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Step-wise pterional combined epidural and subdural approach to clip large carotid-ophthalmic segment aneurysms

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Abstract

Background Microsurgical clipping of large ophthalmic-carotid artery (OA) aneurysms is technically challenging. Among the reported approaches, pterional combined epidural and subdural approach is one of the efficient choices.

Method We have applied this approach to treat a 33-year old female patient with a left large OA aneurysm. The step-wise technical details of this approach are reported.

Conclusion We show that it is a safe way to clip large OA aneurysms through a step-wise pterional combined epidural and subdural approach, which could make a clear anatomy and a confident manipulation.

Keywords Ophthalmic-carotid artery aneurysm · Large · Clipping

Abbreviations

CSF	Cerebrospinal fluid
CT	Computed tomography
ICA	Internal carotid artery
DSA	Digital subtracted angiography
MEP	Motor evoked potentials
MRI	Magnetic resonance imaging
OA	Ophthalmic-carotid artery
SEP	Somatosensory evoked potentials

Relevant surgical anatomy (Fig. 1)

The lateral wall of the cavernous sinus consists of two layers [4]. The outer layer is a dura layer which envelopes the temporal lobe, whereas, the inner layer is a semitransparent layer which is mainly formed by the sheath of cranial nerves passing through the lateral wall of the cavernous sinus. These two layers loosely attach to each other and have a cleavage within them, except at the superior orbital fissure where the cranial nerves III, IV, and V1 cross each other [4]. The cranial nerves III, IV, and V1 go through the inner layer of the lateral wall. Most of the inner layer is complete membrane apart from the space between the cranial nerves III and V1. The anterior clinoid process has three bony attachments, anterolaterally lesser wing of the sphenoid bone, medially optic canal roof, and inferomedially optic strut. The clinoidal carotid artery is located at the inferomedial aspects of the clinoid process. It is covered by the carotid collar which comes from the inner layer of the cavernous sinus. This dura collar loosely attaches to the carotid artery until it distally joins the distal dura ring.

Description of the technique (see supplementary video)

A 33-year old young lady reported left visual loss since last year. Neuroimaging studies indicated a left large ophthalmic-carotid artery (OA) aneurysm (Fig. 2). Visual acuity was 0.8 at left side and 1.0 at the other side. Step-wise microsurgical clipping of the aneurysm was performed using a combined epidural and subdural approach which was pioneered by Dolenc in 1985 [1] and Hakuba in 1989 [3].

After using general anesthesia, SEP and MEP are equipped. The patient is placed supine with the head turning from 20 to 30 degrees towards the opposite side to the aneurysm. The upper

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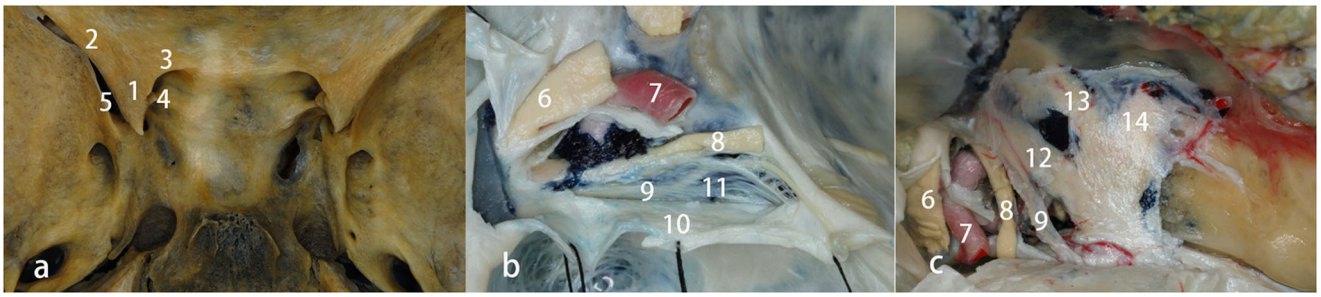

Fig. 1 Relevant surgical anatomy. **a** Skull anatomy of parasellar space. Anterior clinoid process has three attachments as a lesser sphenoid wing, optic roof, and optic strut. **b** The outer layer of the lateral wall of cavernous sinus has been partially peeled off. **c** Neurovascular structures of the parasellar space. (1) Anterior clinoid process, (2) lesser sphenoid wing, (3) optic roof, (4) optic strut, (5) superior orbital fissure, (6) optic nerve, (7) ICA, (8) oculomotor nerve, (9) trochlear never, (10) out layer of lateral wall, (11) inner layer of lateral wall, (12) ophthalmic nerve, (13) maxillary nerve, (14) mandibular nerve

body is elevated 15 degrees. A frontotemporal scalp incision is planned and neck carotid artery exposure is prepared in case of unintentional usage. A classical pterional craniotomy is performed to expose the dura mater. The orbit roof is carefully removed to preserve the integrity of the periorbita.

Epidural anterior clinoidectomy

The anterior clinoidectomy can be safely performed following a three-step procedure. Firstly, both the sphenoidal lesser wing and greater wing are continued to be removed to expose the superior orbital fissure. At this stage, the anterolateral attachment of the anterior clinoid process has been divided, and the orbitotemporal ligament is ready to be cut. The cleavage between the two layers of the lateral wall of the cavernous sinus usually could be easier to find at the middle part of the superior fissure. After the establishment of the cleavage, the outer layer of the cavernous sinus is peeled off until the clinoid process tip comes into view, which could make a confident anterior clinoidectomy. Secondly, unroof the optic canal. The optic canal could be precisely located by defining the inlet intracranially and outlet in the orbit. A fine diamond drill is used to unroof the optic canal. Continuous cool water irrigation is necessary to prevent heat injury to the optic nerve. After this step, there is only optic strut attaching the anterior clinoid process if there is no middle clinoid process. Therefore, the third step is to hollow the anterior clinoid process until its attachment with the optic strut is shelled. Subsequently, the anterior clinoid process could be easily freed and removed.

Aneurysm exposure and clipping

After all the above epidural work has been finished, the anterolateral and anteromedial spaces of the parasellar region are ready to be used for sufficient aneurysm exposure. The dura mater is incised by a "工" fashion to merge the epidural and

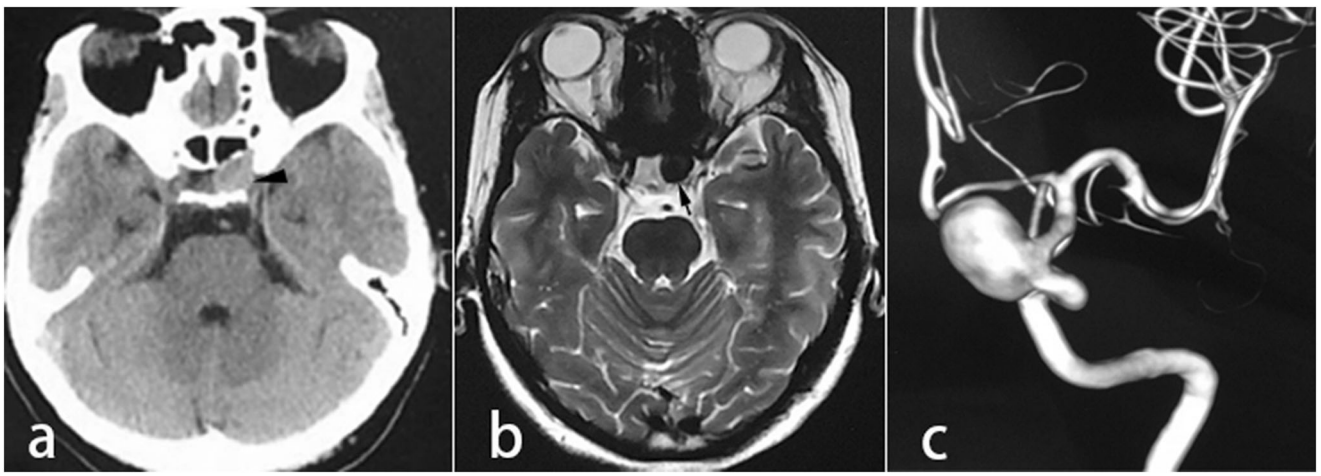

Fig. 2 Imaging studies before surgery. **a** CT scan indicates a left sellar lesion (arrowhead). **b** MRI T2-weighted image indicates the lesion with flow void signal (arrow). **c** DSA 3-dimensional image indicates a left OA aneurysm

intradural space. The falciform ligament is incised along the lateral margin of the optic sheath until the Zinn's ring. The dura is cut further along the distal dura ring, which is finally circumferentially divided to fully release the internal carotid artery. Additionally, the medial proximal aneurysm neck could be sufficiently exposed. Care should be taken not to injure the ophthalmic artery when cutting the medial part of the distal dura ring. The carotid collar is cut to expose the clinoidal segment of the internal carotid artery, which is usually temporarily clipped during the aneurysm clipping procedure to make a definite proximal control. The aneurysm is extensively explored. Lastly, the aneurysm is clipped gradually after several attempts of clip adjustments. The angulated and fenestrated clips are essential for this kind of aneurysms clipping. The aneurysm was punctured to make a confident clipping. After careful hemostasis, the optic canal and optic strut bony deficits are sealed by muscle pieces followed by dura suture and wound closure. Postoperative imaging studies indicated a successful obliteration of the aneurysm (Fig. 3). The patient did well and her left visual acuity was recovered to 1.0 on the 7th day after the operation.

Indications

This approach can be applied to patients who have ophthalmic segment ICA aneurysm without contraindications for microsurgery.

Limitations

The operation is technically demanding. Long-term lab training and a clear understanding of local anatomy will be needed.

How to avoid complications

The optic nerve should be fully released to prevent unintentional injury during its mobilization. The distal dura ring should be fully cut to free the carotid artery and expose the whole aneurysm neck. Small muscle pieces are used to seal the bony deficits in order to prevent CSF leakage.

Specific perioperative considerations

Neuroimaging studies should be carefully reviewed. Optic strut and optic canal hyperpneumatization require a careful drilling and strict skull base reconstruction at the end of the operation. Parent artery and aneurysm neck calcification significantly increase the operative risks. Therefore, in that case, alternative treatments such as major vessel sacrifice combined with blood flow replacement or endovascular treatments could be considered.

Specific information to give to the patient about surgery & potential risks

Pterional combined epidural and subdural approach to clip large OA aneurysms is relatively safe and efficient for visual improvement. It needs to be performed by doctors with extensive hands-on experience. However, it was reported that there are still some patients having poor visual improvement although the surgery has been successfully performed [2]. The potential risks for the surgery involve CSF leakage, intraoperative aneurysm rupture, carotid artery compromise, and cranial nerves injury.

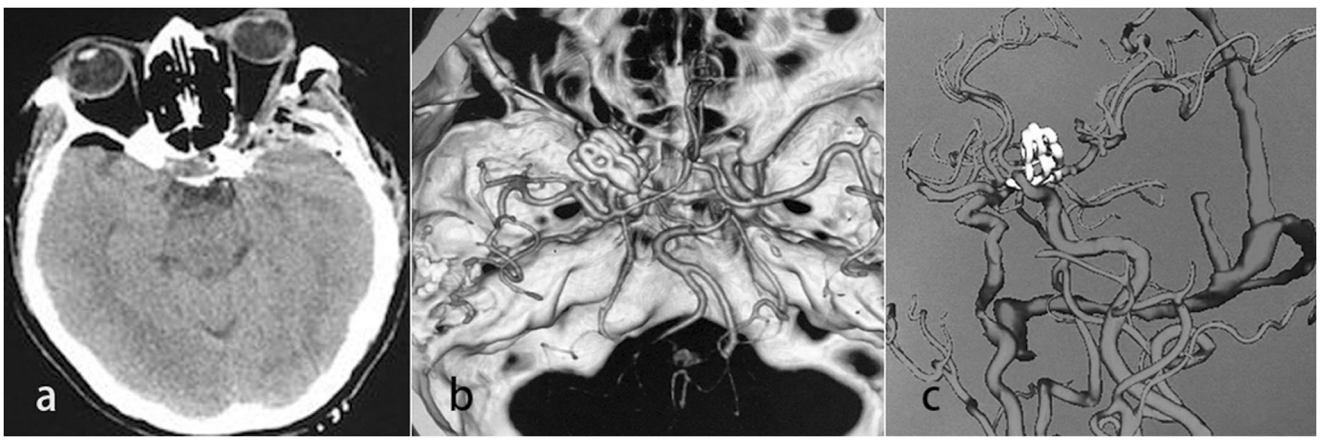

Fig. 3 Postoperative imaging studies. **a** CT scan indicates neither brain infarction nor intracranial hemorrhage. **b** and **c** CT angiography indicates a complete aneurysm obliteration and no compromise of the parent artery

A summary of 10 key points

1. A preoperative imaging workup should be performed to carefully determine the surgical candidates.
2. SEP and MEP monitoring should be applied to detect potential ischemic events during the operation.
3. It is a safe way to follow a step-wise epidural anterior clinoidectomy.
4. Peeling off the outer layer of the lateral wall of the cavernous sinus to fully expose the anterior clinoid process is helpful for safe epidural anterior clinoidectomy.
5. The cleavage between the two layers of the lateral wall of the cavernous sinus is easier to be found at the middle portion of the superior orbital fissure.
6. Using a high-speed diamond drill and continuous cool water irrigation is critical for a safe optic canal unroofing.
7. Dividing the clinoidal segment ICA sufficiently is required for a safe proximal control.
8. It is necessary to fully open the optic sheath for a safe optic nerve mobilization.
9. Distal dura ring should be cutoff sufficiently to fully release the internal carotid artery.
10. It is crucial to use muscle pieces for cranial base reconstruction at the end of the operation.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The study has been approved by the Local University Hospital Ethics Review Board (Xuanwu Hospital, Capital Medical University).

Informed consent Written consent form has been obtained from each patient.

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