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SURGICAL TECHNIQUES FOR TREATMENT AND PREVENTION OF ENTRAPPED TEMPORAL HORN AFTER RESECTION OF TRIGONE VENTRICULAR TUMORS

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Aim. To analyze the effectiveness of treatment and prevention of entrapped temporal horn (ETH) using various techniques.

Materials and methods. The study included 14 patients who underwent treatment or surgical prevention of ETH of the lateral ventricle after surgical resection of tumors in the projection of the trigone of the lateral ventricle. In 3 cases, microsurgical ventriculocisternostomy was performed; in 3 cases, shunting surgeries for ETH treatment; in 8 cases, ETH stenting.

Results. Tumor resection level, stenting effectiveness per presence/absence of hydrocephalus, and adequacy of the chosen ETH treatment and prevention methods were analyzed. In all 3 cases of ventriculocisternostomy, tumor resection was radical, stoma was strong, ETH opened, hydrocephalus was absent. In 3 patients with shunt implantation, radical resection was performed in 1 case; in 2 cases subtotal resection was achieved; shunt dysfunction due to tumor progression was observed in 1 patient during long-term follow-up. In 7 of 8 patients with cases of ventricular stent implantation for treatment/prevention of ETH, tumor resection was total; in 1 patient subtotal. Stenting performed in the postoperative period for treatment of hydrocephalus had positive clinical effect in 100 % of cases (non-focal neurological symptoms, stasis in the fundus, speech disorders regressed). In stenting for hydrocephalus prevention, a positive effect was also observed (no increase in the size of the ventricular system, shunting surgeries in the postoperative period were not required).

In the analyzed patient group ($n = 14$), *de novo* neurologic deficit did not develop, no cases of infectious complications and cerebrospinal fluid leak were observed, stent did not dysfunction.

Conclusion. Intraoperative ventriculocisternostomy is a reliable physiological technique for ETH prevention. Stenting of the ventricular system is an accessible and effective technique for ETH prevention. Single-step stenting after tumor resection allows to avoid this complication in the long-term and is not associated with surgical complications of distal stenting. The use of stenting surgeries has its advantages and disadvantages which makes this method acceptable but not universal. Implantation of shunt in the long-term period is the method of choice for ETH treatment.

Keywords: entrapped temporal horn, trigone ventricular tumors, ventriculocisternostomy, shunting surgeries, entrapped temporal horn stenting

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BACKGROUND

Microsurgical resection of trigone ventricular tumors can lead to development of a specific complication – entrapped temporal horn (ETH) [1]. This is a secondary complication and develops when the temporal horn is sealed off from the ventricular system after tumor resection. It is easy to see on postoperative computed tomography and/or magnetic resonance images [2].

Continuous secretion of cerebrospinal fluid from the choroid plexus in a relatively closed space leads to progressive enlargement of the temporal horn which, in turn, leads to temporal herniation and compression of the brainstem manifesting through depressed level of consciousness, hemiparesis, memory loss, loss of visual fields [3].

Literature data on ETH are limited and mostly include small case series or individual case descriptions, as well as proposals of approaches to surgical treatment [4–12]. Usually, ETH is manifested symptomatically, and its treatment requires surgical intervention. Cases of asymptomatic ETH with its spontaneous regression exist, therefore the incidence of this complications is hard to determine [1, 2].

According to literature data, there are no representative studies on incidence of this complication, no precise algorithm of management and treatment of such patients, no defined indications for surgical treatment. Nevertheless, literature contains reports on treatment approaches.

In this article, analysis of ETH treatment and ways of its prevention are presented. The proposed technique allows to avoid this complication and the necessity of its treatment in the long-term.

Aim of the study is to analyze the effectiveness of treatment and prevention of ETH using various techniques.

MATERIALS AND METHODS

Clinical data of patients. The study included 14 patients who underwent surgical treatment or surgical prevention of ETH of the lateral ventricle after surgical resection of tumors in the projection of the trigone of the lateral ventricle between 2020 and 2021.

Among 14 patients, in 3 cases microsurgical ventriculocisternostomy was performed; in 3 cases, shunting surgeries for ETH treatment; in 8 cases, ETH stenting after resection of lesions in the trigone of the lateral ventricle. In 4 patients, ETH stenting was performed intraoperatively (as complication prevention); in 4 patients, in the postoperative period in the first 3 months after resection of trigone ventricular tumor (due to development of monoventricular hydrocephalus). Patient data are presented in Table. 1.

Ventriculocisternostomy. Operation technique: amygdala area is gradually aspirated, and the interpeduncular cistern is opened. Additionally, the Liliequist membrane is dissected. This allows to visualize the basilar artery, nerve III on the left and right. In the interpeduncular cistern, adhesions are dissected, and the temporal horn is connected with the basal cisterns (Fig. 1).

Table 1. *Baseline characteristics for patients with entrapped temporal horn by groups with different types of treatment*

Characteristic	Stenting ($n = 8$)	Shunting ($n = 3$)	Cysterno-stomy ($n = 3$)
Average age (range), year	41 (28–63)	53 (43–68)	30 (24–35)
Sex, *n* (%):			
female	5 (62.5)	1 (33.3)	2 (66.7)
male	3 (37.5)	2 (66.7)	1 (33.3)
Clinical presentation, *n* (%):			
headache	8 (100)	2 (66)	1 (33)
increased intracranial pressure	3 (37.5)	0	1 (33)
decreased level of wakefulness	2 (25)	2 (66)	2 (66)
pyramidal symptoms	2 (25)	0	0
violation of visual fields	4 (50)	0	0
nausea, vomiting	5 (62.5)	2 (66)	1 (33)
episyndrome	2 (25)	0	0
unsteadiness	4 (50)	1 (33)	0
Histological type of tumor, *n* (%):			
high grade gliomas	4 (50)	2 (66)	2 (66)
neurocytoma	3 (37.5)	0	1 (33)
meningioma	1 (12.5)	1 (33)	0

ETH stenting. Technique of ventricular system stenting: after resection and good visualization of the main anatomical landmarks – entrance into the temporal horn, choroid plexus, and entrance into the ventricle – rostral end is implanted into the body of the ventricle 3–4 cm deep, and the distal part of the catheter is guided intro the temporal horn. Depending on obstruction level, stenting can be ipsilateral (connecting the anterior horn, foramen of Monro, and temporal horn) or contralateral (anterior horn – pellucid septum – temporal horn). At the end of the *Results*

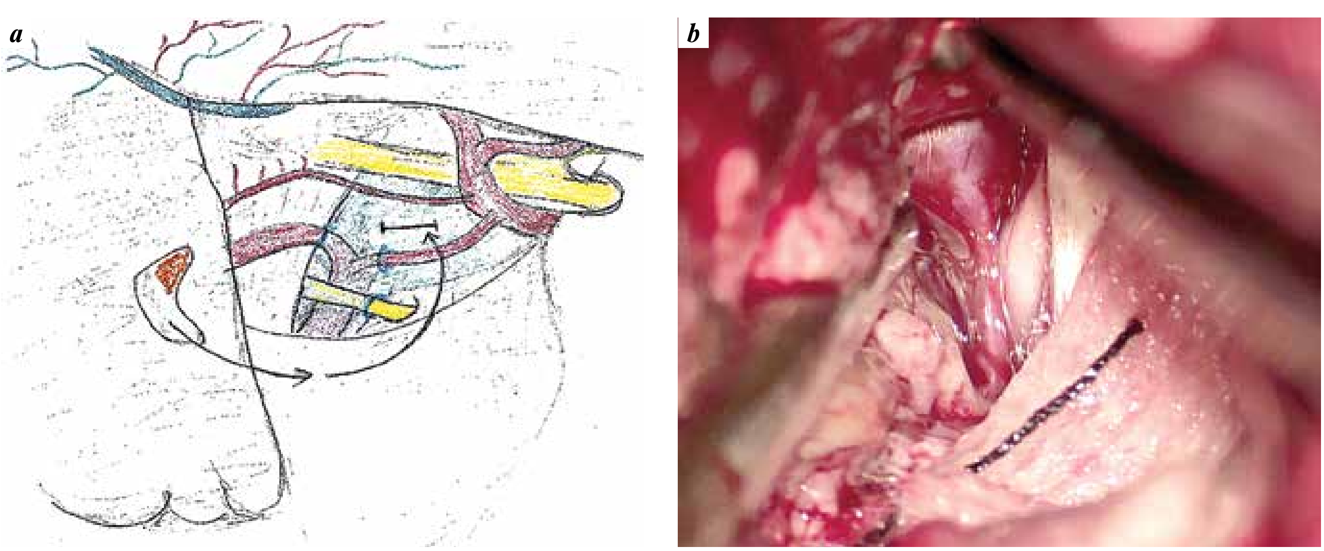

Fig. 1. *Ventriculocisternostomy stages: a – dissection of the Lilliquist membrane for ventriculocisternostomy (diagram); b – entrance into the pontomedullary cistern from the posterior connecting artery to the posterior cerebral artery (intraoperative photo)*

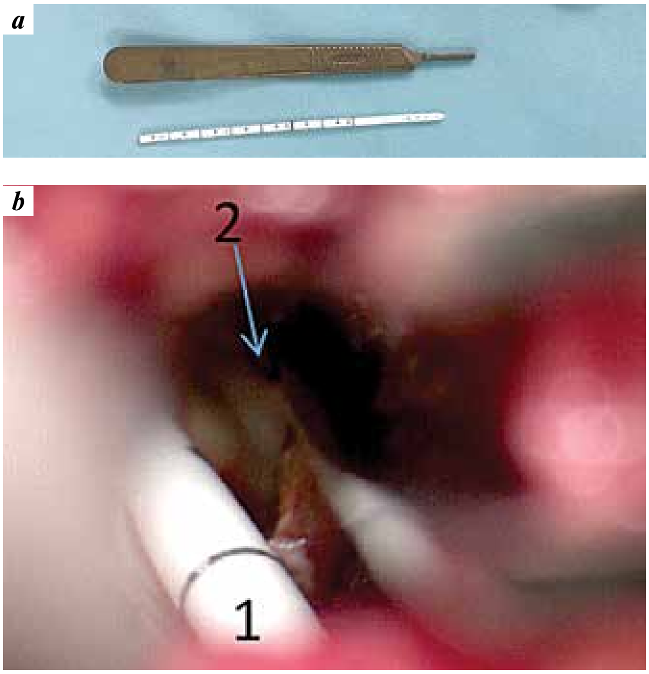

Fig. 2. *Ventricular stenting: a – ventricular catheter (photo); b – ventricular catheter (1) inserted into the slit-like lumen of the temporal horn (2) (intraoperative photo)*

section, a case of single-step resection of a ventricular tumor with stenting is presented (see Fig. 4 below).

For stenting, a ventricular catheter is used. The length is chosen individually based on neuroimaging and ventriculometry data. On average, ventricular catheter is 7–10 cm long. Additionally, at the ventral part of the catheter, a hole is made with surgical scissors. To lock it in the area of anatomical narrowing, a cuff is used cut from the ventricular catheter (Fig. 2).

Under microsurgical control, the surgeon lowers the stent to the desired depth connecting the ventricular system elements. In cases of stent instability, a cuff is made. The wound is irrigated with physiological solution multiple times, surgical gauze is used if necessary.

The main indications for preventative stenting of the temporal horn are diffuse infiltrative tumor growth, gross infiltration of the ependyma at the trigone, residual tumor.

Stenting in the long-term postoperative period is associated with certain difficulties. Changed anatomy, scarring process, and postoperative ependyma changes complicated the search for the entrance into the temporal horn and lateral ventricle. Therefore, for selection of stoma formation and stenting trajectory, detailed study of magnetic resonance imaging (MRI) data with perioperative planning are necessary. As supportive techniques, ultrasound and electromagnetic navigation can be used intraoperatively.

RESULTS

The following parameters were evaluated in the analyzed group: tumor resection level, stenting effectiveness per presence/absence of hydrocephalus during follow-up period, and adequacy of the selected ETH treatment and prevention method. Treatment results are presented in Table 2.

Ventriculocisternostomy for ETH treatment and prevention. In all 3 (100 %) cases, resection was radical, stoma was strong. ETH was opened, no hydrocephalus was observed.

Shunting surgery for ETH treatment. Among 3 patients who underwent stent implantation, radical resection was achieved only in 1 case; in 2 other cases tumor resection was subtotal.

In 1 case, stent dysfunction developed in the long-term due to tumor progression and penetration of the ventricular catheter by the tumor 2 months after ventriculoperitoneal shunt implantation (Fig. 3).

Control MRI 2 months later showed significant negative dynamics: tumor recurrence with growth into the ventricular catheter area which, in turn, led to hydrocephalus progression. Considering continued tumor growth and hydrocephalus progression, repeat surgical intervention was performed: microsurgical resection of occipital lobe glioblastoma recurrence with simultaneous ETH stenting.

Implantation of ventricular stent for ETH treatment and prevention after resection of trigone ventricular tumor. In 7 of 8 cases, resection was total. In 1 case, resection was subtotal. In all cases, the effectiveness of stenting was evaluated in the early postoperative period, during control MRI exam 3–6 months later, and during the follow-up exam. Stenting was considered effective if in the postoperative period clinical symptoms regressed, hydrocephalus did not progress, and shunting surgeries were not necessary. Stenting in the postoperative period (to treat

Table 2. *Results of treatment and prevention of entrapped temporal horn*

Parameter	Stenting (*n* = 8)	Shunting (*n* = 3)	Cysternostomy (*n* = 3)
Tumor resection, *n* (%): total resection (100 %) subtotal resection (90–95 %)	 7 (87.5) 1 (12.5)	 1 (33) 2 (66)	 0 3 (100)
Stenting effectiveness, *n* (%)	8 (100)	3 (100)	3 (100)
Operation selection algorithm	1st line of treatment	Inability to perform microsurgical stenting	Tumor in the temporal uncus

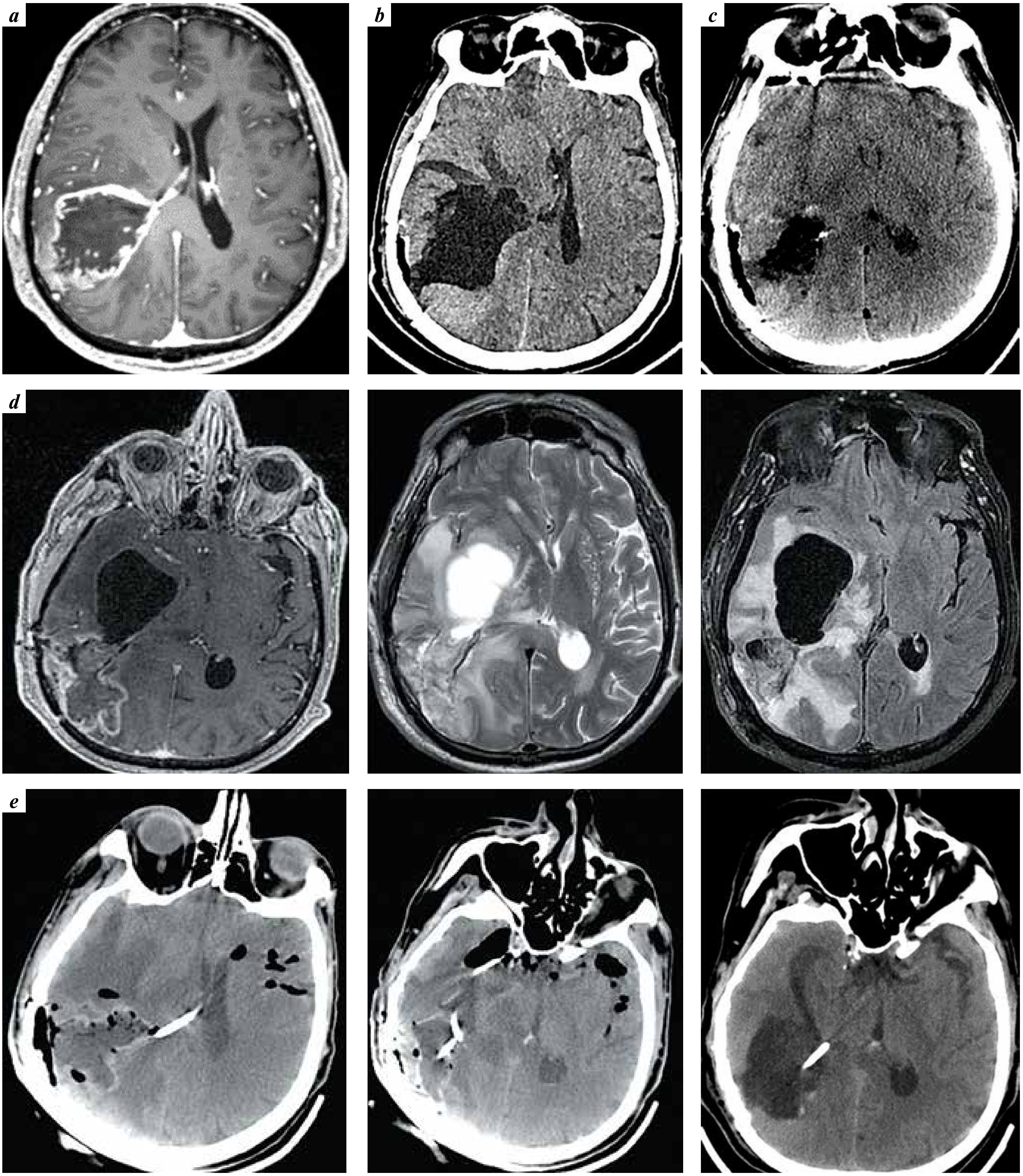

Fig. 3. *Magnetic resonance imaging (MRI) and computed tomography (CT) of the brain of a male patient who underwent shunting surgery: a – contrastenhanced MRI prior to surgery: tumor in the trigone area of the right lateral ventricle is visible; b – CT immediately after surgery: radical tumor resection and absence of surgical complications; c – CT 14 days after tumor resection: appearance of entrapped temporal horn is observed; d – MRI 1 month after surgery; e – CT after shunt implantation: ventricular end of the shunt is visualized in the projection of the entrapped temporal horn*

developed hydrocephalus) had positive clinical effect in 100 % of cases: non-focal neurological symptoms, stasis in the fundus, speech disorders regressed. In patients who underwent stenting to prevent hydrocephalus, positive effect was also observed: the size of the ventricular system did not increase, shunting surgeries were not necessary (Fig. 4).

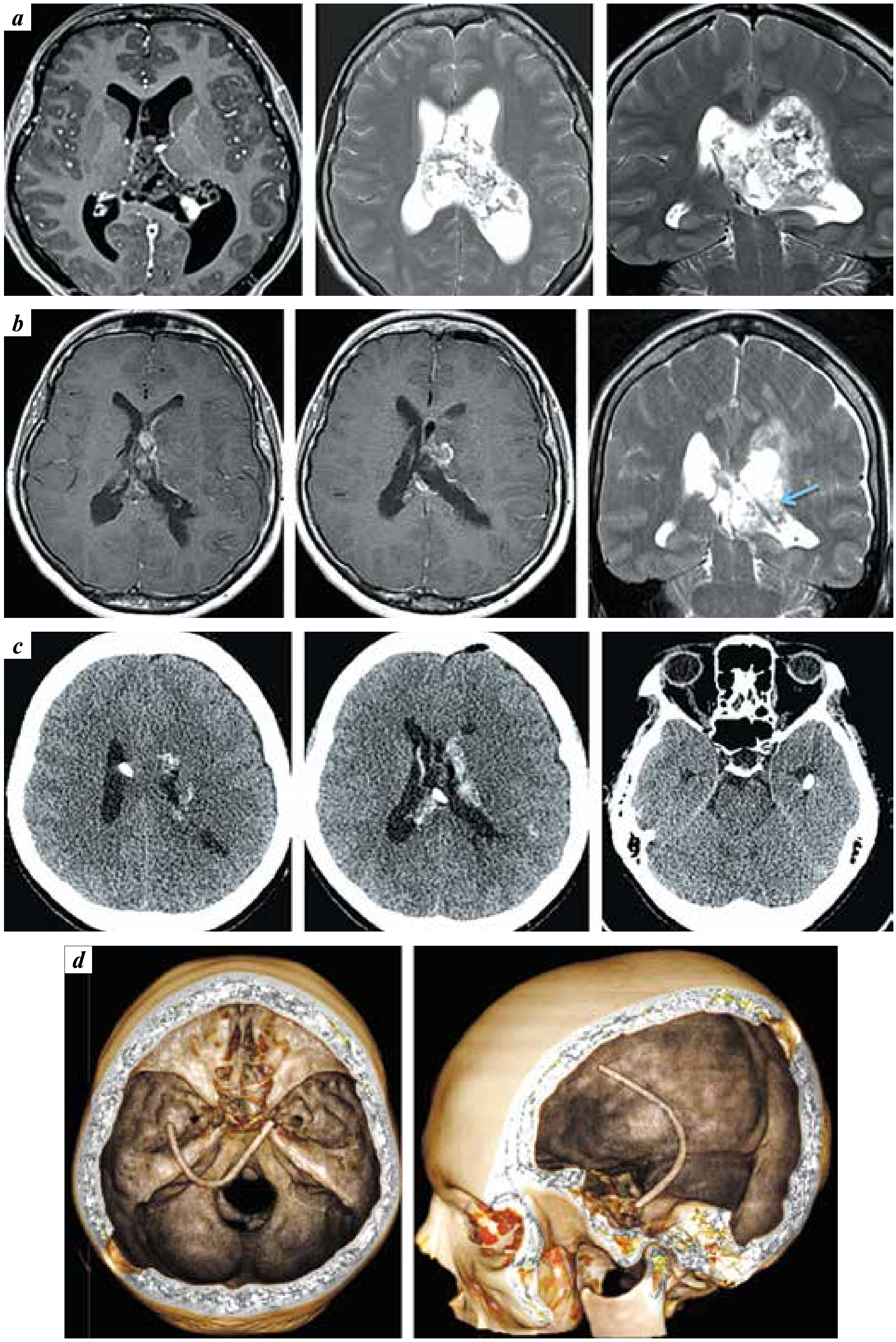

Fig. 4. *Examination data of a female patient who underwent resection of central neurocytoma of the left lateral ventricle with single-step stenting of the ventricular system: a – preoperative contrast-enhanced T1- and T2-weighted magnetic resonance images: hyperintense space-occupying lesion advancing into the pellucid septum, anterior horn, body and trigone of the left ventricle areas heterogeneously accumulating the contrast agent is visualized; b – postoperative contrast-enhanced T1-weighted magnetic resonance images: absence of residual tumor; in the trigone projection, ventricular catheter (arrow) is visualized; c, d – axial computed tomography images (c) and 3D reconstruction (d) show the location of ventricular catheter in the ventricular system*

Complications. In the analyzed group, *de novo* neurologic deficit did not develop, and there were no cases of infectious complications and cerebrospinal fluid leakage. Stent dysfunction was not observed in any of the cases. In 1 case after stent installation, stent instability developed due to continued tumor growth 2 months later with tumor

Table 3. *Advantages and disadvantages of different techniques of entrapped temporal horn (ETH) treatment*

Method of surgical treatment	Advantages	Disadvantages	Показания Indications
Ventriculoperitoneal shunting	• Regression of intracranial pressure • High effectiveness	• Dependence on the shunt • Complications: infections, hypo- and hyperdrainage • Possibility of advancement into the abdominal cavity in cases of malignant tumors	• Suitable for all cases
Frontotemporal stenting	• No risk of malignant cell dispersing outside the ventricle	• Impossible in narrow ventricles • Tumor growth can dislodge the stent	• Wide ventricular system, especially the anterior horn
Endoscopic fenestration	• No risk of malignant cell dispersion • Can be used in cases of ventriculitis	• Possibility of spontaneous stoma closure, especially after radiotherapy • Requires neuronavigation	• Suitable anatomy for the surgery • Requires biopsy
Endoscopic fenestration with stenting	• No risk of malignant cell dispersion • Stent provided additional stoma strength	• Risk of stent infection • Tumor growth can dislodge the stent • Risk of stent migration • Requires neuronavigation	• Favorable anatomy for the surgery • Requires biopsy
Microsurgical connection of the ETH with the ambiens cistern	• No risk of malignant cell dispersion	• More invasive procedure	• Alternative to endoscopy • Required biopsy
Microsurgical fenestration	• Restores cerebrospinal fluid dynamics between the ETH and lateral ventricle	• Risk of stoma closure	• Favorable anatomy for microsurgical fenestration of the wall between the ETH and the ventricular system

penetration into the ventricular catheter which led to hydrocephalus progression (see Fig. 3).

DISCUSSION

Partial isolated enlargement of the lateral ventricle is a special form of obstructive hydrocephalus which causes enlargement of the temporal horn, occipital horn, and trigone. The first description of ETH was presented by Cairns and Daniel in 1947. According to Y. Wang et al., ETH develops in 19 % of cases of trigone ventricular tumor resection [1].

According to literature data, in 68.4 % patients ETH is a late complication (mean time between tumor resection and ETH development is 4.4 months, range is 1–10 months) [1]. Late ETH development can be caused by slow nature of obstruction and decreased production of cerebrospinal fluid from the choroid plexus after its coagulation during tumor resection from the trigone [6, 7]. Therefore, patients who had successful resection of trigone ventricular tumors, must be followed-up for a long time. In cases when discharged patient demonstrates new neurologic deficit or impairment, immediate computed tomography or MRI are necessary to find the cause of focal symptoms. If diagnosis of late postoperative ETH is confirmed, the patient should be carefully monitored, and in many cases repeat surgical intervention is necessary.

Currently, there is no universal technique for treatment of this complication [1, 8]. All methods of EHT surgical treatment can be divided into 3 groups:

- shunting surgeries;
- surgeries creating additional communication between the elements of the ventricular system (stoma formation);
- stenting surgeries (stent installation into the stoma).

The most common are shunting surgeries. Various techniques of ETH shunting have been described: single-step shunting of the frontal and temporal horns [9] and shunting of the temporal horn into the prepontine cistern [10]. In temporal-to-frontal horn shunt, 2 ventricular catheters are installed: in the frontal horn at first (usually, from the Kocher point), then into the temporal horn (near the lower part of the temporal bone squama), and the catheters are attached through a connector to the cerebrospinal fluid pump [9]. Temporal horn-to-prepontine cistern shunt requires stereotactic navigation [10]. The use of these techniques is limited by the necessity of stereotactic navigation, absence of visual control, and possibility of hyperdrainage syndrome. Non-resorptive hydrocephalus is a valid advantage of shunting surgeries.

The aim of microsurgical connection of the temporal horn with the basal cisterns is creation of physiological stoma between the temporal horn and cerebrospinal fluid pathways. The undeniable advantage of this approach is the absence of implants. To create such stoma, the surgeon should have sufficient microsurgical experience. Cases of stoma dysfunction due to scarring process were described.

There is a large number of articles on endoscopic and microsurgical treatment of this complication. Enlarged ventricular system and good visualization of the neurovascular structures make microsurgery and videoendoscopy the most widely available and simple methods of surgical treatment of ETH. Usually, fenestration is used with neuronavigation to select the optimal perforation point. The point of the surgery is to dissect adhesions (most commonly located at the trigone) and restore normal flow of the cerebrospinal fluid [11]. Additionally, the literature present successful cases of neuroendoscopic temporal ventriculocisternostomy [12]. The ideal point of perforation was chosen in the area below the visual tract and anterior choroid artery and above nerve III and posterior communicating artery.

The described cases of ventricular system stenting (single-step after tumor resection or postoperative) demonstrate the possibility of reliable ETH prevention after resection of trigone ventricular tumors disturbing connection between the ventricular system chambers. The disadvantage of this method is the presence of a foreign body.

In every individual case, the operating surgeon should make the optimal decision on ETH treatment based on anatomical characteristics, ETH severity, edema, etc. Advantages and disadvantages of various ETH treatment methods are listed in Table 3.

CONCLUSION

Intraoperative single-step ventriculocisternostomy is a reliable method of physiological ETH prevention. To create stoma, the surgeon should have good manual microsurgical skills. Stenting of the ventricular system is a widely available and effective microsurgical method of ETH prevention. Single-step stenting allows to avoid this complication and repeat surgeries in the long-term and is not associated with surgical difficulties of late stenting.

The use of stenting surgeries has a number of significant advantages: operation and catheter implantation are fully performed under visual control of the surgeon, absence of syphon and valve mechanisms prevents hyperdraining and slit ventricle syndrome.

The obvious advantages and disadvantages (possibility of catheter infection, technical difficulty, high invasiveness of the procedure) make this method acceptable but not universal. Implantation of a shunting system in the long-term is the method of choice for ETH treatment. The absolute indication for the use of a shunting system is non-resorptive hydrocephalus. The effectiveness of shunting system is limited by its dysfunction.

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N.S. Grachev: data collection for analysis;
V.Yu. Zhukov: scientific editing;
D.I. Pitskhelauri: performing surgical operations.

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