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Results of Surgical Treatment of Intracerebral Tumor of the Right Temporo-Occipital Region of the Brain

Ravshanov Davron Mavlonovich [1], Aliev Mansur Abdukhalikovich [2], Kayumov Mansur Jalil o'gli [3]
[1]Assistant at the Department of Neurosurgery at Samarkand State Medical University
[2]Head of the Department of Neurosurgery, Samarkand State Medical University
[3]Master's degree resident of the Department of Neurosurgery at Samarkand State Medical University

Introduction. Brain tumors (BT) are a highly heterogeneous group of neoplasms that differ in their molecular characteristics, clinical manifestations, therapeutic approaches, and survival prognosis [1]. The pathophysiology of BTs is determined by multiple factors, including their origin (primary or secondary tumors), microenvironmental features, vascular architecture, and individual patient characteristics [2,3]. Tumor metabolism is known to be closely linked to vascular function and morphology, which is reflected in the pattern of contrast enhancement during neuroimaging [4].

In clinical practice, determining the tumor type, its grade of malignancy, and prognostic molecular markers (IDH, MGMT) plays a key role in selecting optimal therapy and assessing prognosis [5,6]. For these purposes, noninvasive imaging methods using computed tomography (CT) and magnetic resonance imaging (MRI), as well as radiomics and artificial intelligence technologies, are being actively developed [7].

Gadolinium-enhanced MRI is the gold standard for diagnosing brain tumors; however, CT has several advantages, including quantitative assessment of blood-brain barrier disruption and neoangiogenesis [1,6]. Modern dual-energy CT (DECT) technologies, particularly dual-layer DECT (dlDECT), enable spectral analysis of tissues and quantitative assessment of iodine, calcium, and soft tissue content. The dlDECT technique is based on the separation of photons of different energies at the detector level, which provides stable and standardized spectral information without increasing radiation exposure.

Despite the advantages of DECT, data on its use in differentiating brain tumors are extremely limited, which is explained by the dominance of MRI and the lack of standardized CT protocols [6]. In the present study, based on the analysis of standardized dlDECT data performed before stereotactic biopsies, an assessment was made of the possibility of using quantitative parameters of attenuation and iodine accumulation in tumor foci to differentiate various nosological forms of brain tumors.

Purpose of the study

To evaluate the potential of quantitative analysis of contrast enhancement and iodine mapping obtained using dual-energy CT for differentiating various types of brain tumors and to determine their relationship with molecular markers (IDH and MGMT). To further describe the surgical outcomes of a patient with an intracerebral tumor of the right temporo-occipital region and to evaluate the practical value of these data for preoperative planning.

Materials and methods

The study was conducted retrospectively with approval from the local ethics committee. Data were included on 139 consecutive patients who underwent dual-energy CT (IQon Spectral CT, Philips Healthcare, Best, the Netherlands) between January 2021 and April 2025 before stereotactic biopsy of suspicious intracerebral lesions. Age, gender, body weight, scan parameters, and histopathological diagnosis were recorded for each patient. Cases with fewer than five observations of a given tumor type or inconclusive histological results were excluded from the analysis.

Scanning was performed using a standardized stereotactic protocol with intravenous administration of an iodine-containing contrast agent. dlDECT provided simultaneous acquisition of polyenergetic reconstructions and spectral iodine density maps (IDMs).

In each case, ROI density measurements were performed in contrast-enhancing areas of the tumor and in symmetrical areas of the contralateral white matter. The contrast-to-noise ratio (CNR) was calculated to assess the degree of enhancement.

Biopsy and surgical material were examined to determine the tumor type, degree of malignancy, and mutational status of IDH1/2 and MGMT promoter methylation using PCR.

4. Surgical treatment of a clinical case

A patient with an intracerebral tumor in the right temporo-occipital region underwent microsurgical removal of the tumor under the control of neuronavigation and fluorescence navigation with 5-aminolevulinic acid (5-ALA).

Results. Of the 139 included patients (52 women, 76 men; mean age 59.4 ± 17.1 years), the following main groups were identified based on histological results: glioblastomas - 62 cases; metastases - 48 cases; primary CNS lymphomas - 15 cases; oligodendrogliomas and astrocytomas grades II–III - 14 cases.

The highest contrast enhancement values were observed in lymphomas (IDM CNR = 3.28 ± 1.23), which was significantly higher compared to glioblastomas (2.37 ± 1.55; $p < 0.005$) and metastases (1.95 ± 1.14; $p < 0.02$). The differences between glioblastomas and metastases were statistically insignificant.

Low-grade tumors had low IDM CNR values (1.22–1.27 ± 0.45–0.82).

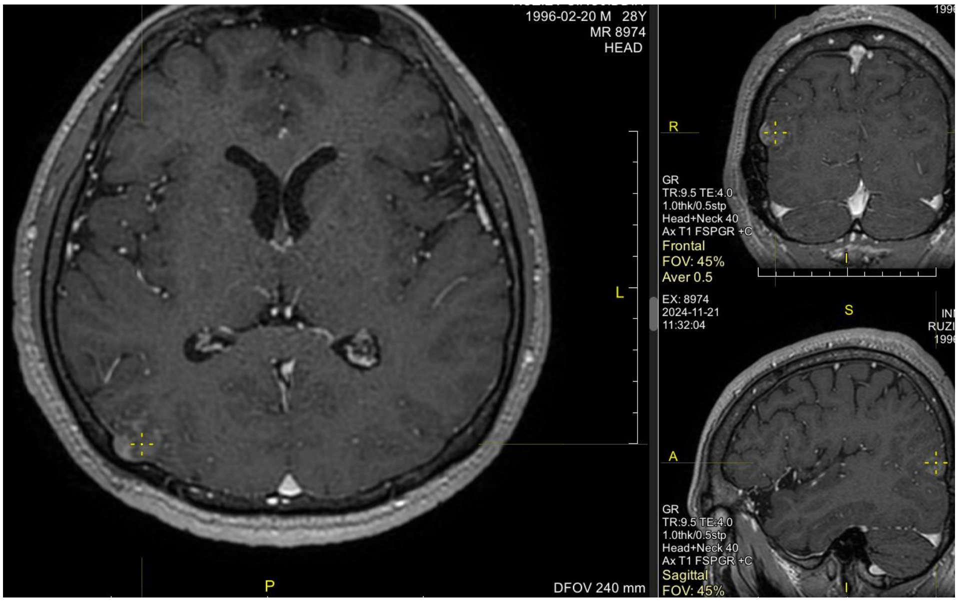
CNR values calculated using standard Hounsfield (HU) values were comparable to or slightly higher than those based on iodine maps. MRI was performed on a 3-Tesla scanner (Siemens/GE/Philips) using T1, T2, FLAIR, DWI/ADC sequences, and gadolinium-enhanced T1. DSC perfusion and MR spectroscopy were used when necessary.

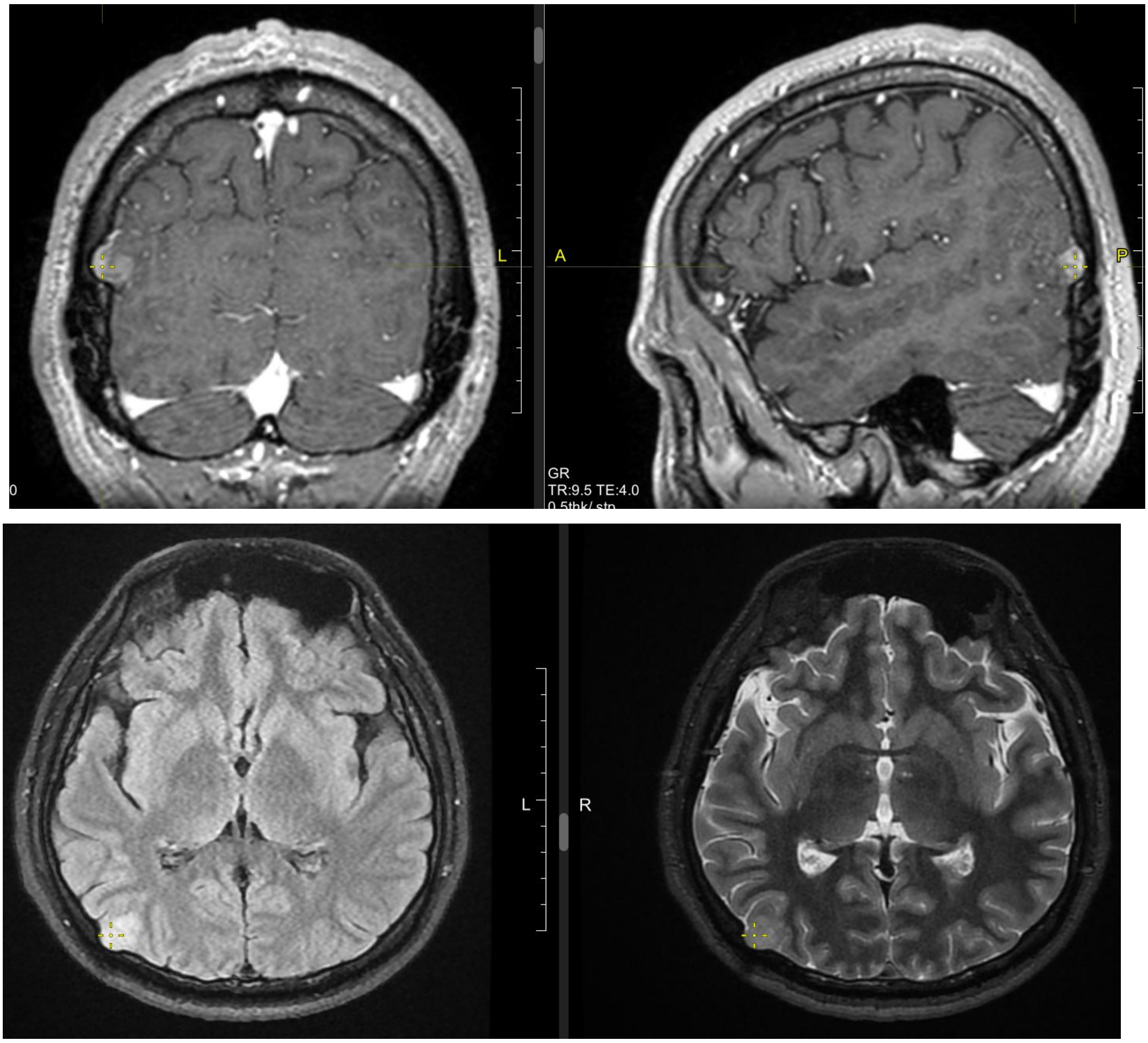
Keywords: neurooncology, tumor differentiation, iodine quantification, dual-energy computed tomography

Clinical example

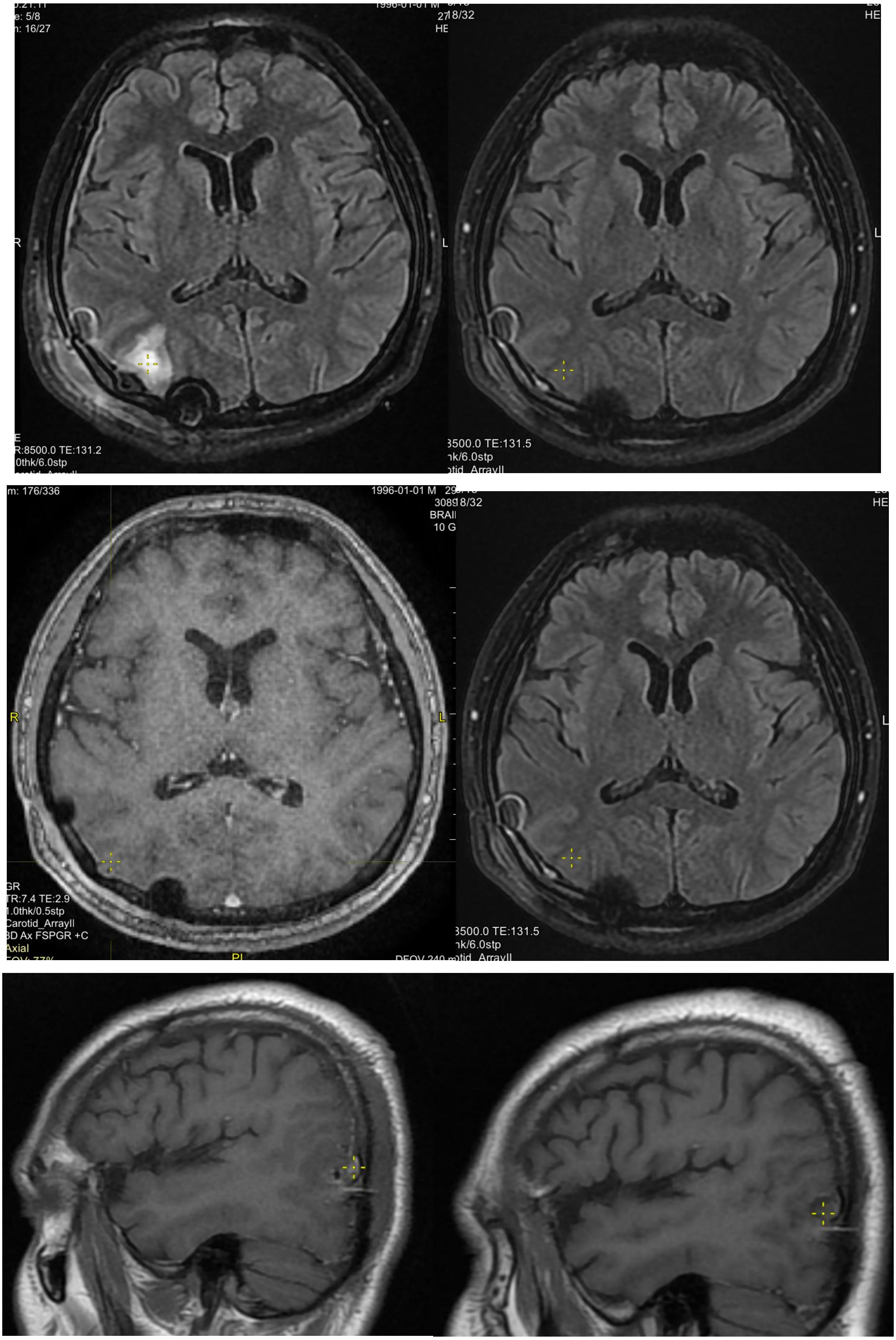
A patient with a tumor in the right temporo-occipital region showed significant contrast enhancement with an IDM CNR of 2.4, consistent with the glioblastoma spectrum, according to dlDECT. Following microsurgical removal, the tumor was confirmed as an IDH-wild-type glioblastoma with partial MGMT methylation. The postoperative period was uneventful, and MRI revealed total tumor resection.

Pic 1. Intracerebral tumor of the right temporal lobe of the brain





Pic 2. Post operating condition



Discussion

The results of the study confirm that quantitative assessment of contrast enhancement and iodine uptake in dlDECT allows statistically distinguishing between groups of brain tumors. High CNR values in lymphomas correspond to intense contrast accumulation due to dense vascularization and severe disruption of the blood-brain barrier. Glioblastomas and metastases demonstrate similar levels of enhancement, which explains their similarity in MRI. Modern neuroimaging relies primarily on magnetic resonance imaging (MRI), which is the "gold standard" for primary diagnosis and follow-up [8,9]. However, dual-energy computed tomography (DECT), and in particular dual-slice detector DECT (dlDECT), opens up new possibilities for quantitative assessment of contrast enhancement and can serve as an additional tool for preoperative planning and assessment of tumor vascular characteristics [10–12].

The role of MRI in the diagnosis of brain tumors

Gadolinium-enhanced MRI remains the primary method for assessing the extent, structure, and biological properties of brain tumors. The following modes are used: T1- and T2-weighted images for assessing the structure, presence of edema, cystic inclusions, and hemorrhage; FLAIR for detecting white matter infiltration; DWI and ADC maps for analyzing cellularity and diffusion characteristics; MR spectroscopy for assessing metabolic features (e.g., choline, NAA, and lactate levels); Perfusion MRI (DSC, DCE) for quantitative assessment of vascularization and vascular permeability; fMRI and DTI for functional mapping and assessment of pathway involvement before surgery [3, 6].

An additional advantage of DECT is the ability to simultaneously analyze multiple energy ranges and quantify iodine without the need for rescanning. However, the study showed that traditional density (HU) measurements have comparable or even slightly better tumor differentiation than iodine mapping. This suggests that the dual-energy feature does not always provide additional diagnostic value.

An interesting observation is that both iodine and standard CNR measurements were able to distinguish between IDH-mutated and IDH-wildtype gliomas, highlighting the possible prognostic significance of these parameters.

Conclusion. Quantitative indicators of weakening and iodine accumulation Dual-energy CT allows statistical differentiation between the main subtypes of brain tumors.

1. CNR calculated from standard HU values, showed equal or slightly better diagnostic efficiency compared to parameters based on iodine cards.
2. The dlDECT technique can be used for non-invasive tumor pre-classification in combination with radiomics and deep learning methods.
3. CNR for both HU and IDM measurements allowed us to distinguish between gliomas with and without the IDH mutation, which opens up possibilities for assessing molecular characteristics using CT data.
4. The use of these technologies in preoperative planning of surgical treatment helps to improve the accuracy of diagnosis and the safety of operations.

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