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TECHNICAL NOTE

# Management of large intraventricular meningiomas with minimally invasive port technique: a three-case series

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**Abstract**
The use of minimally invasive transcranial ports for the resection of deep-seated lesions has been shown to be safe and effective. To date, most of the literature regarding the tubular retractors used in brain surgery is comprised of individual case reports that describe the successful resection of deep-seated lesions such as thalamic pilocytic astrocytomas, colloid cysts in the third ventricle, hematomas, and cavernous angiomas. The authors describe their experience using a tubular retractor system with three different cases involving large intraventricular meningiomas and examine radiographic and patient outcomes. A single-institution, retrospective case series was performed from a skull base database. Patients who underwent resection of intraventricular > 4-cm meningiomas with port technology were identified. The authors reviewed three cases to illustrate the feasibility of minimal access port surgery for the resection of these lesions. Complete resection was achieved in all cases. None of the patients developed permanent neurological deficits. There were no major complications related to surgery and no mortalities. Good clinical and surgical outcomes for atrium meningiomas can be achieved through the minimally invasive port technique and tumor size does not appear to be a limitation.

**Keywords** Brain port · Meningioma · Minimally invasive · Port technique · Tubular retractor · Ventricular tumor · Ventricular atrium

## Introduction

Intraventricular meningiomas originate from abnormal embryologic migration of arachnoid cap cells into the choroid plexus and account for 0.5–3.7% of all meningiomas [1–4].

Tumors located at the trigone of the lateral ventricle pose a challenge to neurosurgeons due to the complex anatomical boundaries of the ventricular atrium [5]. Intimate understanding of the anatomy is critical in avoiding surgery-related morbidity.

There has been a strong trend towards expanding the use of minimally invasive and port techniques in neurosurgery. One of the advantages of its use for the resection of intra-axial lesions is limiting retractor-induced parenchymal injury associated with the use of blade or ribbon systems [6]. To date, most of the literature regarding the tubular retractors used in brain surgery is comprised of individual case reports that describe the successful resection of deep-seated lesions such as thalamic pilocytic astrocytomas, third ventricle colloid cysts, hematomas, and cavernous angiomas [7–14].

We present and discuss our experience with minimally invasive port technique resection of intraventricular meningiomas.

## Anatomy and approaches to the atrium of the lateral ventricle

The atrium of the lateral ventricle has borders formed by the white matter fibers extending from the corpus callosum, the

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caudate, as well as the tracts of the optic pathway [5]. The relevant vasculature of the atrium includes the anterior and lateral posterior choroidal arteries, which share multiple anastomoses in the choroid plexus, and the medial atrial veins and lateral atrial veins, which can join near the choroidal fissure to form the common atrial vein [5]. Familiarity with this regional anatomy is critical for tailoring the surgical trajectory for atrial tumors, which include anterior, posterior, and lateral approaches to the atrium.

## Anterior approach

When considering the anterior approach, the surgeon is planning to access the atrium with a frontotemporal craniotomy and a splitting of the Sylvian fissure. The transverse gyrus of Heschl is a surface landmark for the atrium of the ventricle. Retraction of the frontal lobe allows for identification of this gyrus at the posterior-medial aspect of the superior temporal gyrus. The posterior insular cortex can then be traversed to enter the atrium [5, 15].

This approach may risk the auditory cortex particularly if performed on the patients' left side.

## Posterior approaches

The posterior interhemispheric approaches traverse the corpus callosum. For lesions that extend from the atrium towards the splenium, a transcallosal approach that allows for access to posterior aspect of the corpus callosum and splenium is most appropriate. Once the lateral ventricle is entered, it is followed laterally to access the atrium [5]. This approach has the downside of potential right-left disconnection as a complication, which can be manifested as the alien hand syndrome.

More expansive tumors that involve the medial occipital lobe, the pulvinar, and the pineal gland may be managed via an interhemispheric transprecuneus approach. An opening through the precuneus anterior to the parietal-occipital sulcus allows for access to the atrium posterior to the choroidal fissure from a medial to lateral orientation [5]. The disadvantage of this angle of approach is related to the difficulties to reach very lateral extensions of the tumor and its attachments. Furthermore, there are often cortical veins draining to the superior sagittal sinus that can prevent proper exposure without the risk of cortical venous infarct.

For masses residing in the inferior portion of the atrium, a paramedian, supracerebellar transtentorial approach can be used. A craniotomy using this trajectory has also been described for atrial tumors residing in the dominant hemisphere and has claimed to potentially result in damage to only short association u-fibers surrounding the collateral sulcus [16, 17]. After the tentorium is incised and is used to assist with downward retraction of the cerebellum, the posterior-mesial temporal lobe and the ambient cistern can be visualized. A corticectomy of the occipitotemporal gyrus or dissection of the collateral sulcus that advances laterally provides access to the atrium; the surgeon should be cautious of the atrial veins that lie in the medial wall of the atrium [17]. Any superior extension of the tumor represents a limitation to reach with this approach.

The endoscopic-assisted, contralateral, transfalcine, transprecuneus approach has been favored by a few authors—despite its deep trajectory—because it can offer a wider surgical corridor with limited postoperative complications; a series of ten patients showed no new complications and a postoperative modified Rankin score of 0–1 in nine of these patients at 1-year follow-up [18]. On the other hand, by using this approach, the surgeon is exposing and putting at risk the contralateral normal brain with its respective superficial venous system. Furthermore, there is a potential for psychological complications due to the damage of the lesion ipsilateral cingulate gyrus.

## Lateral approaches

The temporal approaches are used for tumors involving the middle and posterior one-third of the atrium. Transcortical temporal approaches are most ideal for lesions of the non-dominant hemisphere due to the risk for injury to language centers; however, traversing the middle and inferior temporal gyri can still cause visual field cuts because optic radiation fibers travel lateral to the atrium and temporal horn [5, 15]. Nevertheless, there has been suggestion that a transcortical approach through the left or right middle temporal gyrus can avoid producing postoperative deficit [19].

Alternatively, a more preferable route that greatly avoids potential eloquent tissues is the subtemporal approach, which follows the floor of the middle cranial fossa towards the occipitotemporal gyrus. An incision can be safely made in this gyrus to access the atrium while avoiding unnecessary manipulation of local draining veins. This approach is also limited in the reach and safe dissection of the superior aspect of the tumor and may also put the vein of Labbé at risk.

## Supero-lateral approach

Intraparietal trans-sulcal or transcortical superior parietal lobule approaches are direct and effective operative corridor through the roof of the ventricular trigone. Since this region of the atrium is devoid of fibers of the optic radiation, this approach, at least theoretically, does not risk damage to visual areas and, hence, effectively avoids common complications attributed to atrial ventricular surgery. The latter is further augmented with the integration of modern neuroimaging techniques, such as diffusion tensor imaging (DTI) and neuronavigation, which enable neurosurgeons to plan a safe trajectory through a minimal incision and craniotomy [20]. In this scenario, the tubular retractor can be utilized to reach the atrium of the ventricle minimizing white fiber disruption.

## Materials and methods

A single-institution, retrospective case series was performed from a skull base database. The study was performed under Institutional Review Board approval and did not require patient consent. Patients who underwent resection of intraventricular meningiomas > 4 cm with port technology were identified and information regarding patient's demographics, presenting symptoms, neurological exam, operative notes, postoperative course, histopathological diagnosis, clinical follow-up, and radiological imaging.

## Results

The authors reviewed three cases to illustrate the feasibility of minimal access port surgery for the resection of large intraventricular meningiomas.

### Parietal approach port technique

The patient is placed in a lateral decubitus position with the head turned 15° so that nasion is rotated contralateral towards the floor. This positioning allows for the bulk of the tumor to be orthogonal to the port's entry point. A round 4-cm craniotomy is fashioned in order to allow for dynamic angulation of the tubular retractor to cover the anterior-posterior and medial-lateral dimensions of the tumor with the fulcrum at the superficial cortex (Fig. 1). After the dural opening, the intraparietal sulcus is identified under microscopic visualization posterior and lateral to the vein of Trolard.

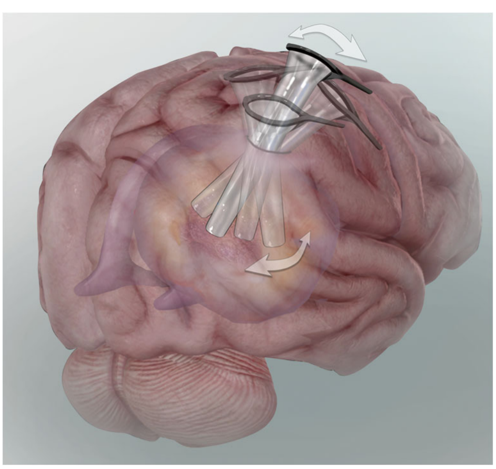


**Fig. 1** Dynamic angulations of the tubular system in order to cover the entire surface of the tumor. Once the port is secured to a retractor system, it can be adjusted in order to accommodate the surgeon's view of the mass

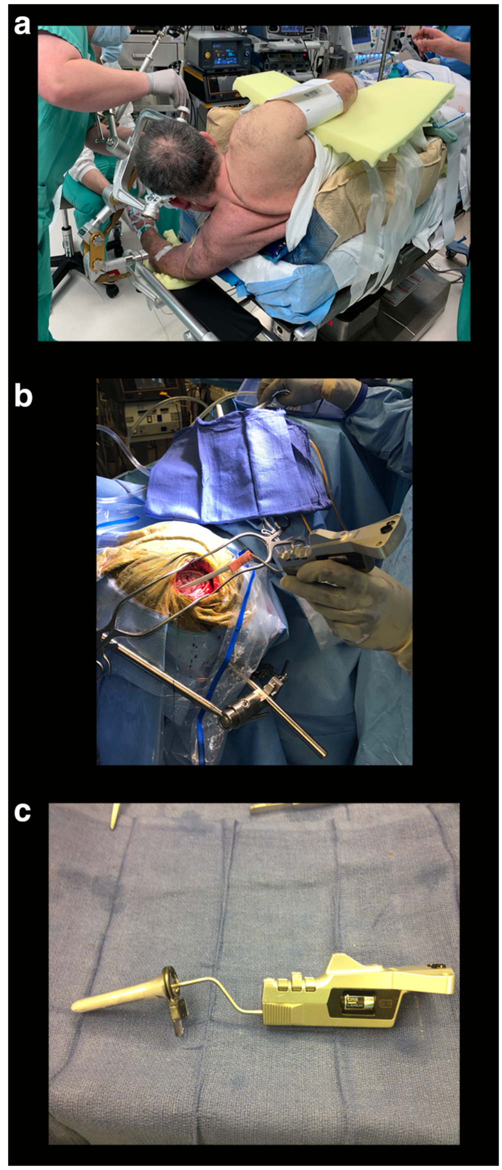


**Fig. 2** The setup for parietal port approach to the atrium of the lateral ventricle. **a** Patient positioning. **b** The 6-mm peel-away sheath used in combination with navigation probe to establish the trajectory. **c** The navigation system's probe is placed inside the port and secured with bone wax for retractor insertion under image guidance

A transcortical approach was used for our series, but a trans-sulcal route is also possible and potentially preferred depending on the type of port used; ports with blunt edges are more suitable for transcortical approaches while those with a sharp tip should be used for trans-sulcal trajectories. A small corticectomy (2–3 mm in length) is performed in the posterior aspect of the superior parietal lobule in order to avoid visual pathways as well as the components of the superior longitudinal fasciculus. A 6-mm peel-away sheath is passed with image guidance towards the portion of the tumor closest to the corticectomy.

Once the path is created with the sheath, a 12 × 8 × 70 mm Viewsite Brain Access System port (Vycor Medical Inc.,

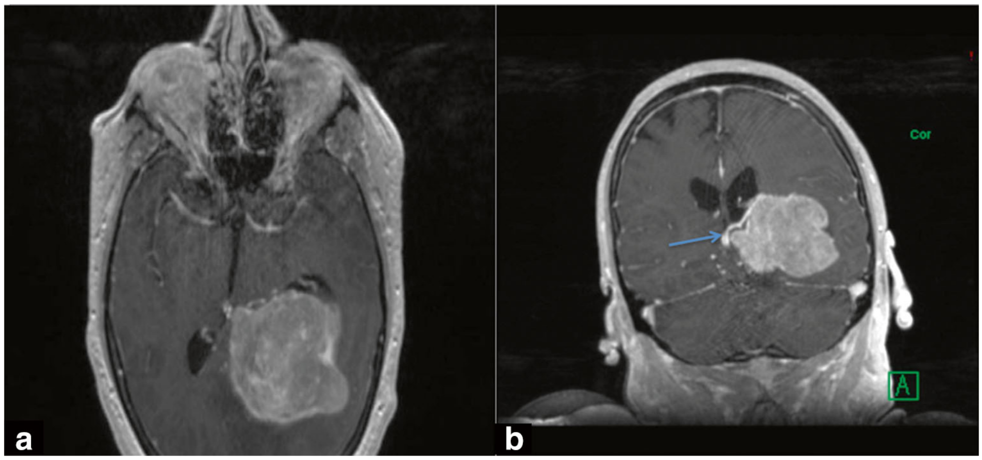



**Fig. 3** The axial (**a**) and coronal (**b**) contrast-enhanced, preoperative MRI showed a heterogeneously enhancing mass arising from the atrium of the left lateral ventricle and causing mass effect on the left lateral ventricle, thalamus, and corpus striatum. The arrow in (**b**) shows a deep draining vein associated with the tumor

Boca Raton, FL) is then introduced with the navigation probe inside the port (Fig. 2). The port bluntly spreads the white matter fibers around it, limiting potential harmful sequelae from its use. The tubular retractor is then attached to a flexible arm secured to the skull clamp.

The microscope is then brought to the surgical field and the surface of the tumor is visualized and coagulated with low-profile bipolar forceps. The tumor is debulked progressively with an ultrasonic aspirator as the tubular retractor is angulated in multiple directions keeping the fulcrum at the cortical surface (Fig. 1). After at least 30 min, the port can be exchanged for a larger tubular retractor (17 × 11 × 70 mm) without further parenchymal disruption due to an ostium and channel through the cortex towards the tumor that is created.

Only after significant debulking of the tumor, an extracapsular dissection is attempted with a bimanual microsurgical technique and dynamic mobilization of the port optimizing visualization. It is critical to identify the choroidal arteries providing blood supply to the anterior surface of the tumor. Those vessels are then coagulated and transected at the point that they enter the tumor. The intraventricular veins must be carefully dissected and freed in order to avoid a venous infarct. Once the tumor is resected, hemostasis is achieved, and the tubular retractor is removed slowly. An external

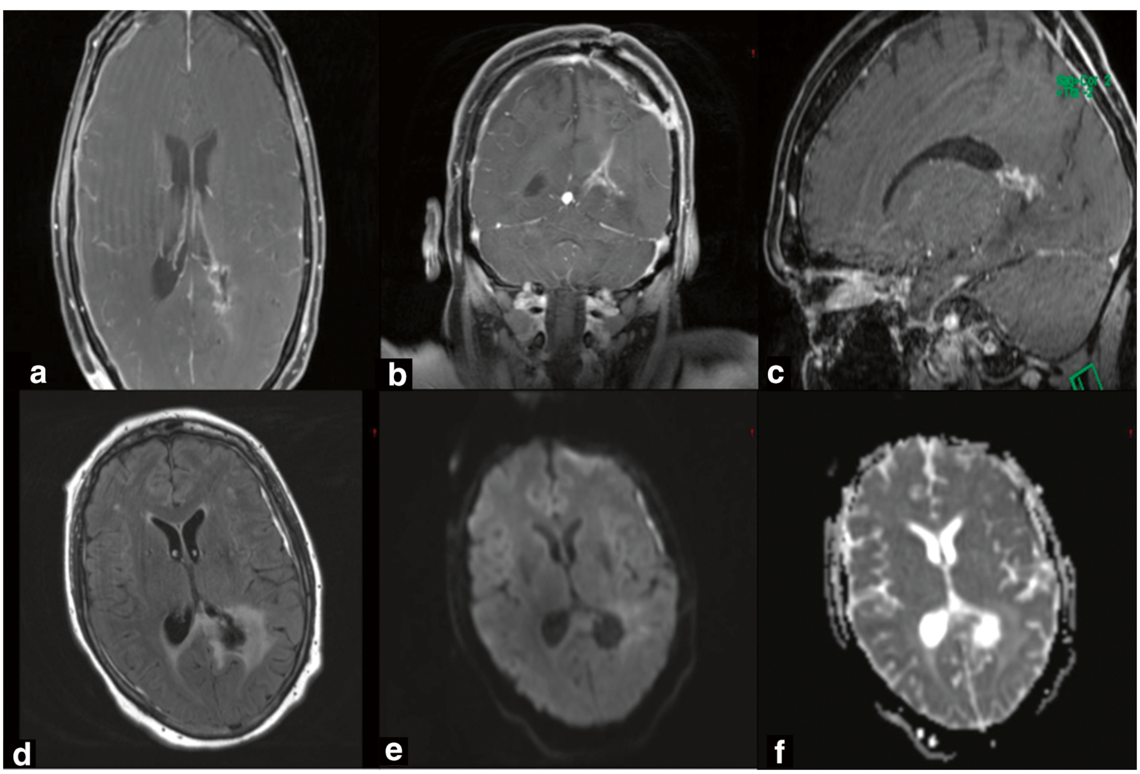


**Fig. 4** The axial (**a**), coronal (**b**), and sagittal (**c**) contrast-enhanced, postoperative MRI revealed a complete tumor resection. Minimal FLAIR changes (**d**) and no signs of ischemia as seen on the DWI and ADC sequences (**e**, **f**)

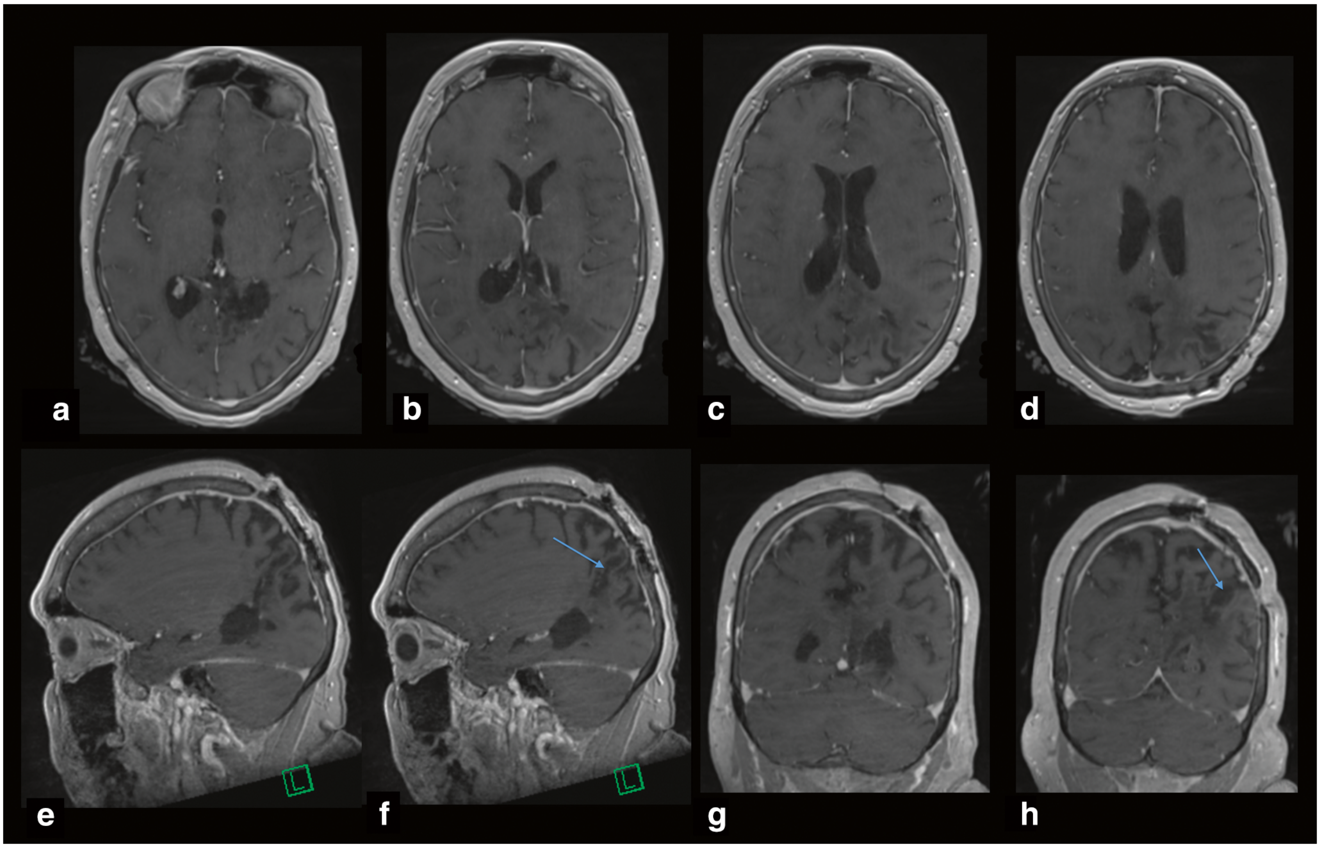



**Fig. 5** Late postoperative, contrasted axial (**a**–**d**), sagittal (**e**, **f**), and coronal (**g**, **h**) MRI showing the complete removal of the meningioma. The arrows in images **f** and **h** indicate the path of the port towards the atrium with minimal surrounding intrinsic parenchymal changes

ventricular drain (EVD) catheter was left in place and kept open postoperatively. More than one stage may be required for large lesions as these tumors collapse after internal debulking, allowing a potentially safer dissection of the surrounding structures during a subsequent surgery.

## Case 1

A 53-year-old woman with history of breast and ovary cancers presented with headache and speech changes. Neurological exam revealed right homonymous hemianopsia and stammering that affected speech prosody. Routine magnetic resonance imaging (MRI) revealed a giant homogeneously enhancing tumor involving the left atrium that appeared consisted with a meningioma (Fig. 3).

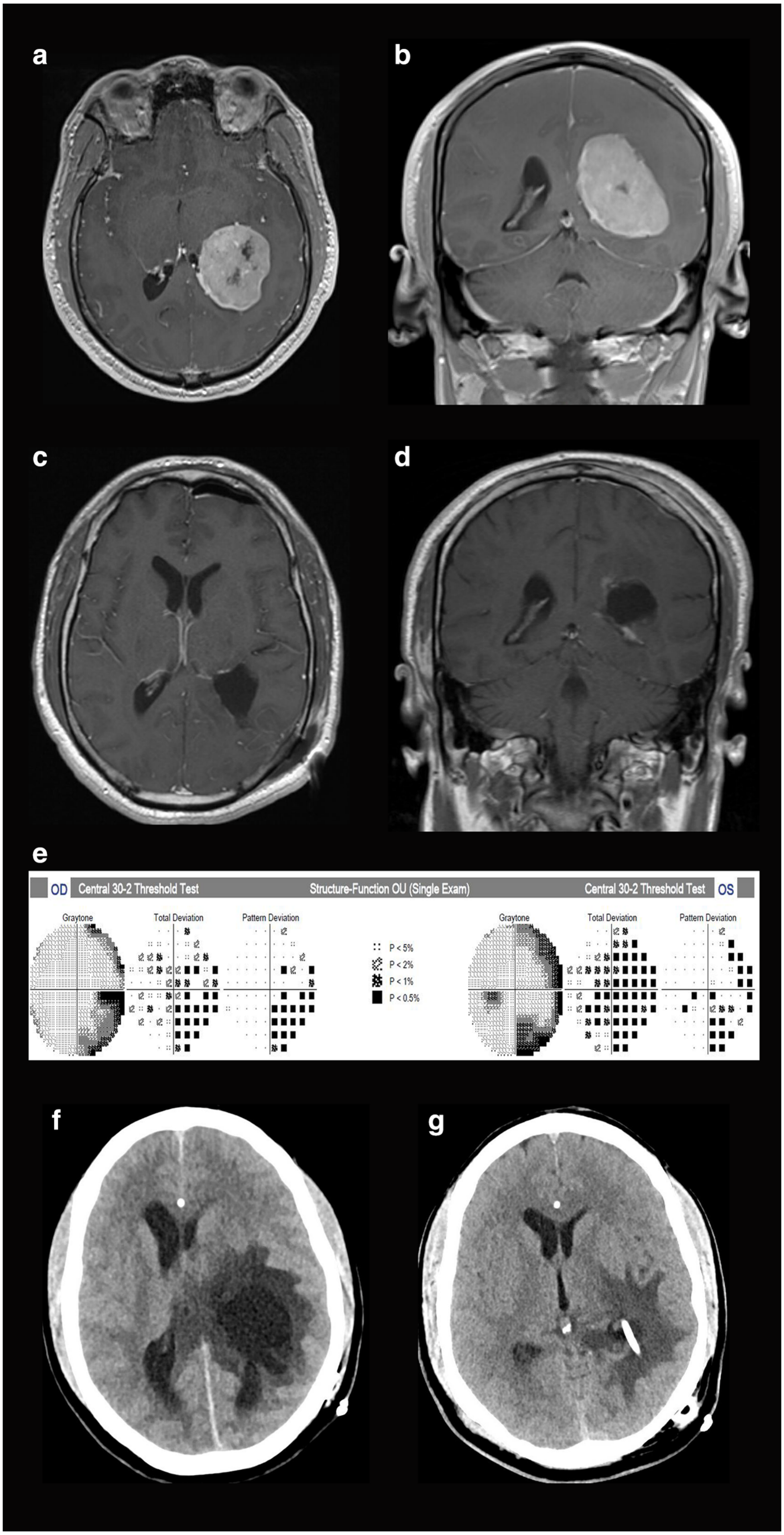
The parietal approach port technique was performed as described above. The patient underwent a staged resection a few days apart given the solid and fibrous nature of the tumor. Aggressive debulking followed by extracapsular dissection allowed safe separation of tumor from draining veins and normal structures.

There were large draining veins on the medial aspect of the tumor; therefore, the authors deliberately aimed to discriminate between tumor capsular veins and ventricular veins in order to avoid complications related to venous infarct. Once all the vessels were released and no longer tethering the tumor, it could be gently rolled away from the choroid plexus and removed.

Postoperatively, the patient did not require long-term cerebrospinal fluid diversion and EVD was weaned. She recovered well after surgery with complete improvement of her visual symptoms and no new neurological deficit. She did not suffer any obvious or aggravating agnosia, apraxia, or visuospatial complications based on follow-up neurologic exams. Pathology confirmed atypical meningioma (WHO II). Postoperative MRI revealed complete resection of the tumor and a small tract towards the tumor with minimal FLAIR changes and no signs of ischemia (Fig. 4). Adjuvant radiation therapy was not recommended due to complete tumor resection. The patient is neurologically intact and she has been followed for over 7 years with no signs of tumor recurrence (Fig. 5).

## Case 2

A 40-year-old man presented with papilledema on a routine eye examination. He was neurologically intact, but was noted on ophthalmological exam to have 4+ disc edema bilaterally.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Central 30-2 Threshold Test
Structure-Function OU (Single Exam)
Central 30-2 Threshold Test
OS
Graytone
Total Deviation
Pattern Deviation
P < 5%
P < 2%
P < 1%
P < 0.5%
Graytone
Total Deviation
Pattern Deviation
f
g

◀ **Fig. 6** Axial (**a**) and coronal (**b**) contrast-enhanced, preoperative MRI showing large atrium meningioma. Postoperative axial (**c**) and coronal (**d**) contrast-enhanced MRI confirming complete tumor resection. Visual field test (**e**) showing no significant postoperative deficit. Computed tomography scan showing trapped ventricle (**f**) with resolution after permanent cerebrospinal fluid diversion (**g**)

Bedside visual field testing revealed no apparent deficit, although formal testing was deferred. MRI demonstrated a large left-sided intraventricular mass consistent with meningioma (Fig. 6), and he was scheduled for urgent intervention via a parietal approach port technique as described above. Surgery was uneventful and a total resection was obtained. Pathology was WHO grade I meningioma. Approximately 2 weeks after the initial surgery, he presented with trapping of the resection cavity and CSF dilation of the space. This was fenestrated back into the rest of the ventricular system, and his headaches from that episode resolved. Unfortunately, 3 months later, he again trapped this CSF space and so the decision was made to place a ventriculoperitoneal shunt into the area. The patient recovered uneventfully from the shunt placement. Follow-up visual field testing at 4 months after surgery demonstrated a small contralateral right visual field deficit. At 1 year postoperatively, there is no evidence of tumor recurrence or progressive neurological deficits (Fig. 6).

## Case 3

A 66-year-old man presented with ophthalmological findings of left visual field deficit and papilledema, with occasional headaches. He was otherwise neurologically intact with the exception of the left field deficit. MRI revealed a large right-sided intraventricular mass consistent with meningioma (Fig. 7) and he was scheduled for urgent intervention via a right parietal approach port technique. Surgery was uneventful and a complete resection was obtained. Pathology confirmed WHO grade I meningioma. He recovered uneventfully and remained neurologically well, with some improvement in the visual field deficit, although it did not resolve entirely. At

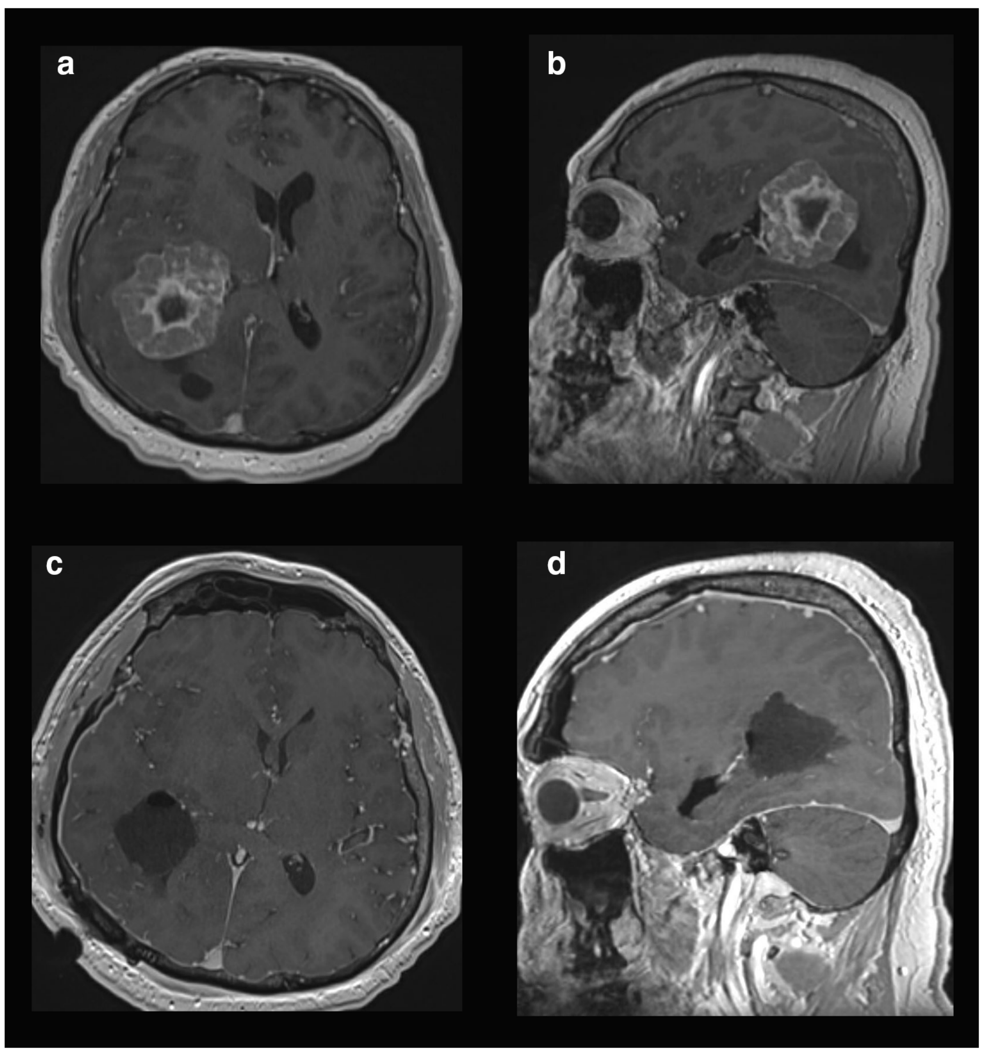


**Fig. 7** Axial (**a**) and sagittal (**b**) contrast-enhanced, preoperative MRI showing large atrium meningioma. Postoperative axial (**c**) and sagittal (**d**) contrast-enhanced MRI confirming complete tumor resection

10 months postoperatively, there is no evidence of tumor recurrence or progressive neurological deficits (Fig. 7).

## Discussion

There has been a strong trend towards expanding the use of minimally invasive techniques in neurosurgery due to the potential to decrease procedure-related morbidity. A specific advantage of port techniques for intra-axial or intraventricular tumors is limiting retractor-induced parenchymal injury associated with the use of blade or ribbon systems [6].

Fixed systems that use blades for retraction can injure the brain through direct cortical and subcortical compression as well as ischemic damage from suboptimal perfusion of local tissue [6, 21, 22].

In a study of patients undergoing open cerebrovascular surgery, the pH and the partial pressures of oxygen and of carbon dioxide were measured and the results indicated the presence of ischemic changes with brain retraction [23]. Intraparenchymal microdialysis probes have also been used to analyze metabolic changes in retracted brain tissue, confirming parenchymal damage and cellular injury [24].

Because of these findings, multiple attempts have been made to adjust surgical techniques and retractor blade designs. However, despite engineering alterations, there were no differences seen among flat, flat with round edges, and curved retractor profiles in their risk for producing ischemic injury [25].

Port technology has been advanced to help reduce operative morbidity. This modality has been in existence since the 1980s when cylindrical retractors were used instead of retractor blades because less damage was done to the surrounding cortex [26]. This technique has since gained popularity, particularly for accessing deep-seated lesions [27, 28].

The main advantage of the tubular retractor system is that the beveled/tapered edge of the port allows for tissue displacement around the tubes rather than transection or retraction of white matter tracts with blades. Minor disruption of brain tissue has been supported by postoperative MRI findings, which show minimal FLAIR, T2, and ADC/DWI changes [27].

To our knowledge, this is the first reported series of large intraventricular meningioma removed via port technique. Our patients had neither postoperative radiographic abnormalities nor clinical neurologic deficit as a result of their surgery, which we believe is a result of limited brain retraction and preservation of venous structures.

## Conclusion

The use of tubular retractors is feasible and it is a useful tool for approaching the ventricular trigone. Good clinical and surgical outcomes for atrium meningiomas can be achieved through minimally invasive port technique and tumor size does not appear to be a limitation.

**Data availability** All study data will be made available upon request.

### Compliance with ethical standards

**Conflict of interest** Daniel Prevedello is a paid consultant for Medtronic and Stryker and receives royalties from KLS Martin. The other authors declare that they have no conflict of interest.

**Ethics approval** The study was performed under Institutional Review Board approval and did not require patient consent.

**Code availability** N/A

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