in the identification of cancerous tissues during brain tumor surgeries and potentially enhancing surgical outcomes. A notable example is FastGlioma, which combines AI with stimulated Raman histology (SRH) to provide rapid, high-accuracy diagnostic insights from tissue biopsies in mere seconds . Research indicates that streamlined architectures, such as an 8-layer convolutional neural network (CNN), can achieve accuracy levels of up to 99.48% in binary classification while decreasing inference time by 40% compared to traditional models. Likewise, modified U-Net architectures, enhanced with spatial attention mechanisms, have shown Dice scores of 96% for tumor segmentation, utilizing 60% fewer parameters than standard models . Beyond mere detection, these models are increasingly anticipated to predict clinical outcomes, including patient survival and treatment responses. The synergy of efficiency and interpretability—especially when combined with Explainable AI techniques— positions lightweight models as formidable tools for scalable and transparent brain tumor diagnostics.

Explainable AI:

In addition to improvements in efficiency, there is a growing emphasis on the explainability and transparency of AI models to foster trust among clinicians.

Simultaneously with the initiatives aimed at enhancing efficiency, there is an increasing focus on the explainability and transparency of AI models to bolster clinician trust. Progress in Explainable AI (XAI) has rendered deep learning models for brain tumor diagnosis considerably more interpretable, effectively addressing the ongoing "black-box" issue in medical AI.

Techniques such as Grad-CAM and attention mechanisms emphasize the specific regions of images that the model deems most pertinent, thus enhancing transparency and building confidence in its predictions . For instance, one study integrated deep learning with natural language processing to generate descriptive reports of tumor regions, achieving a Dice coefficient of 0.93 for segmentation accuracy a method that improves interpretability and clinician trust.

In another instance, CNN-TumorNet achieved a classification accuracy of 99% for brain tumors while utilizing LIME to elucidate predictions for malignant gliomas, thereby contributing to diagnostic clarity . Likewise, hybrid models such as ViT-GRU merge transformer-based attention maps with post-hoc XAI techniques to validate the relevance of features, especially in complex and heterogeneous tumor regions . These frameworks for explainability not only enhance diagnostic performance but also aid in regulatory compliance by rendering AI systems more auditable and transparent within clinical environments.

Liquid biopsy and AI-based genetic profiling:

The integration of deep learning (DL) with liquid biopsies, such as the analysis of circulating tumor DNA (ctDNA), facilitates non-invasive observation of tumor mutations.

Artificial intelligence (AI) algorithms evaluate genomic data to detect genetic alterations associated with brain tumors, thereby aiding in early diagnosis and forecasting patient outcomes.

Benchmarking and standardization:

The process of standardization is increasingly becoming significant within the regulatory framework for artificial intelligence in the healthcare sector.Public datasets, such as BraTS, along with structured challenges, have stimulated innovation and established benchmarks for evaluating different deep learning techniques. Furthermore, the standardization of imaging protocols and annotation guidelines is enhancing the consistency and dependability of these models.

Integration with clinical workflows:

Extensive testing has confirmed the clinical advantages of DL systems. One study revealed that the diagnostic accuracy of neuroradiologists increased by 12% (from 63.5% to 75.5%) with the aid of AI.Another trial involving nearly 280

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patients showed that the combination of SRH imaging and AI achieved an accuracy of 94.6% for intraoperative brain tumor diagnosis, which is comparable to traditional pathology (93.9%) while also reducing the diagnosis time to less than three minutes .

These developments highlight the potential of AI to improve clinical decision-making, enhance patient outcomes, and provide radiologists and oncologists with more comprehensive support. **7. Regulatory success:**

Regulatory frameworks are expected to develop with more stringent guidelines regarding AI model transparency, bias reduction, and monitoring of real-world performance. Regulatory authorities are emphasizing robust clinical validation across diverse populations and imaging conditions prior to granting approval for AI models intended for healthcare applications. The FDA's approval of Vysioneer, Cam-bridge, MA, Inc.'s VBrain, a deep learning algorithm designed for brain tumor contouring , marks a notable achievement in the integration of AI for brain tumor diagnosis and treatment planning.AI-driven technologies are progressively being incorporated into hospitals, improving accuracy in radiology and neurosurgery. For example, AI-enhanced neuro-navigation facilitates lesion localization

8. Market growth:

The increasing prevalence of brain cancer in the United States, along with an aging demographic, is fueling the demand for sophisticated diagnostic and treatment options. Artificial intelligence and machine learning are transforming diagnosis by enhancing imaging analysis and predicting tumor behavior, resulting in a swiftly growing **Physical and Emotional Impact on Patients:**

Cognitive impairment:

Brain tumors can affect cognitive function, including memory, attention, and decision-making.

Physical symptoms:

Patients may experience headaches, seizures, weakness, and other physical symptoms.

Emotional changes:

Brain tumors can cause emotional changes, such as anxiety, depression, and mood swings.

Personality changes:

Some patients may experience personality changes, such as irritability, apathy, or impulsivity.

[47]

Impact on Family Members:

Emotional burden: Family members may experience emotional distress, including anxiety, depression, and caregiver burden.

Caregiver role: Family members may take on a caregiving role, which can be time- consuming and stressful.

Financial burden: Brain tumors can result in significant medical expenses, lost income, and financial strain.

Social isolation: Family members may experience social isolation due to the demands of caregiving and the patient's reduced ability to participate in social activities. [48] **Impact on Relationships:**

Strain on relationships: Brain tumors can put a strain on relationships between patients and their family members, friends, and caregivers.

Changes in communication: Patients may experience changes in communication skills, which can affect relationships.

Intimacy and relationships: Brain tumors can affect intimacy and relationships due to physical and emotional changes. [49

Coping Strategies:

Seek support: Patients and family members can benefit from seeking support from healthcare professionals, support groups, and loved ones.

Counseling: Counseling can help patients and family members cope with emotional changes and relationship challenges.

Education: Educating patients and family members about brain tumors and their treatment can help them feel more in control.

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Self-care: Encouraging patients and family members to prioritize self-care, including exercise, healthy eating, and relaxation techniques, can help manage stress and improve overall well-being.

Medications for Brain Tumors

Brain tumor treatment often involves a combination of medications to manage the tumor and its symptoms. Here are some common medications used[51]

1. Chemotherapy Drugs

Temozolomide: A chemotherapy drug used to treat certain types of brain tumors.
Carmustine (BCNU): A chemotherapy drug used to treat brain tumors, including glioblastoma.
Lomustine (CCNU): A chemotherapy drug used to treat brain tumors, including glioblastoma.
Vincristine: A chemotherapy drug used to treat certain types of brain tumors.
5.Cisplatin,Carboplatin, Etoposide,procarbazine, and Irinotecan: Other chemotherapy drugs that may be used to treat brain tumors.

2. Targeted Therapy Drugs

Everolimus (Afinitor): A targeted therapy drug used to treat certain types of brain tumors, including subependymal giant cell astrocytoma (SEGA).
Bevacizumab (Avastin): A targeted therapy drug used to treat certain types of brain tumors, including glioblastoma.
Belzutifan: A targeted therapy drug used to treat certain types of brain tumors.
Voranigo (IDH1/IDH2 inhibitor): A targeted therapy drug used to treat certain types of brain tumors, including gliomas with IDH1 or IDH2 mutations.

3. Symptom-Management Medications

1. Steroids (e.g., Dexamethasone): Used to reduce swelling and inflammation in the brain.
2. Anticonvulsants (e.g., Levetiracetam, Lacosamide, Lamotrigine): Used to prevent seizures in people with brain tumors.
3. Pain relievers (e.g., Acetaminophen, NSAIDs): Used to manage pain and discomfort associated with brain tumors.

These medications can help manage brain tumor symptoms and slow tumor growth, but they may also have side effects and interact with other medications

II. CONCLUSION

In conclusion, brain tumors are a complex and heterogeneous group of neoplasms that require a multidisciplinary approach to diagnosis and treatment. Despite advances in surgical techniques, radiation therapy, and chemotherapy, the prognosis for patients with brain tumors remains variable and often poor. Further research is needed to better understand the underlying biology of brain tumors and to develop more effective and targeted therapies. Early detection and diagnosis are critical to improving patient outcomes, and ongoing research into biomarkers and imaging modalities holds promise for improving diagnostic accuracy and speed. Ultimately, a comprehensive and collaborative approach to brain tumor research and treatment is essential for improving patient outcomes and advancing our understanding of these devastating diseases.

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