Burdenko's Journal of Neurosurgery
2024, №1, pp. 39-47
https://doi.org/10.17116/neiro20248801139

Surgical treatment of focal drug-resistant epilepsy associated with temporal lobe encephalocele

© N.A. KALYBAEVA[1], A.V. DIMERTSEV[3], M.V. MAZALOVA[1], A.K. KUZOVKINA[1], G.E. ALTUNINA[1], M.A. ODENIYAZOVA[3], A.S. BALATSKAYA[3], N.P. UTYASHEV[3], V.G. BYCHENKO[2], O.YU. BRONOV[3], N.V. PEDYASH[3], M.YU. ZEMLYANSKY[1, 3], D.N. KOPACHEV[1, 4], A.A. ZUEV[3], A.L. GOLOVTEEV[1]

[1]Epilepsy Center, Moscow, Russia;
[2]Kulakov National Medical Research Center for Obstetrics, Gynecology and Perinatology, Moscow, Russia;
[3]Pirogov National Medical Surgical Center, Moscow, Russia;
[4]Neurology Research Center, Moscow, Russia

ABSTRACT

Background. In recent years, temporal lobe encephalocele has become more common in patients with focal drug-resistant epilepsy. Despite available experience, there are still no clear recommendations for choosing the extent of surgery in these patients.

Objective. To evaluate the effectiveness of diagnosis and surgical treatment of focal drug-resistant epilepsy associated with temporal lobe encephalocele.

Material and methods. The study included 21 patients with focal temporal lobe epilepsy and temporal lobe encephalocele. All patients underwent continuous video-EEG monitoring and MRI of the brain. There were 12 (57.4%) selective encephalocele resections and 9 (42.6%) anterior temporal lobectomies. The median follow-up period was 31 months.

Results. The overall effectiveness of surgical treatment with postoperative Engel class I was 76% (16 cases). Selective encephalocele resection was followed by postoperative Engel class I in 10 patients (83%). There were 6 (67%) patients with similar outcomes after temporal lobectomy. Mean volume of resected tissue adjacent to encephalocele was 8.3 cm^3.

Conclusion. Surgery is a highly effective treatment for patients with epileptic seizures following temporal lobe encephalocele. In our sample, favorable postoperative outcomes were achieved in 76% of patients (Engel class I). There were no significant differences in effectiveness between selective resection and temporal lobectomy. Further research is necessary for a clear protocol of surgical treatment of focal drug-resistant epilepsy associated with encephalocele.

Keywords: *encephalocele, epilepsy, epilepsy surgery.*

INFORMATION ABOUT THE AUTHORS:
Kalybaeva N.A. — https://orcid.org/0000-0002-2899-0734
Dimertsev A.V. — https://orcid.org/0000-0003-4578-2205
Mazalova M.V. — https://orcid.org/0009-0007-9689-3139
Kuzovkina A.K. — https://orcid.org/0009-0007-1323-696X
Altunina G.E. — https://orcid.org/0009-0003-1380-4649
Odeniyazova M.A. — https://orcid.org/0000-0003-0506-003X
Balatskaya A.S. — https://orcid.org/0000-0002-8710-6742
Utyashev N.P. — https://orcid.org/0000-0002-0770-2983
Bychenko V.G. — https://orcid.org/0000-0002-1459-4124
Bronov O.Yu. — https://orcid.org/0000-0002-2784-302X
Pedyash N.V. — https://orcid.org/0000-0002-2713-5904
Zemlyansky M.Yu. — https://orcid.org/0009-0000-6671-9067
Kopachev D.N. — https://orcid.org/0000-0002-5501-9062
Zuev A.A. — https://orcid.org/0000-0003-2974-1462
Golovteev A.L. — https://orcid.org/0000-0001-6468-5350
Corresponding author: Dimertsev A.V. — e-mail: dimertsev@gmail.com

TO CITE THIS ARTICLE:
Kalybaeva NA, Dimertsev AV, Mazalova MV, Kuzovkina AK, Altunina GE, Odeniyazova MA, Balatskaya AS, Utyashev NP, Bychenko VG, Bronov OYu, Pedyash NV, Zemlyansky MYu, Kopachev DN, Zuev AA, Golovteev AL. Surgical treatment of focal drug-resistant epilepsy associated with temporal lobe encephalocele. *Burdenko's Journal of Neurosergery = Zhurnal voprosy neirokhirurgii imeni N.N. Burdenko*. 2024;88(1):39–47. (In Russ.). https://doi.org/10.17116/neiro20248801139

Abbreviations

FDRE — focal drug-resistant epilepsy
EC — encephalocele
TL — temporal lobectomy
VEM — video-EEG monitoring

Introduction

About 70 million people worldwide suffer from epilepsy. Its prevalence in developed countries is 43.4—67.8 people per 100,000. Drug-resistant epilepsy comprises 30—40% of these cases [1]. Different data on drug-resistant epilepsy are due to insufficient epidemiological data in regions with low socio-economic development and incorrect criteria of drug resistance [2]. It is known that focal epilepsy (focal drug-resistant epilepsy) prevails, and temporal forms are the leading abnormalities. With development of neuroimaging technologies and accumulation of surgical experience, surgeon knew that such a complex anomaly as encephalocele (EC) may be a structural basis for temporal lobe epilepsy. Temporal encephalocele is most often detected at the base of the middle cranial fossa (up to 99%), and incidence of encephalocele in frontal, parietal or occipital lobes does not exceed 1% [3]. The cause of EC is not completely clear. According to literature data, most of them are congenital and arise due to incomplete closure of neural tube or ectopic location of meningeal membrane at the fetal stage [4]. The role of local inflammation, tumors, idiopathic intracranial hypertension, consequences of trauma and previous surgical interventions is discussed in pathogenesis of EC [5—7].

ECs are usually asymptomatic. CSF fistulas, conductive hearing loss, recurrent meningitis, intracranial abscess and drug-resistant epilepsy are possible in some cases [8]. The mechanism of seizures appears to be mechanical irritation, traction, secondary gliosis or dysplasia of adjacent cerebral cortex [9].

ECs may be unilateral and bilateral (up to 18%), while both unilateral and bilateral ECs can be epileptogenic [10]. Diagnosis and treatment of epilepsy associated with temporal encephalocele depend on effectiveness of antiepileptic therapy. Most authors recommend resection for temporal FDRE, and extent of surgery can vary from local resection of EC to anteromedial temporal lobectomy [11, 12]. Despite available experience, there are still no clear recommendations for extent of surgery in these patients.

The purpose of the study was to evaluate the effectiveness of diagnosis and surgical treatment of focal drug-resistant epilepsy associated with temporal lobe encephalocele.

Material and methods

There were 21 patients with FDRE associated with EC of temporal lobe pole between October 2015 and April 2022. The study group included patients with drug resistance. Age of patients ranged from 19 to 59 years (median 31; IQR 9). There were 12 (57%) men. Median age at onset of seizures was 21 years (IQR 17). Median period between onset of attacks and identification of EC as the cause of attacks was 14 years (IQR 12).

To verify the cause of attacks, we performed video electroencephalographic (EEG) monitoring (VEM) and magnetic resonance imaging (MRI) of the brain in all patients.

VEM was performed on 32-channel systems (sampling frequency 256 Hz, filters 0.1—70 Hz). Recordings were made on cup electrodes installed according to the international 10—20 system with additional electrodes on zygomatic arch. Duration of examination ranged from 12 to 240 hours. We analyzed semiotics of seizures, interictal and ictal epileptiform activity. There were 1—3 attacks in 16 out of 21 (76%) patients.

All patients underwent MRI according to a specialized protocol (the International League against Epilepsy guidelines).

Patients with signs of mesial temporal lobe epilepsy were excluded. We analyzed EC dimensions considering axial T2WIs of the brain, as well as the largest anteroposterior and lateral dimensions of bone defect in mutually perpendicular planes.

If MRI capabilities were insufficient, computed tomography (CT) of the brain was additionally performed (n=9; 43%). In these cases, we assessed EC dimensions according to these data **(fig. 1)**.

In addition, we performed PET/CT with [18F]-fluorodeoxyglucose ([18F]-FDG) in 6 (28.6%) patients and stereo-electroencephalographic monitoring (stereo-EEG) in 1 (4.8%) patient.

Patients underwent 2 surgical treatments (selective resection of EC and anteromedial temporal lobectomy and amygdalohippocampectomy according to standard protocols [Surgical Techniques for the Treatment of Temporal Lobe Epilepsy Faisal Al-Otaibi]). Resection of dominant temporal lobe was performed with intraoperative awakening and linguistic testing, and resection of neocortex was performed with preservation of appropriate speech zones.

Statistical analysis was carried out using the jamovi project software (2021, version 1.6). Distribution of quantitative variables was tested using the Shapiro—Wilk test. Differences between two independent samples were analyzed using the Mann—Whitney test and Student's t test. We used the χ^2 test for analysis of three or more groups with subsequent assessment of critical value. Results are presented as mean ± standard deviation and probability ratio with 95% confidence interval. The null hypothesis was rejected at p-value <0.05.

Results

When analyzing the semiotics of attacks, we found vegetative and cognitive attacks with feeling of deja vu, fear, heat and ascending sensation in the chest in 14 (67%) pa-

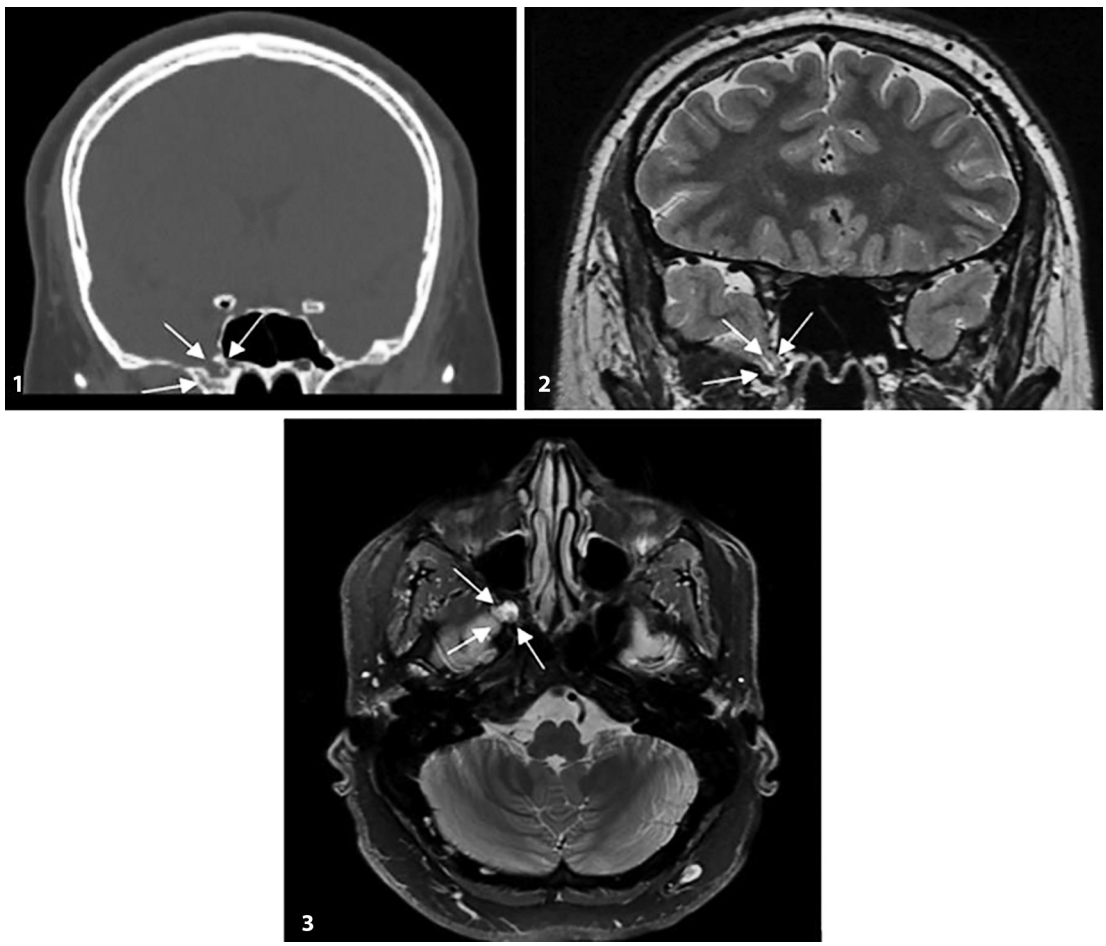


Fig. 1. **Neuroimaging data in a patient with encephalocele (arrows) of the right temporal lobe. Brain tissue signal intensity differs from intact areas.**
1 — frontal CT scan, multiplanar reconstruction; 2 — oblique frontal T2WI; 3 — axial T2WI.

tients. In 2 (9.5%) cases, attacks were accompanied by ictal speech; motor aphasia occurred in 16% of cases. Opercular and/or bimanual automatisms were noted in 16 (76%) patients. Ipsilateral manipulative automatisms were found in 14 (19%) cases. In 16 (76%) patients, focal seizures tended to develop into uni- or bilateral tonic-clonic seizures.

According to interictal VEM data, unilateral regional epileptiform activity was recorded in 15 (71%) patients, bilateral activity — in 6 (29%) cases. Ictal pattern began regionally in 7 (33%) patients, diffusely or in both frontal lobes with regional accent — in 5 (24%) patients **(fig. 2, 3)**. There was no ictal pattern in 5 (24%) cases. No seizures were recorded in 4 (19%) patients.

ECs were diagnosed at primary MRI in 4 (19%) patients, after the second examination — in 6 (28.6%) cases, after the third MRI — in 8 (38%) cases, after the fourth examination — in 3 (14.4%) cases.

EC dimensions: width 3.55—15.56 mm (median 7.34 mm), length 4.33—20.1 mm (median 8.71 mm).

Twelve (57.4%) patients underwent selective resection of EC, 9 (42.6%) ones underwent standard temporal lobectomy. The follow-up period ranged from 8.5 to 68 months (median 31 months; IQR 20). Engel outcomes in 21 patients depending on location and extent of resection (selective/lobectomy) are presented in **table 1**.

When comparing the effectiveness of selective resection of EC and temporal lobectomy, we found Engel outcome 1 in 10 (83.4%) out of 12 patients after selective resection. The same class was found in 66.7% (n=6) of patients after 9 temporal lobectomies **(table 2)**.

Statistical analysis found no influence of EC lateralization, age and gender of patients, age of onset of attacks and period between clinical manifestation and surgery/detection of EC on postoperative outcomes.

Discussion

Temporal lobe epilepsy comprises 65% of structural focal epilepsies [1]. According to literature data, temporal EC is detected in approximately 2—4% of patients with FDRE. Incidence of EC in temporal lobe epilepsy is up to 10% [2, 3].

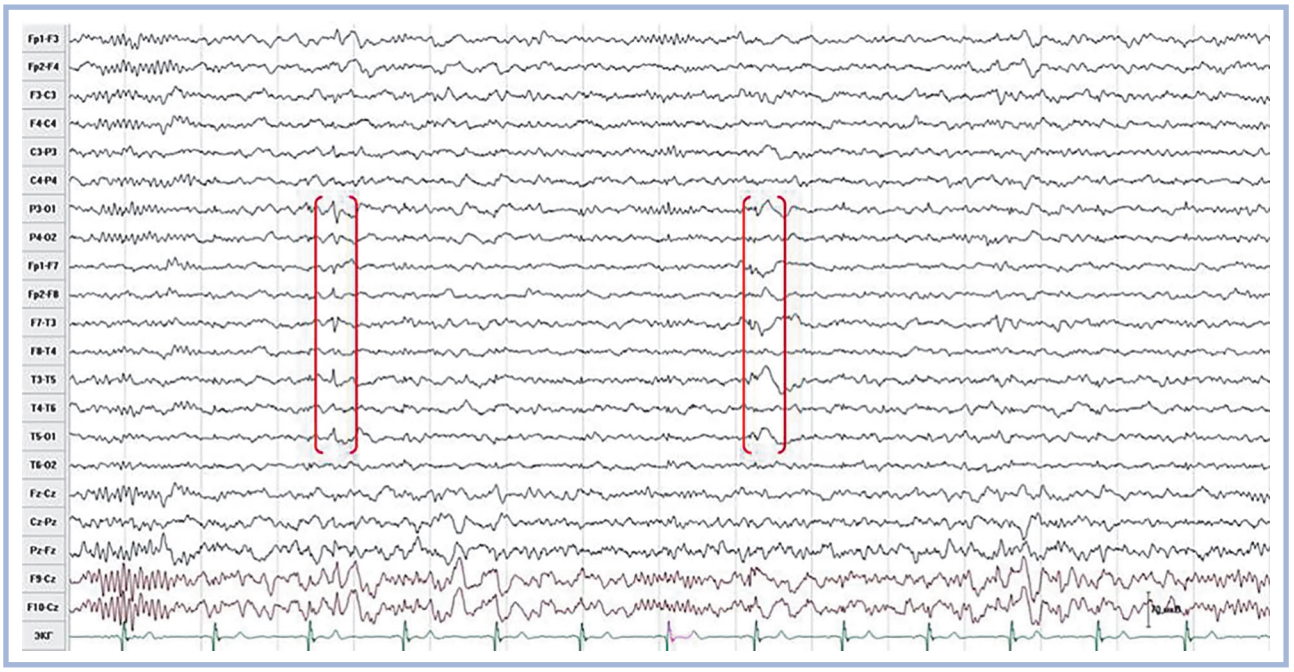


Fig. 2. **Sleep EEG in a patient with encephalocele of the left temporal lobe pole. Interictal regional epileptiform activity in the left temporal region (F7-T3-T5).**

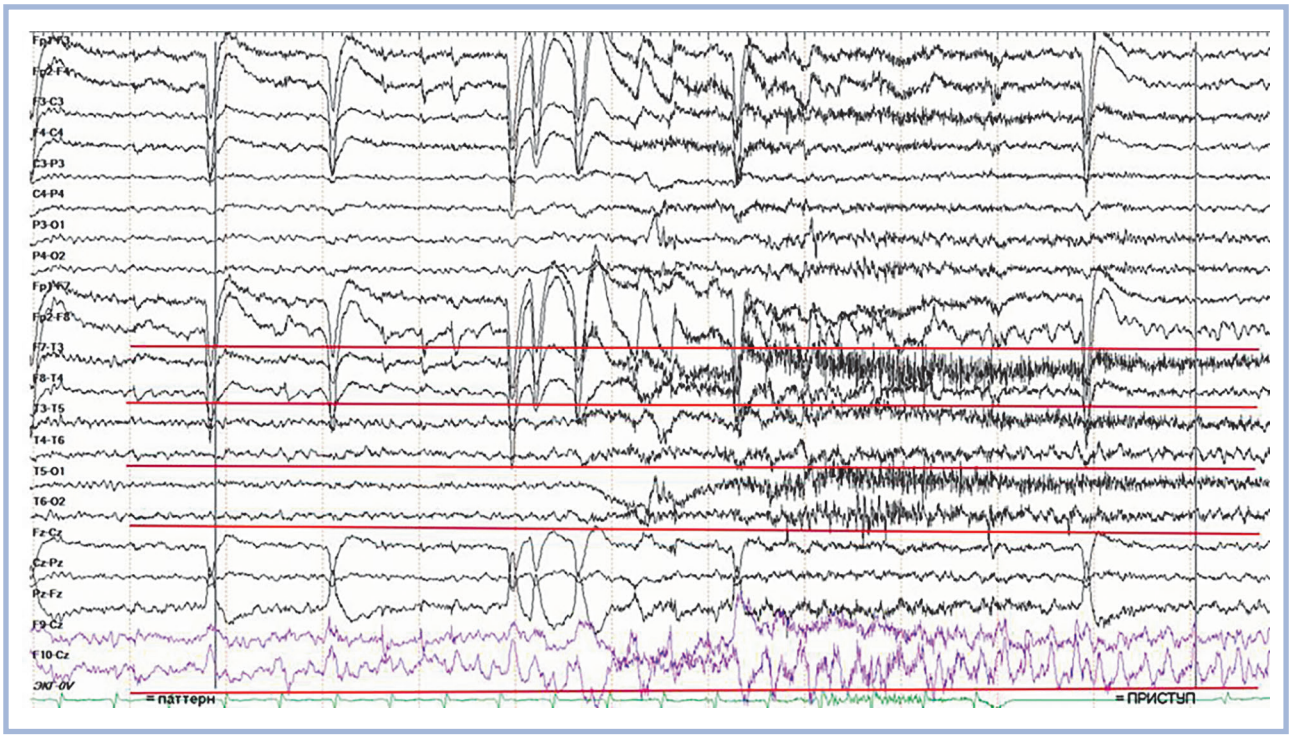


Fig. 3. **Waking EEG in a patient with encephalocele of the left temporal lobe pole.**
Ictal pattern in the right temporal region (T4-T6-F8-F10).

The onset of attacks in patients with EC occurs over the age of 30 years. One of the explanations for late clinical manifestations may be predominant acquired forms of EC over congenital ones [7, 13]. According to other authors, the most common type of EC is congenital form [14]. In our sample, the median onset of seizures was 21 years. There were no data on previous infection, trauma, surgery or other factors predisposing to EC.

Delayed verification of EC as the cause of attacks from the moment of their debut is 5—9 years [15]. In our study,

Table 1. **Postoperative outcomes depending on location of encephalocele and extent of surgery**

Side of encephalocele, *n* (%)		Surgery (selective/lobectomy), (%)	Engel class selective/lobectomy		
			I, *n* (%)	II, *n* (%)	IV, *n* (%)
Left	10 (47.6)	9/1 90/10	7/0 78/0	1/1 11/100	1/0 11/0
Right	9 (42.9)	2/7 22.2/77.8	2/5 100/71.4	— —	0/2 0/28.6
Bilateral	2 (9.5)	1/1 50/50	1/1 100/100	— —	— —
Total	21 (100)	12/9 57.1/42.9	10/6 83.4/66.7	1/1 8.3/11.1	1/2 8.3/22.2

Table 2. **Effectiveness of surgeries according to classification of postoperative outcomes**

Surgery	Engel class			*p*-value
	I	II	IV	
Selective resection of encephalocele, *n* (%)	10 (83.4)	1 (8.3)	1 (8.3)	0.630
Anterior temporal lobectomy, *n* (%)	6 (66.7)	1 (11.1)	2 (22.2)	

mean period between onset of attacks and detection of EC was 14 years. The causes of delayed diagnosis of EC may be small incidence of this malformation and no awareness of specialists.

In our sample, EC was diagnosed during primary MRI only in 19% of cases. Skull base CT is necessary to confirm bone defect in the middle cranial fossa [15]. M. Giulioni et al. [16] believe that CT is advisable in all patients with MR-negative drug-resistant temporal lobe epilepsy to exclude EC.

Our diagnostic algorithm consisted of primary high-resolution MRI of the brain. At the same time, 9 (43%) patients required CT to verify EC. As in other structural forms of epilepsy, we used PET-CT with 18-fluorodeoxyglucose in difficult diagnostic situations (6 (28.6%) patients). We have not found any studies on effectiveness of PET-CT in preoperative diagnosis of epilepsy in patients with temporal EC. Some authors described PET in cases of suspected temporal EC in focal forms of epilepsy [17]. R. Toledano et al. [18] revealed focal hypometabolism in 5 patients with suspected EC of temporal lobe poles using PET-CT.

In addition to neuroimaging, EEG is important in preoperative diagnosis of epilepsy [19]. In our work, 6 (29%) patients had regional discharges of epileptiform activity in both temporal lobes. Unilateral epileptiform activity is associated with better outcomes. Nevertheless, bilateral EEG discharges are not a contraindication for surgical treatment [20]. In this case, recording ictal patterns allows one to clearly localize the area of primary excitation. When analyzing the semiotics of attacks, we found no pathognomonic signs for EC. Clinical picture of episodes does not differ from other forms of structural focal temporal lobe epilepsy that is consistent with other data [21]. Ascending epigastric sensation, de ja vu, oral and manual automatisms are the main symptoms to suspect involvement of temporal lobe.

An additional diagnostic option for assessing the seizure initiation zone may be stereo-EEG monitoring [22]. In our work, this method allowed us to localize the area of onset of attack and perform temporal lobectomy with Engel outcome I in 1 patient. The patient underwent bilateral implantation of 15 stereotactic electrodes in temporal lobes (2 on the right, 2 on the left), right frontal lobe (4) and right insula (7). We recorded 3 focal epileptic seizures. In all cases, ictal pattern was initiated under contacts of electrodes in medial parts of the right temporal lobe pole (7H1-7H2, 8H1-8H2) in the form of regional rhythmic gamma activity with subsequent peak waves, gradual evolution of pattern and subsequent (after 12 seconds) spread to other contacts of the same and other electrodes **(fig. 4)**.

Most studies devoted to EC have demonstrated high effectiveness of surgical treatment of epilepsy [23]. Extent of resection is the main issue in surgical treatment of patients with FDRE associated with EC. Some authors believe that temporal lobectomy is the most effective method with the highest freedom from seizures [24]. According to their data, local epileptic network can involve neighboring structures including the hippocampus that makes temporal lobectomy more preferable. Despite certain effectiveness, temporal lobectomy is associated with deterioration of verbal memory, mental disorders and upper quadrant hemianopia. Another approach is selective resection of EC together with excision of adjacent brain matter and meninges. This approach is determined by gliotic changes, laminar disorganization, heterotopia or dysplasia in cortical areas surrounding the EC [24]. Some large studies confirmed the effectiveness of selective resection of EC. According to these authors, this surgery not only allows for good outcomes, but also makes it possible to avoid potential cognitive deficits [24].

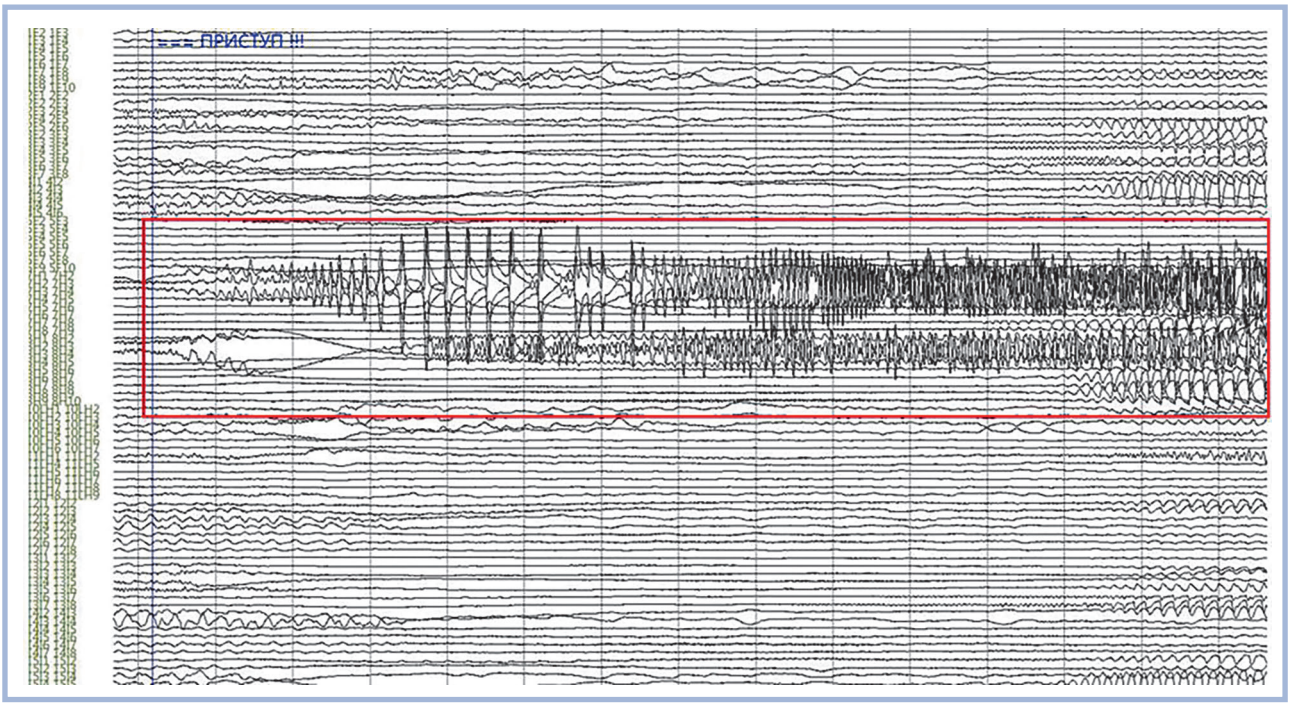


Fig. 4. **Stereo-EEG monitoring in a patient with encephalocele of both temporal lobes and focal cortical dysplasia in the right frontal lobe.**
The red line highlights data from electrodes in medial parts of the right temporal lobe (7N1-7H2, 8N1-8N2).

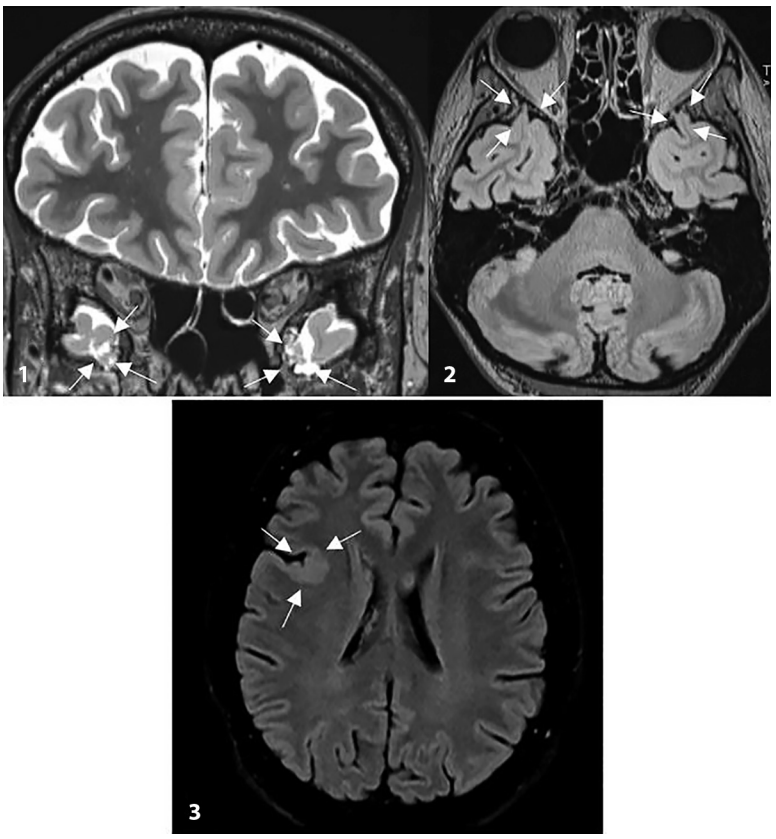


Fig. 5. **MRI in a patient with encephalocele of the right and left temporal lobes and focal cortical dysplasia type IIa of the right frontal lobe.**
1 — T2WI in oblique frontal plane; encephalocele in both temporal lobes (arrows); 2 — axial FLAIR image; encephalocele in both temporal lobes (arrows); 3 — axial FLAIR image; focal cortical dysplasia type IIa of the right frontal lobe between the triangular and opercular gyri (arrows).

Ineffective selective resection in some cases may be due to widespread changes in surrounding tissues and extensive epileptic network. Coincidence of clinical, electrophysiological and imaging data clearly indicating localization of epileptogenic focus can contribute to isolated resection of EC [24]. Thus, each case is individual and requires comprehensive consideration. We found no significant difference in outcomes depending on surgery that coincides with literature data [22, 21]. However, these cohort retrospective studies and similar our trial with small sample do not allow us to obtain comprehensive recommendations on preferable surgical treatment. Currently, various authors often use the argument that temporal lobectomy may be performed at the second stage after ineffective selective resection [24]. However, further researches are necessary to create a unified treatment algorithm.

In our study, the effectiveness of all surgeries (Engel outcome I) was 76%. Selective resection of EC in 12 cases resulted outcome I in 83% of cases (n=10) while anterior temporal lobectomy in 9 patients was followed by outcome I in 67% of patients (n=6). Extent of surgery insignificantly influenced postoperative outcomes. Mean volume of tissue adjacent to EC and subjected to selective resection was 8.3 cm^3. J.H. Faulkner et al. [12] reviewed 14 patients with temporal EC. Effectiveness of temporal lobectomy and selective surgery was similar.

ECs are often bilateral and require a special approach to diagnosis and treatment. Bilateral ECs are not a contraindication for surgical treatment (including unilateral selective resection). Some ECs are asymptomatic and do not participate in epileptic seizures [21]. E. Paule et al. [25] reported postoperative regression of seizures in 2 patients with bilateral EC. In our sample, 2 patients with bilateral malformation underwent selective unilateral resection. Of these, 1 patient had focal cortical dysplasia in addition to bilateral EC according to MRI data **(fig. 5)**.

Conclusion

Temporal encephalocele can cause focal epilepsy. Resection is the most effective method for EC. In our sample, favorable postoperative outcomes were observed in 69% of patients. Of these, selective resection was performed in 57.4%, temporal lobectomy — in 42.6% of cases. No significant effect of extent of surgery on postoperative outcomes was obtained. At the same time, these results may be due to small sample and heterogeneous groups regarding onset of disease, side of EC, age of onset of attacks and period between clinical manifestation and surgery.

Currently, examination of patients with structural epilepsy caused by temporal lobe EC is ongoing. The purpose of the study is a clear protocol for surgical treatment of patients with focal drug-resistant epilepsy associated with temporal lobe encephalocele.

No conflict of interests to declare.

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Received 19.06.2023
Accepted 17.11.2023

COMMENT

Symptoms of skull base defects and encephalocele in the middle cranial fossa vary from predominantly otiatric with conductive hearing loss to neurosurgical ones (CSF leakage and recurrent meningitis).

The authors address another little-known neurosurgical aspect in people with menigoencephalocele, i.e. diagnosis, clinical presentation and surgical treatment of epilepsy. This sometimes occurs in patients with menigoencephalocele in the medial middle cranial fossa. In recent years, this abnormality has become more known as an anatomical substrate of focal temporal lobe epilepsy thanks to widespread MRI protocol for epilepsy and awareness of neurosurgeons and radiologists.

The authors analyze 21 patients with meningoencephalocele of the middle cranial fossa and temporal lobe epilepsy. In 12 cases, the authors performed selective excision of temporal lobe pole hernia with small fragment of adjacent cortex (<9 cm^3) considering electro-clinical characteristics of seizures, neuroimaging data and side of lesion. Nine ones underwent standard anterior temporal lobectomy. The median follow-up period was more than 2.5 years, and Engel outcome I was achieved in 76% of cases. Interestingly, patients after selective cortectomy were somewhat more fortunate than patients after temporal lobectomy (83 versus 67% with cessation of attacks and remission).

The authors discuss etiology and influence of demographic factors on epilepsy and drug resistance, diagnostic methods and lateralization of epileptic focus. They also described a patient with focal cortical dysplasia in addition to encephalocele, but no information about morphology is presented. This is unfortunate, because epileptogenesis and gliotic changes presented as anatomical substrates of epilepsy associated with meningoencephalocele are discussed only with reference to literature data.

However, this report is interesting and informative. Sample size is one of the largest available in the literature. The authors do not clearly answer the question about optimal extent of resection. Nevertheless, the interested reader will find certain useful information and facts, especially valuable for treatment of some so-called MRI-negative patients with temporal lobe epilepsy.

A.G. Melikyan (Moscow)