Application of Endoport-Assisted Neuroendoscopic Techniques in Lateral Ventricular Tumor Surgery

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Research Article

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Abstract

Purpose

The aim of this study was to review the experience of Endoport-assisted neuroendoscopic surgery for lateral ventricular tumors resection, investigate the therapeutic efficiency and discuss the key points.

Methods

We retrospectively reviewed the clinical data of 16 patients suffering from lateral ventricular tumors. All the patients received Endoport-assisted neuroendoscopic surgery from January 2018 to June 2020 in the department of neurosurgery, Nanjing Drum Tower Hospital, the Affiliated Hospital of Nanjing University Medical School.

Results

All the patients received standardized treatment according to the preoperative image data and the postoperative pathology of the tumors. Endoport-assisted Neuroendoscopic surgery achieved complete removal of lateral ventricular tumors in 14 cases (87.5%) and subtotal removal in 2 cases (12.5%, glioma). The perioperative complications were analyzed, 1 acute epidural hematoma occurred during surgery, 1 hemiplegia and 2 obstructive hydrocephalus occurred after surgery. All the complications were managed timely. During the long-time follow up, the patient with glioblastoma died 16 months after surgery, the other patients are still alive with Glasgow outcome scales not less than 4.

Conclusion

Endoport-assisted neuroendoscopic surgery is suitable for the resection of lateral ventricular tumors. This procedure is simple, effective, minimally invasive, and associated with fast postoperative recovery.

Introduction

The lateral ventricle is a paired C-shaped structure that lies deep within the cerebral hemispheres, locating near the center of the brain. It is adjacent to many neural and vascular structures which play a vital role in body functions from basic maintenance of consciousness and internal environment stability to more refined memory, emotion and personal characteristics [1, 2]. Lateral ventricular tumors account for less than 1% of intracranial neoplasm and usually occurs in young adults. Most of lateral ventricular tumors are benign and growing slowly [3, 4]. If the tumors are diagnosed early and resected completely, a clinical cure may be achieved for patients. Therefore, while dealing with lateral ventricular tumors, neurosurgeons should make great effort to achieve both maximum resection of tumors and minimum injury of nerves and blood vessels [5]. With the development of the surgical techniques and the update of minimally invasive concept, endoport-assisted neuroendoscopic techniques has become an important method for the resection of lateral ventricular tumors [2, 6, 7]. Moreover, the popularization of neural navigation system and intraoperative electrophysiological monitoring can further help overcome a series of difficulties such as endoscopic hemostasis, protection of functional areas and nervous nuclei, so as to improve the efficacy of neuroendoscopy in the treatment of lateral ventricular tumors.

Materials And Methods

Clinical Data Collection

We performed a retrospective review of data from all patients who suffered from lateral ventricular tumors and finally underwent Endoport-assisted neuroendoscopic surgery from January 2018 to June 2020 in the department of neurosurgery at Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School. We reviewed medical records, imaging data, pathological report and operation video of each patient and collected the data regarding demographic information, initial symptom, tumor location, pathological diagnosis and whether complicated with preoperative hydrocephalus. Moreover, complications occurred during or after operation were also taken into consideration.

Surgical Equipments

All operations were performed using rigid Karl Storz neuroendoscopy with 0° or 30° optics, 150 mm length and 4 mm diameter (Karl Storz, Tuttlingen, Germany). Endoport (Karl Storz, Tuttlingen, Germany) consists of an outer sheath and an inner obturator, which is specially designed for subcortical or transcranial surgery, especially with great advantage in lateral ventricle surgery. Pneumatic holding arm (Karl Storz, Tuttlingen, Germany) was used to fix neuroendoscopy and snake holding arm (Karl Storz, Tuttlingen, Germany) was used to fix endoport. Conventional craniotomy instruments and neuroendoscopic auxiliary instruments were used for surgical procedures.

Surgical Techniques

Operative approaches for the frontal horns and the body of the lateral ventricle

The transfrontal transcortical approach is an excellent route to the frontal horns and bodies of the lateral ventricle, even anterior part of the third ventricle (Fig. 1). It is a suitable route for resection of tumors that are mainly limited in the frontal horns or the bodies of the lateral ventricle. The patient was placed in the supine position with the head slightly elevated. The head was turned 30° to the contralateral side and fixed with a 3-pin Mayfield head holder. Preoperative magnetic resonance imaging (MRI)-based neuronavigation was used to guide the anatomical localization. The insertion point for Endoport was approximately 3 cm from the midline and 1 cm in front of the coronal suture (Kochers point).

After routine disinfection, a linear incision of was made with the insertion point as the center. A craniotomy (approximately 3 cm diameter) was made above the middle frontal gyrus and the dura was opened with an arc-shaped incision. The ostomy through the middle frontal gyrus was made and inserted Endoport fixed by snake holding arm. Once an outflow of cerebrospinal fluid (CSF) is observed, the lateral ventricle is entered. Use tailed cotton strips to slowly release CSF and insert 0° neuroendoscopy into endoport, then fixed by pneumatic holding arm. The anatomical landmarks of the frontal horn and the body of the lateral ventricle can be identified gradually. Fully observe and carefully remove the tumors under neuroendoscopy. Ultrasonic dissector can be used to deal with tumors with hard texture. For larger tumors, intratumoral decompression was performed first to reduce the volume of tumor gradually. Adjusting the directions of endoport and the neuroendoscopy may be necessary to find the boundary of tumors, striving for complete removal of tumors. After the tumor is resected, bipolar coagulation and hemostatic materials were combined used to achieve thorough hemostasis. Care was taken to protect the surrounding brain tissue and vasculature especially the lateral wall of the lateral ventricle, where thalamus, caudate nucleus and other important nerve nuclei as well as the colliculus veins aggregate. Once damaged, the overall prognosis of patients will be greatly affected. Finally, based on the bleeding situation in the operative field, the decision whether to leave a drainage tube in the ventricle was made for every patient individually. After operation, close monitoring is essential for patients to prevent the occurrence of the postoperative complications.

Operative approaches for the trigone of the lateral ventricle

The trigone is the site of interface between the lateral ventricular body and the occipital and temporal horns (Fig. 2). The transtemporal approach provides a short trajectory and direct access to the temporal horn and the trigone of the lateral ventricle. This route provides a feasible access to remove the tumors filling the trigone of lateral ventricles. The patient was placed in the lateral decubitus position. The head with fixed with a 3-pin Mayfield head holder and rotated to the contralateral side at some angles so that the zygomatic process is uppermost in the operative field. Preoperative magnetic resonance imaging (MRI)-based neuronavigation was used to guide the anatomical localization. The insertion point for endoport was approximately 4.5 cm above and behind the external auditory canal.

After routine disinfection, a linear incision of was made with the insertion point as the center. The dura was opened with an arc-shaped incision. The ostomy through the parietal lobe was made and inserted endoport fixed by snake holding arm. Once an outflow of cerebrospinal fluid (CSF) is observed, the trigone of the lateral ventricle is entered. Use tailed cotton strips to slowly release CSF and insert 0° neuroendoscopy into Endoport, then fixed by pneumatic holding arm. Fully observe and carefully remove the tumors under neuroendoscopy. The following operations of tumor removal were as same as above.

Clinical Efficacy Evaluation.

All the cases underwent computed tomography (CT) scan re-examination within 24 h after the surgery to exclude the occurrence of postoperative complications such as hemorrhage or hydrocephalus. Three days after surgery, all patients underwent plain and enhanced MRI to evaluate the extent of surgical resection. Whether further radiotherapy or chemotherapy is required for patients is based on postoperative pathological analysis. Finally, we conducted follow-ups by out-patients visits or regular telephone interviews at 1, 3, and 6 months postoperatively and once a year thereafter. The recurrence of tumor and the ability of living activities of patients were followed-up and and recorded. Clinical outcomes were evaluated with the Glasgow Outcome Scale (GOS): GOS $\geq$ 4 indicates favorable prognosis and GOS < 4 indicates poor prognosis.

Results

Clinical features and histopathological types of patients with lateral ventricular tumors

The study included 16 patients (5 male/11 female) who suffered from the lateral ventricle tumors and finally underwent endoport-assisted neuroendoscopic surgery. The mean age of the patients was 43.2 years, range from 17 years to 70 years. The initial symptoms they manifested at admission were various, including headache 8, dizziness 3, unconsciousness 1, facial numbness 1 and without apparent symptom 3. About the location of the tumors in these cases, 5 cases involved the body of the lateral ventricle, 3 involved the frontal horn and body, 3 involved the occipital horn, 2 involved the trigone, 2 involved the frontal horn and 1 involved the occipital horn and body. Besides, preoperative concurrent obstructive hydrocephalus was found in 9 cases.

All the tumors were resected by the application of endoport-assisted neuroendoscopic techniques and all the excised specimens were sent to the neuropathology department for the detailed histopathological examination. The postoperative histopathological results of all patients were as follows: central neurocytoma (WHO II) 5, meningioma (WHO I) 5, diffuse astrocytoma (WHO II) 2, astrocytoma (WHO I) 1, glioblastoma (WHO IV) 1, ependymoma (WHO II) 1, colloid cyst 1. All the above clinical features and histopathological types of patients are summarized in Table 1.

Table 1
Clinical features and histopathological types of patients with lateral ventricular tumors

Number	Gender	Age	Initial symptom	Location	Hydrocephalus	Histopathology
01	Female	25	Headache	Frontal horn, body	Yes	Central neurocytoma, WHO II
02	Male	31	Asymptom	Frontal horn	No	Central neurocytoma, WHO II
03	Female	23	Headache	Body	Yes	Central neurocytoma, WHO II
04	Female	17	Headache	Body	Yes	Astrocytoma, WHO I
05	Female	37	Headache	Frontal horn, body	Yes	Glioblastoma, WHO IV
06	Male	70	Unconsciousness	Frontal horn, body	Yes	Diffuse astrocytoma, WHO II
07	Female	60	Dizziness	Trigone	No	Meningioma, WHO I
08	Female	65	Dizziness	Trigone	No	Ependymoma, WHO II
09	Male	64	Facial numbness	Body	No	Diffuse astrocytoma, WHO II
10	Male	59	Asymptom	Frontal horn	No	Colloid cyst
11	Female	36	Headache	Occipital horn	Yes	Meningioma, WHO I
12	Female	20	Headache	Occipital horn, body	No	Meningioma, WHO I
13	Female	62	Headache	Occipital horn	Yes	Meningioma, WHO I
14	Female	25	Headache	Body	Yes	Central neurocytoma, WHO II
15	Male	34	Dizziness	Body	Yes	Central neurocytoma, WHO II

Number	Gender	Age	Initial symptom	Location	Hydrocephalus	Histopathology
16	Female	63	Asymptom	Occipital horn	No	Meningioma, WHO I

Intraoperative and postoperative complications

Above all, four patients experienced intraoperative or postoperative complications: 1 intraoperative and 3 postoperative. One patient developed frontal acute epidural hematoma during operation, without obvious sequelae after timely removal of the hematoma. One patient developed transient hemiplegia postoperatively, which improved after 3 weeks of active treatment. Two patients developed obstructive hydrocephalus following operation: one was relieved after treatment with external ventricular drainage and another one was relieved by dealing with ventriculoperitoneal shunt.

Clinical prognosis

All the patients were regularly followed up at the outpatient clinic post-discharge. The average duration of follow-up is 11.69 months, range from 6 to 28 months. Follow-up results showed that 14 cases were total resection of tumors (without residuum or recurrence during the follow-up period) and 2 cases were subtotal resection (tumor resection > 95%). Of the two cases of subtotal resection, one was pathologically diagnosed as glioblastoma (WHO Ⅳ) and passed away 16 months postoperatively. Another was diagnosed as diffuse astrocytoma (WHO Ⅱ). Now, the patient is long-term survival with tumor after standardized treatment in oncology postoperative. According to the long-term follow-up of daily living activities, 15 cases have a good prognosis (GOS ≥ 4).

Discussion

Although the occurrence of mass lesions in the lateral ventricle is uncommon, it still presents substantial technique challenges to achieve total resection due to its deep location and the neighboring vital anatomic structures [8]. Lesions in the lateral ventricle are mostly benign, growing slowly and usually not identified until they reach a large size or complicate with obstructive hydrocephalus [2]. At present, the preferred treatment for lateral ventricular tumors is still the surgical resection [9, 10]. Complete tumor resection with preservation of the surrounding nonpathologic parenchyma could confer a favorable prognosis for patients. Thus, a number of factors should be taken into consideration for surgeons while they finally choose an operative corridor for each patient. To achieve the target of best prognosis, the surgical route should meet the following requirements: minimal transgression and retraction of normal brain tissues, maximum angles to achieve effective gross total tumor resection and early exposure of vital anatomic structures. In recent years, with the development of the surgical techniques and the concepts renewal of the minimally invasive surgery, endoport-assisted neuroendoscopic techniques has become a reliable method for the resection of lateral ventricular tumors.

In neuroendoscopic surgery, most surgical procedures are performed via congenital or artificial cavities to provide certain space for endoscope to observe the lesions closely. Endoport is a relatively thick, independent working channel that provides good access for operation techniques without damaging para-channel normal brain tissues [7]. It allows endoscope, attractor and surgical instruments to be inserted freely and facilitates bimanual microsurgical technique under direct endoscopic visualization. Endoport-assisted neuroendoscopic surgery could move the channels from multiple angles with limited brain tissue damage, so as to obtain a larger exposure space [11–13]. Compared with traditional craniotomy, Endoport-assisted nueroendoscopic surgery is more minimally invasive in the protection of normal brain tissues than retractor-assisted surgery.

A total of 16 patients with lateral ventricular tumors were included in the study. All patients underwent endoport-assisted neuroendoscopic resection of the tumors, without the use of microscopy. All surgeries were performed by experienced neurosurgeons with rigorous training in neuroendoscopic techniques and solid microsurgical skills. Our preliminary results postoperatively showed a high rate of tumor resection, a good efficiency of hemostasis and a favorable prognosis of patients by the application of this technique.

Now we summarize the technical points of endoport-assisted neuroendoscopic lateral ventricular tumors resection as follows. Firstly, locate the tumors precisely. Accurate localization of tumors intraoperative was the key for a successful operation. Due to the deep location of lateral ventricles, a slight deviation in the direction of endoport insets will directly influence the exposure of tumors. The application of intraoperative is particularly helpful for the accurate localization of tumors. All patients included in this study underwent head CT and MRI preoperatively to obtain the detailed imaging data and perform the precise intraoperative navigation. Furthermore, it has been reported that the application of endoscopic ultrasonography in real-time intraoperative tumor positioning is more conducive to remove tumors completely and protect neighboring important anatomic structures [14]. Secondly, take great advantage of Endoport's benefits. In our study, we employed Endoport to provide surgical channel. The entry site of Endoport mainly selected in the non-dominant hemispheres and non-functional regions. The depth of the inserted-Endoport and the presence of bleeding of brain tissues around the channel could be observed through the transparent sidewalls of Endoport. Intermittent irrigation by using physiological saline was employed during surgery to keep surgical field clear. Adjusting the angle of Endoport intraoperatively based on the size and scope of tumor to obtain a comprehensive observation of tumor is conducive to achieve complete tumor removal. It is important for surgeon to operate gently while adjusting Endoport, avoiding contusion or bleeding of brain tissue. Posterior endoscopic blind area has always been one of the disadvantages of neuroendoscopic surgery [12]. The application of Endoport can completely isolate brain tissue outside the channel, effectively reducing intraoperative worries and avoiding accidental injury of brain tissue. Although it has been reported that tumors with hard texture or large size (> 3 cm) were the main limitations of Endoport-assisted neuroendoscopic surgery. With the improvement of endoscopic channels and the updating of surgical instruments such as ultrasonic dissector, larger tumors can also be removed by endoscopic technology [11, 15]. Thirdly, give full play of the advantages of close observation of neuroendoscopy. Because microscope can only magnify the surgical field on a straight line, it just plays limited roles in total resection of lateral ventricular tumors which is at deep position. Compared with microscope, neuroendoscopy combined with angle endoscopy can magnify the surgical field at a wider angle to show the shape of tumors and peri-tumor structure at maximum range. Thus, a higher rate of tumor removal and better protection of brain tissue were achieved under skilled use of this technique. In the group of patients, follow-up results showed that the total tumor resection rate is 80% and the subtotal tumor resection rate is 20%. Because of the wide observation range of neuroendoscopy, the traction of brain tissue is significant lesser than operated under microscopy, which fully reflects the concept of minimally invasive neurosurgery. Fourthly, keep the cerebrospinal fluid (CSF) circulation unobstructed. CSF circulation disturbance was often complicated in patients with lateral ventricular tumors before operation. It is important to keep the patency of interventricular foramen during operation, avoiding blocked by blood clot. If external ventricular drainage is needed, the flow velocity and flow volume should be controlled postoperatively to avoid the occurrence of ventricular walls adhesion or isolated ventricle. Moreover, the release of CSF during operation when endoport entered the ventricle should also maintain slowly to prevent the rapid collapse of brain tissue [16]. If not, it may readily induce intraoperative epidural hematoma, especially in the young people [17]. Fifthly, perfect postoperative management is extremely important. Patients should be more intensively monitored to avoid the occurrence of various postoperative complications like hydrocephalus, limb movement disorder, stress ulcer, intracranial infection, deep vein thrombosis, etc. Once happening, timely detection and early intervention can help minimize the long-term neurological dysfunction. Further standard treatment is also needed for some patients after discharge according to the specific pathological types. In cases of this group, the patient diagnosed with glioblastoma survived 16 months postoperatively and the patient with diffuse astroglioma achieved long-term survival with residual tumor. Since both tumors originated in the thalamus, in order to preserve the function of the structure as much as possible during the operation, they did not meet the standard of complete tumor resection. No other residual or recurrence of tumors were found during the follow-up.

Overall, Endoport-assisted neuroendoscopic techniques have apparent advantages in dealing with lateral ventricular tumors. Endoscopic excision of lateral ventricular tumors affords high tumors total resection rate, less damage, high safety and good prognosis. This technique is worthy to be popularized in clinical practice.

Conclusion

Endoport-assisted neuroendoscopic surgery is suitable for the resection of lateral ventricular tumors. This procedure is simple, effective, minimally invasive, and associated with fast postoperative recovery.

Declarations

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Chaolong Yan and Huiying Yan. The first draft of the manuscript was written by Chaolong Yan and Wei Jin commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Conflicts of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. No funds, grants, or other support was received.

Ethical approval

This study was conducted retrospectively from data obtained for clinical purposes. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study. Patients signed informed consent regarding publishing their data and photographs.

Data availability

The raw/processed data required to reproduce these findings cannot be shared at this time as the data also forms part of an ongoing study.

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Figures

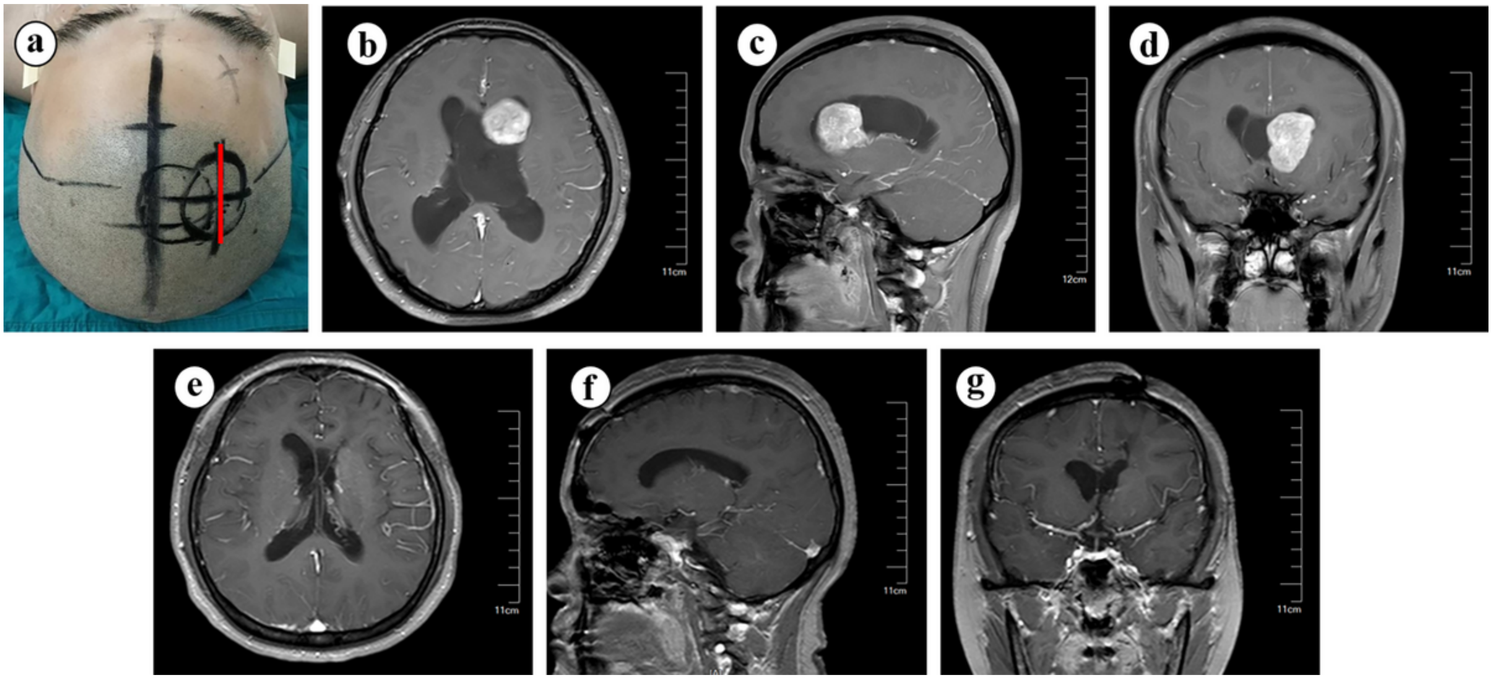

Figure 1

Operative approaches for the frontal horns and the body of the lateral ventricle (a) Schematic diagram of surgical incision (marked with red line). (b-d) Axial, sagittal and coronal images of preoperative enhanced magnetic resonance imaging. (e-g) Axial, sagittal and coronal images of enhanced magnetic resonance imaging at 6 months postoperative.

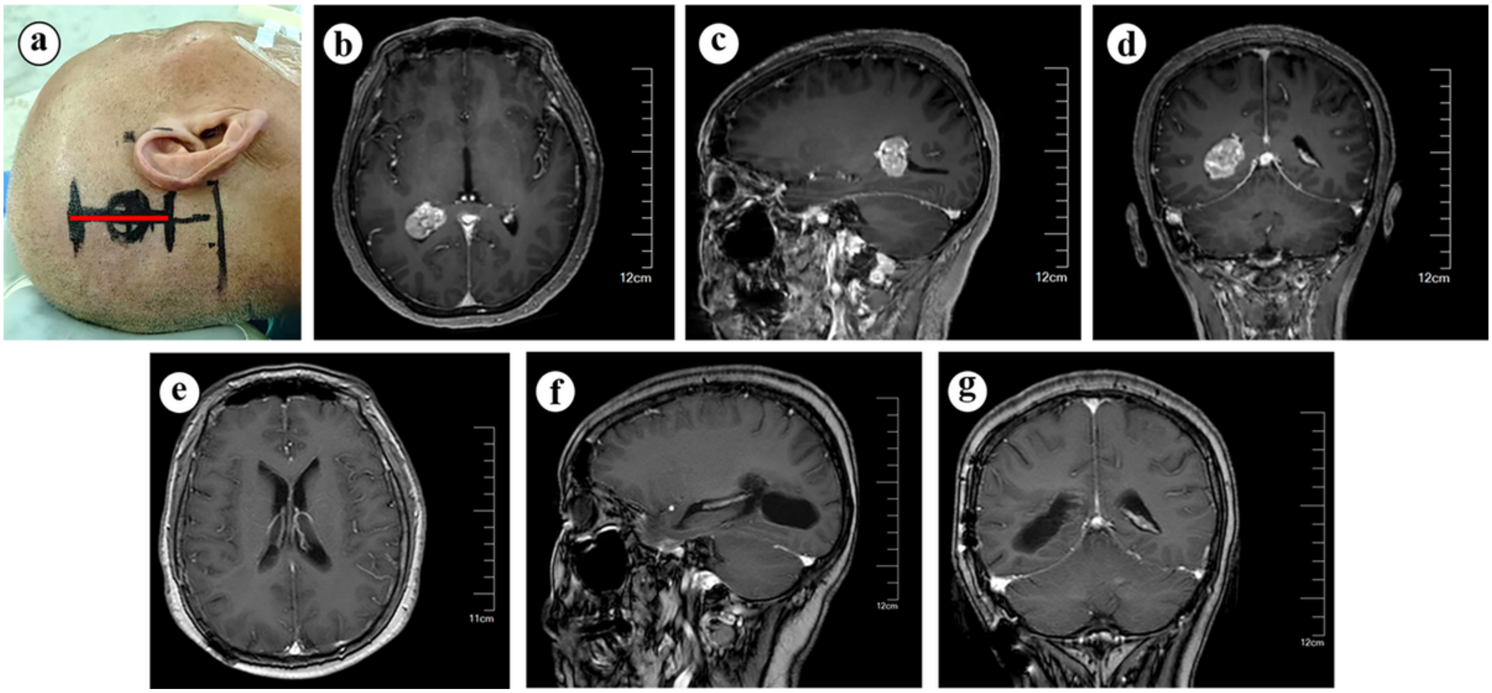

Figure 2

Operative approaches for the trigone of the lateral ventricle (a) Schematic diagram of surgical incision (marked with red line). (b-d) Axial, sagittal and coronal images of preoperative enhanced magnetic resonance imaging. (e-g) Axial, sagittal and coronal images of enhanced magnetic resonance imaging at 6 months postoperative.