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TUMOR-RELATED CEREBRAL EDEMA: MECHANISMS AND IMAGING FEATURES

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Relevance

Brain and central nervous system (CNS) malignancies constitute a serious global health concern due to their high mortality rates, significant socioeconomic burden, limited survival outcomes, and profound negative impact on patients' quality of life. In 2020, approximately 308,102 new cases of brain and CNS tumors were diagnosed worldwide, representing nearly 1.6% of all newly identified cancers. In the same year, an estimated 251,329 deaths were attributed to these tumors, ranking them among the major causes of cancer-related mortality. Although survival rates vary depending on geographic location and access to advanced medical care, the overall prognosis remains unfavorable because many of these tumors are highly aggressive and often detected at advanced stages. Neuroimaging plays a pivotal role in the diagnosis, therapeutic planning, and postoperative monitoring of brain tumors. Computed tomography (CT) remains one of the fundamental imaging modalities in clinical practice. Both contrast-enhanced and non-contrast CT scans are widely used for noninvasive tumor characterization, evaluation of tumor size and location, assessment of mass



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effect, and pre-treatment planning. CT imaging is also essential in differentiating neoplastic lesions from other intracranial conditions. However, diagnostic challenges may arise when interpreting findings such as sclerosis, cystic lesions, or intracranial hematomas, which can mimic malignant tumors. An important and frequently encountered complication of brain tumors is cerebral edema. Tumor-associated cerebral edema, most commonly vasogenic in nature, develops as a result of disruption of the blood–brain barrier, leading to the accumulation of extracellular fluid in the surrounding white matter. This edema significantly contributes to increased intracranial pressure, midline shift, compression of adjacent brain structures, and worsening neurological symptoms such as headache, vomiting, seizures, and altered consciousness. Imaging techniques, particularly CT and MRI, are crucial for detecting and quantifying cerebral edema, evaluating its extent, and monitoring response to therapies such as corticosteroids or surgical decompression. Therefore, accurate radiological assessment not only facilitates tumor identification but also plays a vital role in recognizing and managing tumor-related cerebral edema, ultimately improving clinical outcomes.

Purpose of the study. The aim of this research is to enhance diagnostic accuracy using medical imaging techniques and to improve the effectiveness of early detection of brain tumors.

Materials and methods. The study includes patients diagnosed with brain tumors who are receiving treatment at the Oncology Dispensary of the Andijan region. Postoperative assessment of patients with glial brain tumors was performed using CT and MRI, enabling a detailed evaluation of brain structures after complete tumor removal and visualization of reactive postoperative changes



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resulting from surgical intervention. Typical postoperative findings included the absence of a tumor mass within the surgical cavity, surrounding brain edema with indistinct margins, no evidence of scarring or structural displacement, and a decrease in reactive changes following dehydration therapy. On CT scans, postoperative scars appeared as slightly hyperdense areas with clear boundaries inside cerebrospinal fluid-filled cavities. These areas did not show contrast enhancement and exerted no mass effect on adjacent brain structures, as confirmed by the absence of midline shift, compression of cerebrospinal fluid spaces, or brain herniation. One of the primary objectives of postoperative CT and MRI is the detection of any residual tumor tissue, which is essential for determining prognosis and planning further treatment.

Results. Residual tumor tissue was detected in 48 patients who underwent partial or subtotal resection and in 9 out of 34 patients who had total tumor removal. No residual tumor was identified in 20 patients, while in 5 cases evaluation was limited due to the presence of postoperative hematoma. Performing contrast-enhanced CT within the first 24 hours after surgery improved the detection of remaining tumor tissue. However, MRI conducted on the first postoperative day demonstrated a 50% increase in signal intensity related to hemoglobin degradation products, which complicated interpretation when contrast agents were used. For early postoperative complications occurring within three days—such as hemorrhage, cerebral edema, brain displacement, ischemia, hydrocephalus, or pneumocephalus—rapid CT protocols were preferred because they are less affected by motion artifacts compared to longer MRI examinations. Stereotactic cryotomy was used as part of combined treatment for glial tumors located in deep or functionally significant brain regions, with MRI guidance in six patients. A total of nine procedures were performed, achieving tumor volume



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reduction ranging from partial shrinkage (one-sixth of the mass) to complete removal. In deeply located glial tumors, stereotactic biopsy enabled histological verification, and subsequent cryodestruction was applied as a palliative treatment, including in cases of glioblastoma. Follow-up CT and MRI performed 3–6 months after stereotactic procedures revealed cerebrospinal fluid cysts at the treatment site. Imaging techniques also played a crucial role in determining tumor localization for stereotactic cryodestruction and in identifying postoperative necrosis or hemorrhagic complications. Radiation therapy was administered to 101 of the 118 operated patients, either to prevent tumor recurrence after non-radical resection or as adjuvant therapy in cases of relapse. Dose-dependent effects were observed: no significant injury to surrounding brain tissue at 45–50 Gy, mild density reduction in one patient at 65–70 Gy, and varying degrees of necrosis and edema in poorly differentiated tumors. The greatest tumor regression was noted in highly differentiated tumors, although recurrence was observed within 3–12 months after treatment. Overall, the integrated use of CT and MRI demonstrates their essential role in postoperative management by enabling accurate evaluation, complication detection, and guidance for further therapeutic decisions.

Conclusion

MRI is a highly effective neuroimaging modality for detecting glial brain tumors, providing detailed information about their structure, size, location, and extent. CT complements MRI by accurately assessing density characteristics that correspond to different histological types of intracerebral tumors. Both MRI and CT reveal characteristic imaging features of glial tumors: benign astrocytomas typically present with a homogeneous structure, whereas anaplastic astrocytomas and glioblastomas demonstrate heterogeneous patterns. MRI is particularly sensitive



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in identifying small areas of contrast enhancement in low-grade astrocytomas and can also detect arteriovenous shunts commonly associated with malignant tumors. The diagnostic performance of MRI and CT depends on tumor morphology. MRI demonstrates a sensitivity of 97.1%, specificity of 82%, and overall accuracy of 95%, while CT shows a sensitivity of 94.2%, specificity of 75%, and accuracy of 93%. In postoperative evaluation, especially with contrast enhancement, CT exhibits higher sensitivity (97.4%) compared to MRI (89.9%) in detecting residual tumor tissue. Additionally, CT is especially valuable for the early identification of postoperative complications such as hematomas, increased cerebral edema, ischemic changes, obstructive hydrocephalus, and pneumocephalus, thereby enabling timely clinical intervention.