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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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THE EFFECTIVENESS OF INTRAOPERATIVE ULTRASOUND IN GLIAL TUMOR SURGERY

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Abstract.

Background: Glial tumors constitute a significant proportion of central nervous system neoplasms. The main treatment modalities include surgery, radiotherapy, and/or chemotherapy. Patient prognosis depends on tumor grade, the extent of surgical resection, and, when indicated, the effectiveness of adjuvant treatment. The use of intraoperative ultrasound (IOUS) may provide real-time information during surgery and may facilitate maximal safe resection.

Objective: The aim of this retrospective study was to evaluate the role of IOUS in glial tumor surgery, with particular attention to residual tumor detection, postoperative edema, and neurological outcome in patients operated on with and without IOUS guidance.

Methods: The study included 35 patients with histologically confirmed glial tumors who underwent surgical treatment between 2020 and 2026. Twenty patients underwent surgery with IOUS guidance, whereas 15 underwent microsurgical resection without IOUS. IOUS was performed using SONOLINE G50 (Siemens) and ACUSON X300 (Siemens) systems with 5-10 MHz transducers. Preoperative and postoperative neurological status was assessed clinically by neurosurgeons and neurologists. Postoperative CT was performed on the second postoperative day; contrast-enhanced MRI was performed later, within 21 days to 1 month after surgery. Because standardized KPS or mRS scores and early MRI within 48 hours were not available in this retrospective series, radiological and neurological outcomes were analyzed as descriptive clinical categories.

Results: High-grade tumors (WHO grade III-IV) were diagnosed in 25 patients and low-grade tumors (WHO grade I-II) in 10 patients. In the IOUS group, 16 patients had high-grade and 4 had low-grade tumors; in the non-IOUS group, 9 patients had high-grade and 6 had low-grade tumors. Residual tumor was detected in 7 of 20 patients in the IOUS group and in 9 of 15 patients in the non-IOUS group. Neurological status improved in 12 patients, remained unchanged in 7, and worsened in 1 in the IOUS group; in the non-IOUS group, neurological status improved in 1 patient, remained unchanged in 13, and worsened in 1. Overall postoperative edema increased in 2 cases, remained unchanged in 22, and decreased in 11.

Conclusion: IOUS is a useful adjunct in glial tumor surgery because it provides real-time intraoperative information regarding tumor localization, internal structure, and relationship to surrounding brain tissue. In this retrospective cohort, IOUS was associated with a lower frequency of residual tumor and a more favorable trend in neurological outcome, although the absence of volumetric early postoperative MRI and standardized neurological scores limits definitive conclusions.

Key words. Neurosurgery, intraoperative ultrasound, glioma, neuro-oncology, extent of resection, minimally invasive surgery.

Introduction.

Glial tumors constitute a significant proportion of primary central nervous system neoplasms. Depending on tumor location, they may cause a wide spectrum of neurological deficits. Prognosis is influenced by tumor grade, extent of spread, accuracy of diagnosis, selection of treatment strategy, and extent of surgical resection [1-4].

Treatment of glial tumors includes surgical intervention and, when necessary, radiotherapy and/or chemotherapy. In surgical management, the extent of resection is of particular importance [5,6]. Compared with partial resection, more radical tumor removal is generally associated with improved disease control, while preservation of neurological function remains essential.

The principal goal of surgery is maximal safe resection: removal of as much pathological tissue as possible while minimizing injury to normal brain structures. Because gliomas originate from and infiltrate brain parenchyma, distinguishing tumor tissue from normal tissue can be difficult, particularly in deep-seated or homogeneous lesions. The surgeon's experience is therefore critical, but modern intraoperative technologies can improve orientation and decision-making [7-11].

Various techniques are available for intraoperative guidance, including neuronavigation, intraoperative MRI or CT, electrophysiological neuromonitoring, microscopic fluorescence techniques, and intraoperative ultrasound. Each modality has specific advantages and limitations. Neuronavigation is based on preoperative imaging and does not fully reflect brain shift or intraoperative anatomical changes. Intraoperative MRI and CT provide valuable information but require specialized equipment, may prolong surgery, and are available mainly in specialized centers [12-15].

Intraoperative ultrasound is a safe, noninvasive, radiation-free, and comparatively cost-effective technique that provides real-time information during surgery. It can assist tumor localization, delineation of tumor margins, assessment of tumor consistency and internal structure, visualization of residual tumor tissue, and orientation relative to normal anatomical landmarks such as the falx, tentorium, ventricles, and cerebellar tonsils [16-20].

The aim of the present study was to evaluate the effectiveness of IOUS in glial tumor surgery by comparing patients operated on with and without IOUS guidance. We focused on residual tumor, postoperative edema, neurological status, and the practical value of IOUS in deep-seated lesions and lesions with variable internal composition.

Materials and Methods.

This retrospective study included 35 patients operated on for histologically confirmed glial tumors between 2020 and 2026 in two different clinics. All procedures were performed by four neurosurgeons with radiological support. Patients were included

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if they had preoperative MRI findings consistent with an intracerebral neoplastic lesion and subsequent histopathological confirmation of a glial tumor. Patients with histopathologically verified secondary metastatic tumors, abscesses, or parasitic lesions were excluded.

Patients were divided into two groups according to whether IOUS was used during surgery. The IOUS-guided group included 20 patients. The non-IOUS group included 15 patients who underwent standard microsurgical tumor resection without intraoperative ultrasound guidance.

Preoperative neurological status was evaluated clinically in all patients by neurosurgeons and neurologists. Surgical planning was based on contrast-enhanced MRI. In the IOUS group, ultrasound examination was performed after craniotomy and before dural opening because ultrasound penetration through bone is limited. A transducer enclosed in a sterile sheath was used to assess tumor localization, shape, size, and relationship to surrounding structures. The transducer frequency was selected according to lesion depth. During resection, repeated ultrasound examinations were performed to evaluate tumor borders and detect possible residual tissue. At the end of the procedure, IOUS was repeated when necessary to assess the resection cavity.

Postoperative CT was performed on the second postoperative day. Follow-up contrast-enhanced MRI was performed as part of planned postoperative evaluation, generally from 21 days to 1 month after surgery. Therefore, residual tumor assessment in this study was based on delayed postoperative MRI rather than MRI performed within 48 hours. This is an important methodological limitation because early postoperative MRI is usually preferred for precise quantitative assessment of extent of resection in glioma surgery.

Neurological status after surgery was classified clinically as improved, unchanged, or worsened. Standardized scales such as Karnofsky Performance Status or modified Rankin Scale were not recorded in the original clinical database. Therefore, neurological outcomes were analyzed descriptively. Categorical variables were compared between groups using Fisher's exact test or chi-square testing where appropriate. Because of the small sample size, all statistical comparisons should be interpreted as exploratory.

Results.

The study included 35 patients, 16 females and 19 males, aged 17 to 69 years. Histopathological examination showed high-grade glioma (WHO grade III-IV) in 25 patients and low-grade glioma (WHO grade I-II) in 10 patients. Twenty-eight tumors were supratentorial and 7 were infratentorial. Among supratentorial tumors, 10 were located in the frontal lobe, 8 in the parietal lobe, 6 in the temporal lobe, and 4 in the occipital lobe. Ten supratentorial tumors were located in the dominant hemisphere and 18 in the non-dominant hemisphere. In 3 cases, the lesion extended into deep brain structures including the basal ganglia.

Baseline comparison showed that the IOUS group included 16 high-grade and 4 low-grade tumors, whereas the non-IOUS group included 9 high-grade and 6 low-grade tumors. Basal ganglia involvement was present in 2 patients in the IOUS group and 1 patient in the non-IOUS group. The difference in tumor grade distribution did not reach statistical significance (Fisher's exact test, $p = 0.266$), although high-grade lesions were numerically more frequent in the IOUS group.

In the IOUS-guided group, tumor identification was clear in 5 cases, moderate in 8 cases, and limited in 7 cases. IOUS was most informative when the tumor had heterogeneous internal structure, including necrotic areas, cystic components, or a well-defined capsule. In homogeneous tumors, IOUS differentiation between tumor tissue and normal parenchyma was more limited.

Residual tumor was detected in 7 of 20 patients (35.0%) in the IOUS group and in 9 of 15 patients (60.0%) in the non-IOUS group. Gross total resection or absence of visible residual tumor was observed in 13 of 20 patients (65.0%) in the IOUS group and in 6 of 15 patients (40.0%) in the non-IOUS group. This difference did not reach statistical significance in the exploratory comparison (Fisher's exact test, $p = 0.182$), but the direction of the findings favored the IOUS group.

Postoperative edema increased in 2 cases, remained unchanged in 22 cases, and decreased in 11 cases in the total cohort. In the

Table 1. *Clinical and radiological characteristics of patients with glioma.*

Characteristic	Total cohort (n=35)	IOUS group (n=20)	Non-IOUS group (n=15)	p value
Age range, years	17-69	17-69	17-69	-
Female / male	16 / 19	Not recorded separately	Not recorded separately	-
High-grade glioma (III-IV)	25	16	9	0.266
Low-grade glioma (I-II)	10	4	6	0.266
Supratentorial	28	Not recorded separately	Not recorded separately	-
Infratentorial	7	Not recorded separately	Not recorded separately	-
Dominant / non-dominant hemisphere	10 / 18	Not recorded separately	Not recorded separately	-
Basal ganglia involvement	3	2	1	1.000

Note: *P values are exploratory. Some baseline variables were available only for the total cohort and were not recorded separately by group in the retrospective database.*

Table 2. *Informativeness of IOUS in the IOUS-guided group.*

IOUS visibility	Number of patients (n=20)	Percentage
Clear / good identification	5	25.0%
Moderate identification	8	40.0%
Limited / poor identification	7	35.0%

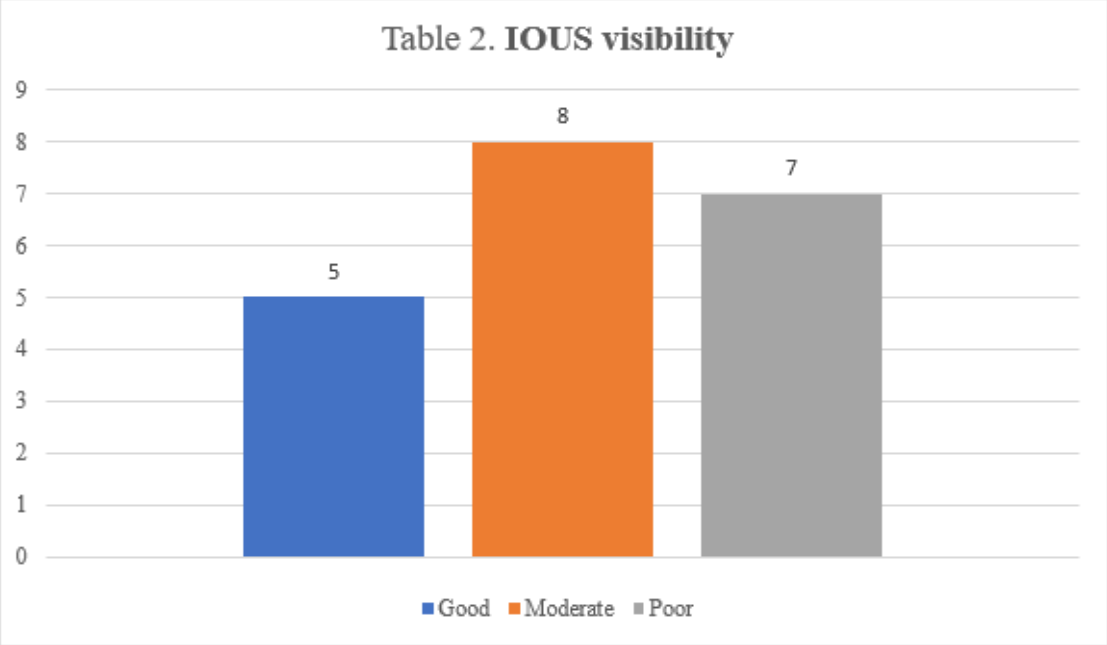


Table 3. *Tumor components identified by preoperative imaging and/or IOUS.*

Imaging/tumor component	Number of observations	Comment
Well-identified capsule	20	May improve delineation
Cystic areas	14	May improve ultrasound contrast
Necrotic areas	25	Often associated with heterogeneous echogenicity
Homogeneous structure	11	Often associated with limited tumor-brain differentiation

Note: *Categories overlap; one tumor could contain more than one component.*

Table 4. *Residual tumor and extent of resection according to IOUS use.*

Extent of resection / residual tumor	IOUS group (n=20)	Non-IOUS group (n=15)	Total	p value
No visible residual tumor / gross total resection	13	6	19	0.182
Residual tumor / partial resection	7	9	16	0.182

Note: *Residual tumor was assessed on delayed postoperative contrast-enhanced MRI performed approximately 21 days to 1 month after surgery, not on MRI within 48 hours.*

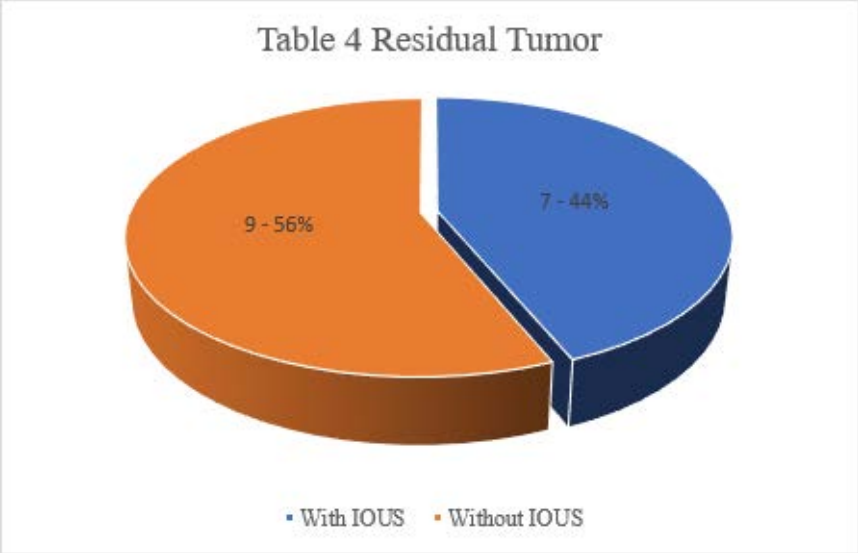


Table 5. *Severity of postoperative edema.*

Postoperative edema	IOUS group (n=20)	Non-IOUS group (n=15)	Total
Increased	1	1	2
Unchanged	10	12	22
Decreased	9	2	11

Note: *The total values were standardized across the manuscript as increased in 2 cases, unchanged in 22 cases, and decreased in 11 cases.*

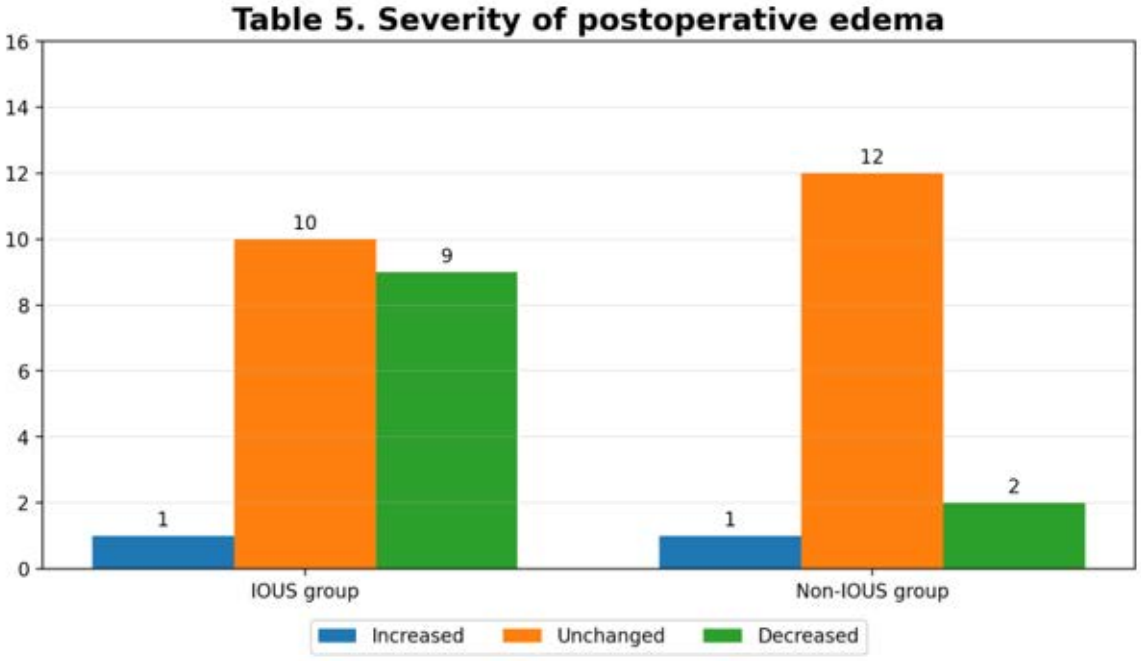
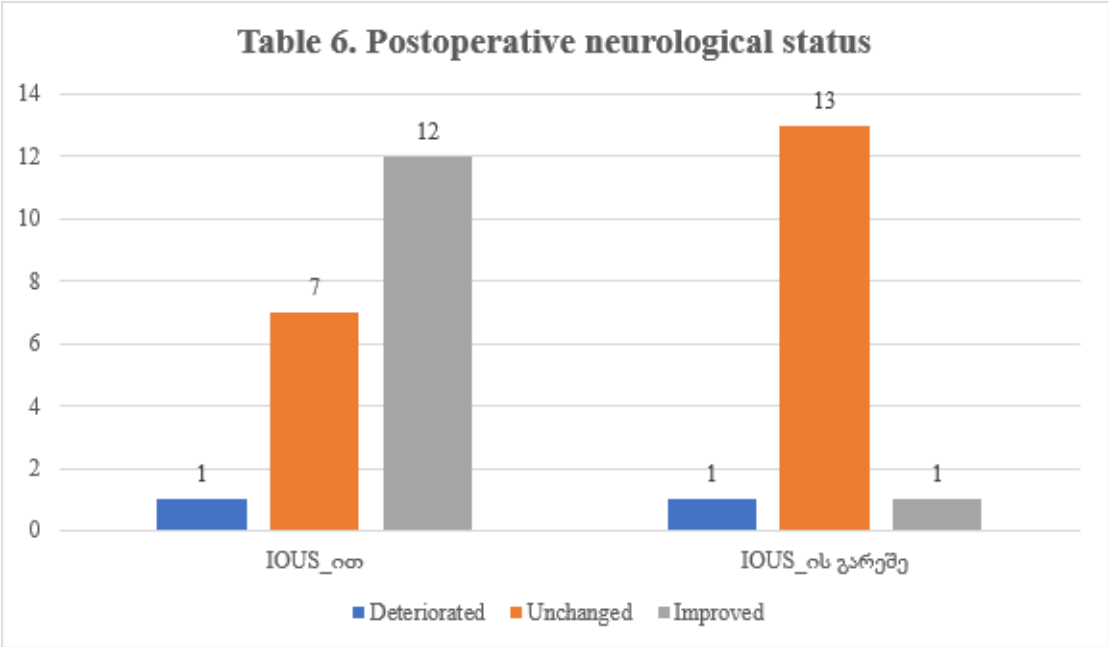


Table 6. *Postoperative neurological status according to IOUS use.*

Postoperative neurological status	IOUS group (n=20)	Non-IOUS group (n=15)	Total	p value
Worsened	1	1	2	0.005
Unchanged	7	13	20	0.005
Improved	12	1	13	0.005

Note: *Neurological outcome was assessed clinically and was not based on standardized KPS or mRS scoring; p value is exploratory.*



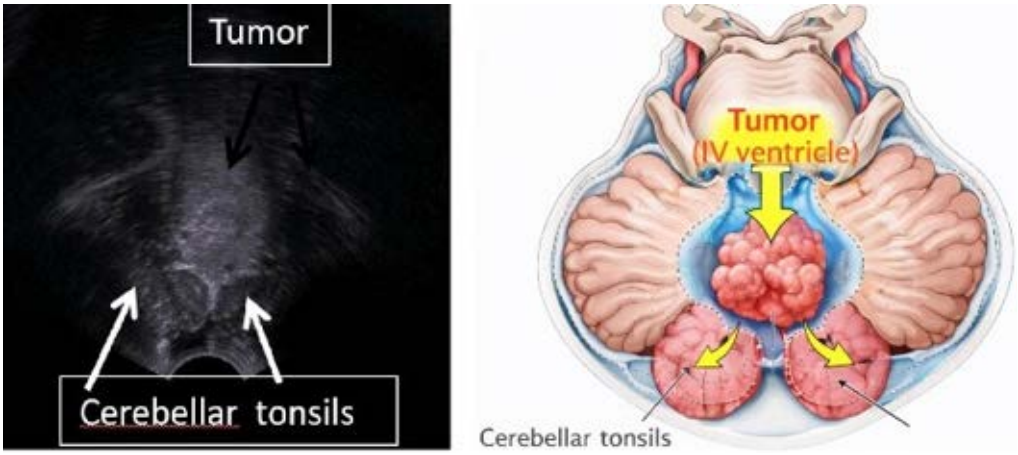


Figure 1. *(A) IOUS image and (B) schematic illustration of a fourth ventricular tumor.*

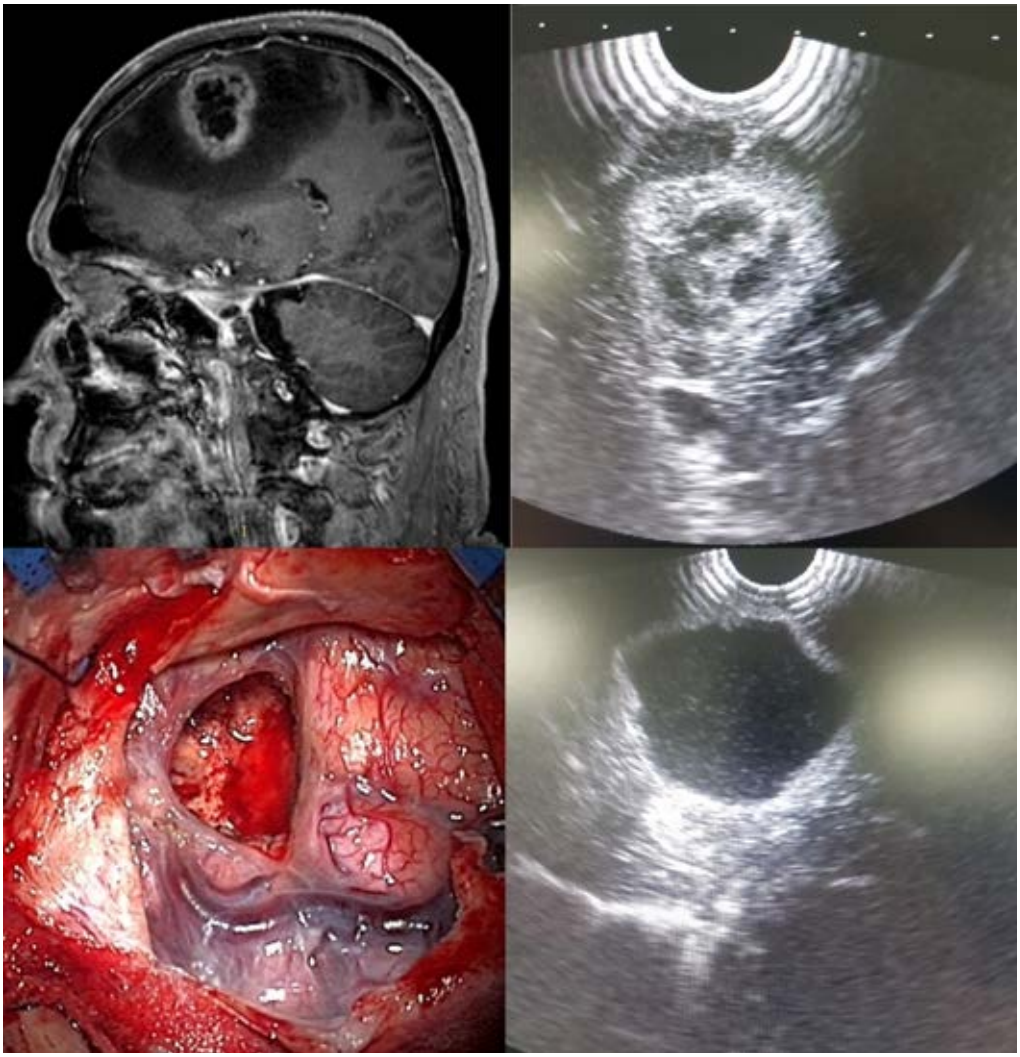


Figure 2. *Frontal lobe glioma (Grade III): (A) preoperative MRI, (B) IOUS before resection, (C) intraoperative image, and (D) IOUS after tumor removal.*

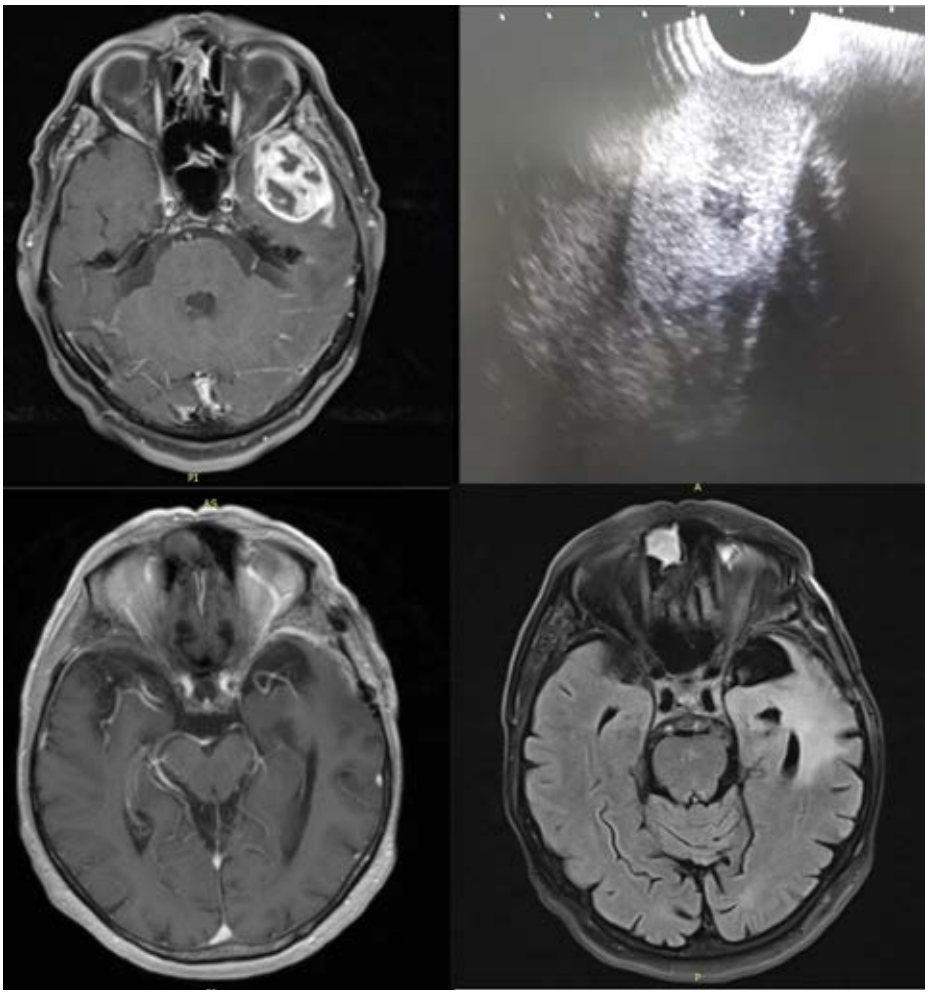


Figure 3. *Frontal lobe glioblastoma (Grade IV): (A) preoperative MRI, (B) IOUS before resection, (C) postoperative MRI, and (D) post-radiation MRI.*

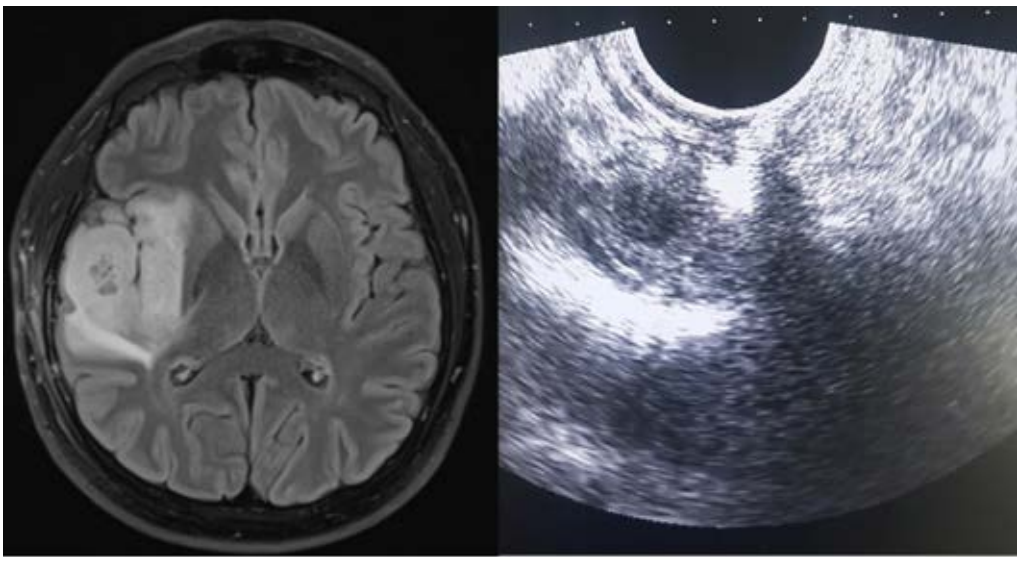


Figure 4. *Temporal lobe diffuse-growing glioma: (A) preoperative MRI and (B) IOUS.*

IOUS group, edema increased in 1 patient, remained unchanged in 10 patients, and decreased in 9 patients. In the non-IOUS group, edema increased in 1 patient, remained unchanged in 12 patients, and decreased in 2 patients. These values are presented in Table 5 and were interpreted descriptively.

Postoperative neurological assessment showed worsening in 1 patient, unchanged status in 7 patients, and improvement in 12 patients in the IOUS group. In the non-IOUS group, neurological status worsened in 1 patient, remained unchanged in 13 patients, and improved in 1 patient. Clinical improvement included reduction of numbness, improvement of weakness, better mental status, and resolution of ataxia. The exploratory comparison showed a statistically significant difference in favor of the IOUS group (chi-square test, $p = 0.005$), but this result should be interpreted cautiously because standardized neurological scores were not recorded.

Postoperative complications included postoperative hemorrhage in 1 patient, requiring reoperation followed by stabilization, and hydrocephalus in 1 patient, requiring ventriculoperitoneal shunt placement. No infectious complications were observed.

Discussion.

The present retrospective study evaluated the practical value of IOUS in glial tumor surgery. The main finding was that IOUS provided real-time intraoperative information that was particularly useful for tumor localization, assessment of tumor structure, and orientation in cases in which the lesion was not visible at the cortical surface. In deep-seated lesions, IOUS helped identify the shortest and safest trajectory to the tumor, potentially reducing unnecessary injury to normal brain tissue.

The group comparison showed a lower proportion of residual tumor in the IOUS group than in the non-IOUS group (35.0% versus 60.0%). Although this difference did not reach statistical significance, most likely because of the small sample size, the trend supports the clinical impression that IOUS may help increase the extent of safe resection. In addition, neurological improvement was more frequently observed in the IOUS group. This finding is clinically relevant, but it should be interpreted cautiously because neurological outcomes were not measured using standardized scales.

The informativeness of IOUS depended on tumor structure. Heterogeneous tumors, especially those with cystic or necrotic components and a more distinct capsule, were easier to identify on IOUS. By contrast, homogeneous tumors could be difficult to distinguish from normal brain parenchyma, particularly after cyst evacuation or capsular opening, when the anatomical relationship between tumor and surrounding tissue changed during surgery.

This study has several limitations. First, it was retrospective and included a relatively small number of patients. Second, the groups were not randomized, and the selection of IOUS may have been influenced by tumor complexity. Third, extent of resection was not evaluated by volumetric MRI and early contrast-enhanced MRI within 48 hours was not available; MRI was performed later, generally from 21 days to 1 month after surgery. Therefore, postoperative changes could have influenced radiological interpretation. Fourth, neurological status was assessed clinically rather than by standardized KPS or modified Rankin Scale scores. For these reasons, the findings should be considered exploratory and hypothesis-generating.

Despite these limitations, the study supports the practical value of IOUS as an accessible, real-time adjunct in glial tumor surgery. Future prospective studies should include standardized preoperative and early postoperative volumetric MRI, objective neurological scoring, and larger group sizes to more precisely define the effect of IOUS on extent of resection and functional outcome.

Conclusion.

Intraoperative ultrasound is a valuable adjunct in glial tumor surgery. It provides real-time information about tumor localization, internal structure, and relationship to surrounding anatomical structures. In this retrospective cohort, IOUS was associated with a lower frequency of residual tumor and a more favorable neurological outcome trend. However, because early postoperative volumetric MRI and standardized neurological scoring were not available, the results should be interpreted cautiously. IOUS should be considered an important supportive tool for maximal safe resection, especially in deep-seated or structurally heterogeneous glial tumors.

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აბსტრაქტი.

შესავალი: გლიური სიმსივნეები ცენტრალური ნერვული სისტემის სიმსივნეების მნიშვნელოვან ნაწილს წარმოადგენს. მათი მკურნალობა მოიცავს ქირურგიას, საჭიროების შემთხვევაში კი სხივურ და/ან ქიმიოთერაპიას. ინტრაოპერაციული ულტრაბგერა (IOUS) ნეიროქირურგს რეალურ დროში აწვდის ინფორმაციას სიმსივნის ლოკალიზაციისა და მიმდებარე ქსოვილებთან ურთიერთობის შესახებ.

მიზანი: კვლევის მიზანი იყო IOUS-ის როლის შეფასება გლიური სიმსივნეების ქირურგიულ მკურნალობაში, განსაკუთრებით რეზიდუალური სიმსივნის, პოსტოპერაციული შეშუპებისა და ნევროლოგიური შედეგების თვალსაზრისით.

მეთოდები: კვლევა მოიცავდა 35 პაციენტს, რომლებსაც 2020-2026 წლებში ჩაუტარდათ ოპერაცია ჰისტოლოგიურად დადასტურებული გლიური სიმსივნის გამო. 20 პაციენტი ოპერირებული იყო IOUS-ის გამოყენებით, 15 კი IOUS-ის გარეშე. საკონტროლო CT ჩატარდა მეორე პოსტოპერაციულ დღეს, ხოლო კონტრასტული MRI - მოგვიანებით, ოპერაციიდან 21 დღიდან 1 თვემდე პერიოდში. KPS/mRS სტანდარტიზებული ქულები არ იყო დაფიქსირებული.

შედეგები: მაღაი ხარისხის სიმსივნე დაიქსირდა 25 პაციენტში, დაბალი ხარისხის - 10 პაციენტში. რეზიდალური სიმსივნე გამოვლინდა ლ გუფგაუმჯობესდა 12 პაციენტში, უცვლელი დარჩა 7-ში და გაუარესდა 1-ში; IOUS-ის გარეშე ჯგუფში გაუმჯობესდა 1 პაციენტში, უცვლელი დარჩა 13-ში და გაუარესდა 1-ში. პოსტოპერაციული შეშუპება მთლიან კოჰორტაში გაიზარდა 2 შემთხვევაში, უცვლელი დარჩა 22 შემთხვევაში და შემცირდა 11 შემთხვევაში.

დასკვნა: IOUS წარმოადგენს მნიშვნელოვან დამხმარე ინსტრუმენტს გლიური სიმსივნეების ქირურგიაში. იგი შეიძლება დაეხმაროს სიმსივნის უფრო ზუსტ ლოკალიზაციას, მაქსიმალურად უსაფრთხო რეზექციას და ნევროლოგიური ფუნქციის შენარჩუნებას, თუმცა შედეგების საბოლოო შეფასებისთვის საჭიროა პროსპექტული კვლევა ადრეული პოსტოპერაციული MRI-ით და სტანდარტიზებული ნევროლოგიური სკალებით.

Аннотация.

Введение: Глиальные опухоли составляют значительную часть опухолей центральной нервной системы. Лечение включает хирургическое вмешательство, а при необходимости лучевую и/или химиотерапию. Интраоперационное ультразвуковое исследование (IOUS) предоставляет хирургу информацию в реальном времени о локализации опухоли и ее отношении к окружающим тканям.

Цель: Целью исследования была оценка роли IOUS в хирургическом лечении глиальных опухолей, особенно в отношении резидуальной опухоли, послеоперационного отека и неврологического исхода.

Материалы и методы: В исследование вошли 35 пациентов, оперированных в 2020-2026 гг. по поводу гистологически подтвержденных глиальных опухолей. У 20 пациентов операция проводилась с использованием IOUS, у 15 - без IOUS. Контрольная КТ выполнялась на вторые сутки после операции, а контрастная МРТ - позднее, через 21 день - 1 месяц после операции. Стандартизированные шкалы KPS/mRS в исходной базе данных не фиксировались.

Результаты: Высокозлокачественные опухоли были выявлены у 25 пациентов, низкозлокачественные - у 10 пациентов. Резидуальная опухоль определялась у 7/20 пациентов в группе IOUS и у 9/15 пациентов в группе без IOUS. В группе IOUS неврологический статус улучшился у 12 пациентов, остался без изменений у 7 и ухудшился у 1; в группе без IOUS улучшение отмечено у 1 пациента, отсутствие изменений у 13 и ухудшение у 1. В общей когорте послеоперационный отек увеличился в 2 случаях, остался без изменений в 22 и уменьшился в 11 случаях.

Заключение: IOUS является полезным вспомогательным методом при хирургии глиальных опухолей. Он может способствовать более точной локализации опухоли, максимально безопасной резекции и сохранению неврологической функции. Однако для окончательной оценки необходимы проспективные исследования с ранней послеоперационной МРТ и стандартизированными неврологическими шкалами.