PUBLIC HEALTH AND TECHNOLOGIES IN BRAIN TUMOUR TREATMENT

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ABSTRACT

Brain tumours are intracranial lesions that occupy space in the skull. Brain tumors are relatively rare but deadly cancers, and present challenges in the determination of risk factors in the population. These tumors are inherently difficult to cure because of their protected location in the brain, with surgery, radiation and chemotherapy options carrying potentially lasting morbidity for patients and incomplete cure of the tumor. Brain tumors are life threatening because the space Inside the skull is limited, their growth increases intracranial pressure, and may cause edema, reduced blood flow, and displacement, with consequent degeneration, of healthy tissue that controls vital functions. Brain tumors are, in fact, the second leading cause of cancer related deaths in children and young adults. The development of methods to prevent or detect brain tumors at an early stage is extremely important to reduce damage to the brain from the tumor and the therapy. Developing effective prevention or early detection methods requires a deep understanding of the risk factors for brain tumors. In addition to putting pressure on the healthy parts of the brain, it can lead to significant health problems. Depending on the region of the brain tumor, it can cause a wide range of health issues. As malignant brain tumors grow rapidly, the mortality rate of individuals with this cancer can increase substantially with each passing week. Hence it is vital to detect these tumors early so that preventive measures can be taken at the initial stages. Computer-aided diagnostic (CAD) systems, in coordination with artificial intelligence (AI) techniques, have a vital role in the early detection of this disorder.

KEYWORDS

Brain tumors Imaging techniques, Treatment modalities, Surgery advancements, Radiation therapy, Chemotherapy innovations, Artificial intelligence in diagnosis.

HEALTH AND TECHNOLOGY IN BRAIN TUMOR TREATMENT

A brain tumor is an uncontrolled and abnormal growth of brain cells. Any unexpected development can affect a person's functioning because the human skull is a rigid structure with a limited volume depending on the brain region involved. In addition, it can spread to other organs, further compromising human functions (1) Non-invasive techniques include physical inspections of the body and imaging modalities employed for imaging the brain (2) In comparison to brain biopsy, other imaging modalities, such as CT scans and MRI images, are more rapid and secure. Radiologists use these imaging techniques to identify brain problems, evaluate the development of diseases, and plan surgeries (3). However, brain scans or image interpretation to diagnose illnesses are prone to inter-reader variability and accuracy, which depends on the medical practitioner’s competency (2) It is crucial to accurately identify the type of brain disorder to reduce diagnostic errors. Utilizing computer-aided diagnostic (CAD) technologies can improve accuracy. The fundamental idea behind CAD is to offer a computer result as an additional guide to help radiologists interpret images and shorten the reading time for images. This enhances the accuracy and stability of radiological diagnosis (4). Several CAT-based artificial intelligence techniques, such as machine learning (ML) and deep learning (DL), are described in this review for diagnosing tissues and segmenting tumors. The segmentation process is a crucial aspect of image processing. This approach includes a procedure for extracting the area that helps determine whether a region is infected. Using MRI images to segment brain tumors presents various challenges, including image noise, low contrast, loss borders, shifting intensities inside tissues, and tissue-type variation. Brain tumor detection and segmentation is the most difficult and critical task for many medical imaging applications, as it often requires a large amount of information. Tumors come in different shapes and sizes. Automatic or semi-automatic detection/segmentation using artificial intelligence is now crucial in medical diagnosis. Before treatment, such as chemotherapy, radiation or brain surgery, medical professionals must identify the boundaries and areas of brain cancer and find out exactly where it is and what exact areas it affects.

Brain tumors can be divided into several categories depending on the kind, place of origin, pace of development, and stage of progression; as a result, tumor classification is crucial for targeted therapy. Brain tumor segmentation aims to delineate accurately the areas of brain tumors. A specialist with a thorough understanding of brain illnesses is needed to manually identify the proper type of brain tumor. Additionally, processing many images takes time and is tiresome. Therefore, automatic segmentation and classification techniques are required to speed up and enhance the diagnosis of brain tumors. Tumors can be quickly and safely detected by brain scans using imaging modalities, including computed tomography (CT), magnetic resonance imaging (MRI), and others. Machine learning (ML) and artificial intelligence (AI) have shown promise in developing algorithms that aid in automatic classification and segmentation utilizing various imaging modalities. The right segmentation method must be used to precisely classify patients with brain tumors to enhance diagnosis and treatment.

IMAGING MODALITIES FOR BRAIN TUMOUR DETECTION

For many years, the detection of brain abnormalities has involved the use of several medical imaging methods. The two brain imaging approaches are structural and functional scanning [5]. Different measurements relating to brain anatomy, tumor location, traumas, and other brain illnesses compose structural imaging [6]. The finer-scale metabolic alterations, lesions, and visualization of brain activity are all picked up by functional imaging methods. Techniques including CT, MRI, SPECT, positron emission tomography (PET), (FMRI), and ultrasound (US) are utilized to localize brain tumors for their size, location as well as shape, and other characteristics. (7)

1.MRI

MRI is a non-invasive procedure that uses non-ionizing safe radiation [8] to show the 3D anatomical structure of anybody region without the need to cut tissue. It uses RF pulses and a strong magnetic field to produce images [9]. The frame is designed to be placed in a strong magnetic field. The water molecules in the human body are initially in equilibrium when the magnets are turned off. The field is then activated by moving the magnets. The water molecules of the body align with the direction of the magnetic field under the influence of this strong magnetic field [8]. Protons are stimulated to turn against the magnetic field and reorient by applying a pulse of high radio frequency energy to the body in the direction of the field. Protons are stimulated to turn against the magnetic field and reorient by applying a pulse of high radio frequency energy to the body in the direction of the field. When the RF energy pulse is stopped, the water molecules return to their equilibrium state and realign with the magnetic field [8]. This causes the water molecules to produce RF energy, which is detected and converted into visual images by the scanner (10) Tissue structure determines the amount of RF energy that water molecules can use. As we can see in Figure 1, the whole brain has white matter (WM), gray matter (GM) and CSF according to a structural MRI scan (11). The main difference between these tissues in a structural MRI scan is based on the amount of water they contain, where WM is 70% water and GM contains 80% water. CSF fluid consists almost entirely of water, as shown in Figure 1.

Another type of MRI, called functional magnetic resonance imaging (fMRI), (12) measures changes in blood oxygen levels to interpret brain activity. A more active area of the brain begins to use more blood and oxygen. As a result, fMRI correlates location and mental process to map activity in the brain.

2.CT-scan: (Computed Tomography)

CT scanners produce fine, detailed images of the inside of the body using a rotating x-ray beam and an array of detectors. Computer images taken from different angles are processed with special algorithms to create cross-sectional images of the whole body [13]. However, a CT scan can provide more detailed images of the skull, spine, and other bony structures near the brain tumor, as shown in Figure 2. Patients usually receive contrast injections to highlight the abnormal tissue. A patient can sometimes take a dye to improve their image. If an MRI is not available and the patient has a pacemaker-like implant, a CT scan may be performed to diagnose a brain tumor. Advantages of CT scanning include low cost, better identification of tissue classification, rapid imaging, and wider availability. The radiation risk from a CT scan is 100 times greater than that of a standard X-ray diagnosis [13].

3. *Brain tumor detection using a segmentation-based machine learning technique*

As a large amount of medical MRI image data is collected through image acquisition, researchers are now proposing various machine learning methods to detect brain tumours. These approaches are based on feature extraction, feature selection, dimensionality reduction and classification techniques. Most of the proposed machine learning models focus on binary detection of brain tumors. For example, Kharat et al. proposed binary classification of brain images using support vector machine (SVM) and genetic algorithm (GA) [14). In this study, features are extracted using the Spatial Gray Level Dependence (SGLDM) method. In another study, Bahadure et al. used Berkeley wavelet transforms (BWT) and SVM to segment and classify normal and abnormal brain tissues [14]. They were able to achieve 96.5% prediction accuracy with 135 images. In a related study, Rehman et al applied Random Forest (RF) classification to the 2012 BRATS dataset [15]. They compared their model with other classifiers and found that the RF classifier achieves better results in terms of accuracy and specificity.

Later, to detect brain tumors, Chaplot et al. used discrete wavelet transform (DWT) as the feature discriminator and SVM as the classifier [16). With 52 images, a prediction accuracy of 98 percent was achieved. Later, the k-nearest neighbor (KNN) classifier was used by El-Dahsha et al. to 70 images and the results showed 98.6% prediction accuracy [17). They used DWT and Principal Component Analysis (PCA) for feature extraction and feature reduction. They also used particle swarm optimization (PSO) and SVM to select and classify texture features. Chen et al. used a 3D convolutional network to segment the tumor region to identify different classifications of glioma tumor (18). They also used a method of recursive feature exclusion (RFE) to extract features with significant discriminative information. Recently, Ranjan et al proposed a new model using 2D stationary wavelet transform (SWT) as a feature extractor and AdaBoost and SVM classifiers for brain disorder detection. Although these methods have greatly improved the accuracy of brain tumor detection, they still have several limitations, including:

- Since all these methods are based on a binary classification (normal and abnormal), it is not enough for the radiologist to decide on the treatment of the patient according to tumor classification.
- These methods rely on various manual feature extractions, which are time-consuming, complex, and in many cases inefficient.
- The techniques used in these studies work with very small amounts of data. However, processing large amounts of data required sophisticated classifiers.

4. *Brain tumor detection using convolutional neural networks (CNN)*

CNN introduces a no-segmentation method that eliminates the need for manual feature techniques. Therefore, different researchers have proposed different CNN architectures. Most CNN models report multiple classes of brain tumor detection, including large amounts of image data. For example, Sultan et al. proposed a CNN model with 16 layers [19]. The CNN model was tested on two publicly available datasets. One dataset identified the tumors as meningioma, glioma, and pituitary tumor, and the other dataset distinguished three grades of glioma tumors, including grade II, grade III, and grade IV. They achieved prediction accuracies of 96.1% and 98.7% on datasets of 3064 and 516 images, respectively. Hossain et al used Fuzzy C-Means clustering technique to extract tumor region from MRI images [20). They proposed a new CNN-based model and compared it with six other machine learning models. The reported prediction accuracy of 97.9% is better than previous models.

a new hybrid CNN model was created by Ertosu et al. in another study for multigrade glioma tumors [21). The classification accuracy of grade II, III, and IV glioma tumors was 96.0%, 71.0%, and 71.0%, respectively. In a similar study, Anaraki et al detected glioma tumors with 90.9% prediction accuracy using CNN and GA [22). They achieved 94.2% predictive accuracy in diagnosing pituitary, meningioma and glioma tumors. Recently, Özyurt et al. proposed a combined Neutrosophy and CNN model. In this model, Neutrosophy technology is used to segment the tumor zone, the segmented part is extracted by CNN model and then classified by SVM and KNN classifiers [23). In another study, Iqbal et al introduced a 10-layer CNN model to solve this problem (24). They conducted their experiments on the BRATS 2015 dataset and achieved promising results. As discussed here, CNN seems to do well with large images. However, it also has the following two important limitations:

- The CNN model required a huge amount of images for training, which is often difficult to obtain in the field of medical imaging.
- Convolutional Neural Networks (CNN) are very good at classifying images that are similar enough to the dataset. CNNs, on the other hand, have difficulty classifying images with slight tilt or rotation. This can be improved by increasing the data to continuously introduce new variations into the image during training. To solve this problem, we used a data augmentation technique in our study.

IMAGING MODALITIES FOR BRAIN TUMOUR TREATMENT

1. *Brain tumour treatment using Radiation therapy*

Radiation therapy can be given both inside and outside the body. The use of external beam radiation therapy is the most popular.
A linear accelerator is a sizable device used in this treatment. High energy beams are directed by the machine to a specific point on the body. External beam radiation therapy uses a machine that directs high-energy beams into your body. This is called a linear accelerator. If you lie still, the linear acceleration will move around you. It emits radiation from several angles. Your care team has customized the machine just for you. In this way, it delivers a precise dose of radiation to a precise part of your body (25). You will not feel the radiation when it is delivered. It's like taking an x ray. External beam radiation is an outpatient treatment. This means that you do not need to stay in the hospital after the treatment. It can common to get therapy five days a week over several weeks. Some treatment courses are given over 1 to 2 weeks. The treatment is spread out this way so that healthy cells have time to recover between sessions. Sometimes only one treatment is used to relieve pain or other symptoms from more advanced cancers.

2. *Brain tumor treatment using Chemotherapy*

Chemotherapy uses cancer (cytotoxic) drugs to kill brain tumor cells. Medicines circulate throughout the body in the bloodstream. You may receive chemotherapy after surgery or if the brain tumor comes back. Common chemotherapy drugs for brain tumors include a drug called temozolomide. And a combination of drugs called procarbazine, lomustine and vincristine (PCV (26). Brain tumors can be difficult to treat with some chemotherapy because the brain is protected by the blood-brain barrier. It is a natural filter between the blood and the brain that protects the brain from harmful substances. Figure 3. showing the blood brain barrier. Chemotherapy uses drugs to kill cancer cells. This specific cancer treatment prevents cancer cells from multiplying, dividing and producing new cells. Many cancers can be treated with chemotherapy. Your doctor may call chemotherapy standard chemotherapy, conventional chemotherapy, or cytotoxic chemotherapy. Drug chemotherapy affects the whole body. This means that it circulates throughout the body through the bloodstream. Chemotherapy comes in many forms. Chemotherapy drugs are usually strong chemicals that kill malignant cells at certain stages of the cell cycle. In all living things, new cells are produced in a process called the cell cycle (27). Chemotherapy has a greater effect on these rapidly multiplying cells because cancer cells go through this cycle faster than healthy cells.

CONCLUSION

A brain tumor is an abnormal growth of brain tissue that affects the normal functioning of the brain. The main goal of medical image processing is to find accurate and useful information with as few errors as possible using algorithms. The four steps of brain tumor segmentation and classification using MRI data are preprocessing, image segmentation, feature extraction, and image classification. Automating the segmentation and classification of brain tumors can significantly improve diagnosis, treatment strategy and patient follow-up. Due to the appearance and irregular size, shape and nature of the tumor, it remains difficult to create a fully autonomous system that can be used in clinical layers. The main objective of the review is to present the most advanced imaging techniques in brain cancer, covering the pathophysiology of the disease.

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REFERENCE

[1] .DeAngelis L.M. Brain tumors. N. Engl. J. Med. 2001; 344:114–123. Doi: 10.1056/NEJM200101113440207. [PubMed] [CrossRef] [Google Scholar
[2] Hayward R.M., Patronas N., Baker E.H., Vézina G., Albert P.S., Warren K.E. Inter-observer variability in the measurement of diffuse intrinsic pontine gliomas. *J. Neuro-Oncol.* 2008; 90:57–61. doi: 10.1007/s11060-008-9631-4. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
[3] Mahaley M.S., Jr., Mettlin C., Natarajan N., Laws E.R., Jr., Peace B.B. National survey of patterns of care for brain-tumor patients. *J. Neurosurg.* 1989; 71:826–836. doi: 10.3171/jns.1989.71.6.0826. [PubMed] [CrossRef] [Google Scholar]
[4] . Sultan H.H., Salem N.M., Al-Atabany W. Multi-Classification of Brain Tumor Images Using Deep Neural Network. *IEEE Access.* 2019; 7:69215–69225. doi: 10.1109/ACCESS.2019.2919122. [CrossRef] [Google Scholar
[5] Amyot F., Arciniegas D.B., Brazaitis M.P., Curley K.C., Diaz-Arrastia R., Gandjbakhche A., Herscovitch P., Hinds S.R., Manley G.T., Pacifico A., et al. A Review of the Effectiveness of Neuroimaging Modalities for the Detection of Traumatic Brain Injury. *J. Neurotrauma.* 2015; 32:1693–1721. doi: 10.1089/neu.2013.3306. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
[6] Pope W.B. Brain metastases: Neuroimaging. *Handb. Clin. Neurol.* 2018; 149:89–112. doi: 10.1016/b978-0-12-811161-1.00007-4. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
[7] Abd-Ellah M.K., Awad A.I., Khalaf A.A., Hamed H.F. A review on brain tumor diagnosis from MRI images: Practical implications, key achievements, and lessons learned. *Magn. Reson. Imaging.* 2019;61:300–318. doi: 10.1016/j.mri.2019.05.028. [PubMed] [CrossRef] [Google Scholar]
[8] Ammari S., Pitre-Champagnat S., Dercle L., Chouzenoux E., Moalla S., Reuze S., Talbot H., Mokoyoko T., Hadchiti J., Diffetocq S., et al. Influence of Magnetic Field Strength on Magnetic Resonance Imaging Radiomics Features in Brain Imaging, an In Vitro and In Vivo Study. *Front. Oncol.* 2021; 10:541663. doi: 10.3389/fonc.2020.541663. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
[9] Sahoo L., Sarangi L., Dash B.R., Palo H.K. *Advances in Electrical Control and Signal Systems: Select Proceedings of AECSS, Bhubaneswar, India, 8–9 November 2019.* Volume 665. Springer; Singapore: 2020. Detection and Classification of Brain Tumor Using Magnetic Resonance Images; pp. 429–441. [CrossRef] [Google Scholar]

[10] Kaur R., Doegar A. Localization and Classification of Brain Tumor using Machine Learning & Deep Learning Techniques. *Int. J. Innov. Technol. Explor. Eng.* 2019; 8:59–66. [Google Scholar]
[11] The Radiology Assistant: Multiple Sclerosis 2.0. 1 December 2021. [(accessed on 22 May 2023)]. Available online: https://radiologyassistant.nl/neuroradiology/multiple-sclerosis/diagnosis-and-differential-diagnosis-3#mri-protocol-ms-brain-protocol
[12] . Savoy R.L. *Encyclopedia of Neuroscience.* Elsevier; Charlestown, MA, USA: 1999. Functional magnetic resonance imaging (fMRI) [Google Scholar]
[13] Luo Q., Li Y., Luo L., Diao W. Comparisons of the accuracy of radiation diagnostic modalities in braintumor. *Medicine.* 2018;97: e11256.doi: 10.1097/MD.0000000000011256. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
[14] Kharrat A., Gasmi K., Messaoud M.B., Benamrane N., Abid M. A hybrid approach for automatic classification of brain mri using genetic algorithm and support vector machine. *Leonardo J Sci.* 2010;17(1):71–82. [Google Scholar]
[15] N.B. Bahadure, A.K. Ray, H.P. Thethi, Image analysis for mri based brain tumor detection and feature extraction using biologically inspired bwt and svm. Int J Biomed Imaging 2017. [PMC free article] [PubMed]
[16] Rehman Z.U., Naqvi S.S., Khan T.M., Khan M.A., Bashir T. Fully automated multi-parametric brain tumour segmentation using superpixel based classification. *Expert Syst Appl.* 2019; 118:598–613. [Google Scholar]
[17] Chaplot S., Patnaik L.M., Jagannathan N. Classification of magnetic resonance brain images using wavelets as input to support vector machine and neural network. *Biomed Signal Process Control.* 2006;1(1):86–92. [Google Scholar]
[18] El-Dahshan E.-S.A., Hosny T., Salem A.-B.M. Hybrid intelligent techniques for mri brain images classification. *Digital Signal Process.* 2010;20(2):433–441. [Google Scholar]
[19] W. Chen, B. Liu, S. Peng, J. Sun, X. Qiao, Computer-aided grading of gliomas combining automatic segmentation and radiomics, Int J Biomed Imaging 2018. [PMC free article] [PubMed]
[20] Sultan H.H., Salem N.M., Al-Atabany W. Multi-classification of brain tumor images using deep neural network. IEEE Access. 2019; 7:69215–69225. [Google Scholar]
[21] T. Hossain, F. Shishir, M. Ashraf, M. Al Nasim, F. Shah, Brain tumor detection using convolutional neural network, in: (pp. 1–6). IEEE., 2019 May 3.

[22] . M.G. Ertosun, D.L. Rubin, Automated grading of gliomas using deep learning in digital pathology images: A modular approach with ensemble of convolutional neural networks, in: AMIA Annual Symposium Proceedings, Vol. 2015, American Medical Informatics Association, 2015, p. 1899. [PMC free article] [PubMed]
[23] Anaraki A.K., Ayati M., Kazemi F. Magnetic resonance imaging-based brain tumor grades classification and grading via convolutional neural networks and genetic algorithms. *Biocybern Biomed Eng.* 2019;39(1):63–74. [Google Scholar]
[24] Özyurt F., Sert E., Avci E., Dogantekin E. Brain tumor detection based on convolutional neural network with neutrosophic expert maximum fuzzy sure entropy. *Measurement.* 2019;147 [Google Scholar]
[25] Iqbal S., Ghani M.U., Saba T., Rehman A. Brain tumor segmentation in multi-spectral mri using convolutional neural networks (cnn) *Microscopy Res Technique.* 2018;81(4):419–427. [PubMed] [Google Scholar
[26] . https://www.mayoclinic.org/tests-procedures/radiation-therapy/about/pac-20385162
[27] https://www.cancerresearchuk.org/about-cancer/brain-tumours/treatment/chemotherapy-treatment.

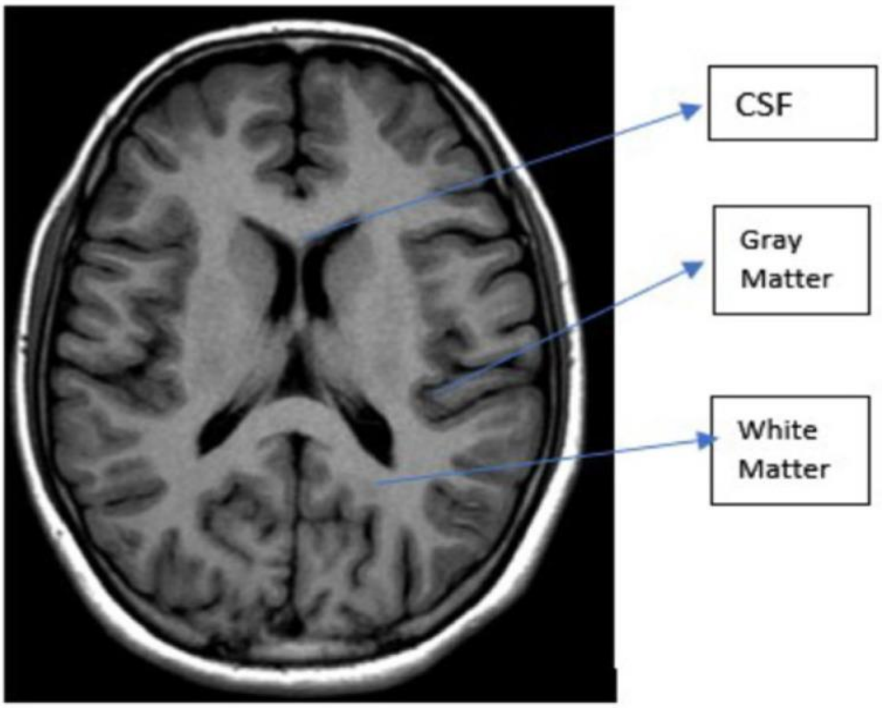

Figure 1.

Healthy brain MRI image showing White matter (WM),

Grey matter (GM), and, (CSF)

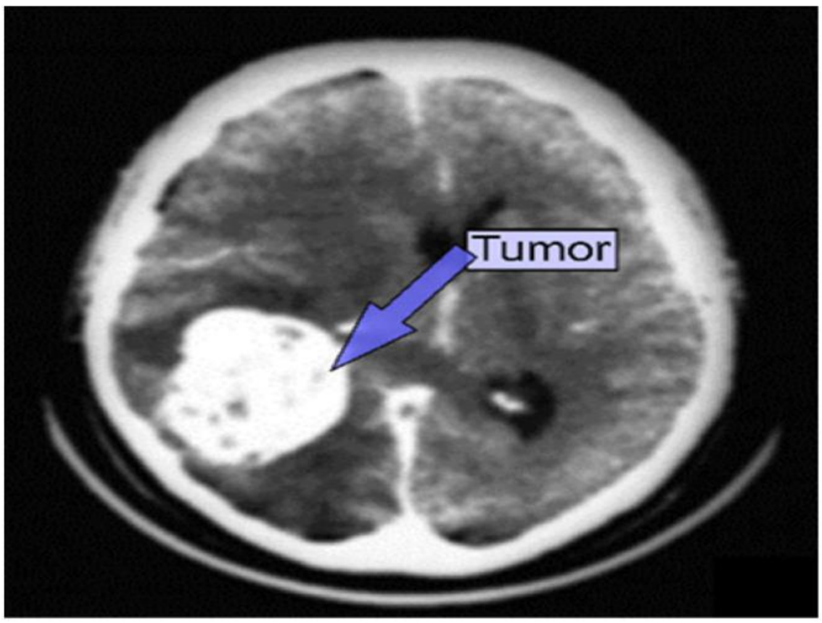

Figure 2.

CT brain tumor

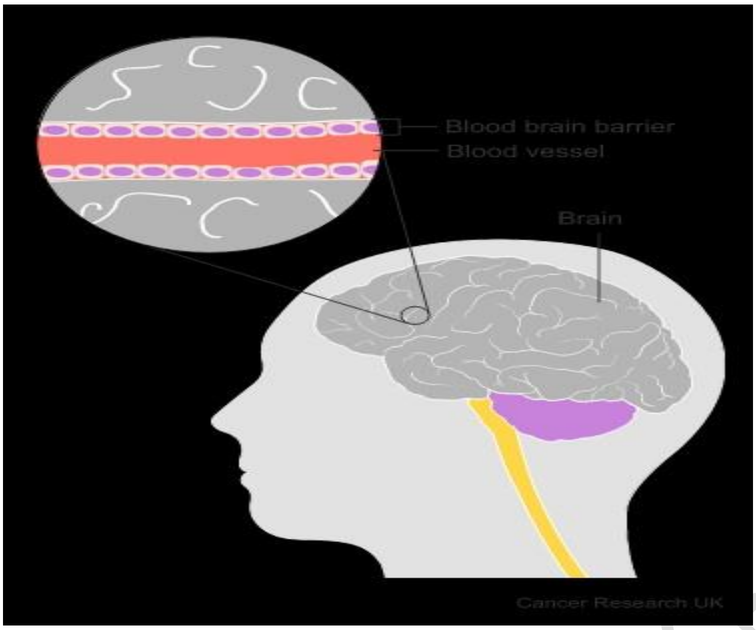

Figure 3.

Chemotherapy for brain tumour showing blood brain