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Surgical management of traumatic intracranial pseudoaneurysms: A report of 12 cases

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Aims: To investigate the characteristics and surgical treatment of traumatic intracranial pseudoaneurysms. **Materials and Methods:** Twelve patients with traumatic intracranial pseudoaneurysms were operated on in our hospital between 2000 and 2006. Their clinical characteristics, radiological features and surgical techniques were analyzed retrospectively. Four traumatic cavernous segment pseudoaneurysms underwent trapping of the internal carotid artery and others underwent "neck reinforcement and clipping" or "crevasse clipping". **Results:** Nine patients were excellent or good and two patients were poor when they discharged. One patient died of postoperative cerebral infarction. Nine patients underwent follow-up (three months to seven years) and rebleeding was not seen in them. **Conclusions:** The surgical treatment of traumatic intracranial pseudoaneurysms is risky and difficult and individualized surgical option is necessary. Understanding the compensation of intracranial blood circulation, preoperative "Matas test" if it is necessary, perioperative hemodynamics testing and the application of revascularization techniques, will help reduce surgical risk and achieve a good surgical outcome.

Key words: False aneurysm, surgery, surgical technique, traumatic aneurysm

The traumatic pseudoaneurysm is often called a pulsating hematoma which forms when the arterial wall is ruptured by trauma and the bleeding is confined only by the adventitia or the surrounding tissues.[1] After a few days, the clot undergoes fibrous organization, is excavated by the arterial flow and becomes progressively the sac of a pseudoaneurysm. It is common in peripheral arteries, but notably rare in intracranial arteries.[2] In contrast to the physical structure of a true aneurysm, which has all anatomical layers (intima, media and adventitia), the wall of a traumatic intracranial pseudoaneurysm is composed mainly of blood clot and a little fibrous tissue.[3] So these aneurysms avulse readily when clips are applied and surgery has been associated with a high rate of patency loss of the parent artery.

Some authors have described this special aneurysm as a single case. We have analyzed the clinical characteristics, radiological features and surgical techniques of traumatic intracranial pseudoaneurysms.

Materials and Methods

Patients and clinical characteristics

Between 2000 and 2006, 12 patients with traumatic intracranial pseudoaneurysms were operated on in our hospital. We retrospectively studied these patients. Twelve patients (nine males and three females) aged from 19 to 40 years (mean, 28.8 years) were diagnosed with traumatic intracranial pseudoaneurysms according to the patient history, operative observation and postoperative pathology. The clinical course of these patients is summarized in Table 1. All patients had head trauma histories and nine patients had skull base fractures. The interval between head injury and acute neurological deterioration varied from seven to 82 days (mean, 28 days). The main clinical presentations included sudden headache or unconsciousness in eight patients, recurrent epistaxis in four patients, paralysis of oculomotor nerve in three patients and visual disturbance in one patient.

Radiological features

All patients underwent computed tomography (CT) scan and digital subtracted angiography (DSA). Subarachnoid hemorrhage was seen in eight patients and intracranial hematoma was seen in three patients. Twelve aneurysms were diagnosed on DSA and they were all located on the anterior circulation arteries. The positions of aneurysms are summed up as below: cavernous sinus segment of ICA in four patients, paraclinoid or supraclinoid segment of ICA in six patients, anterior communicating aneurysm in one patient and anterior cerebral aneurysm in one patient. The DSA of some patients presented the aneurysm as a typical "cucurbit-like" or "blister-like" shape [Figure 1].

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Table 1: Summary of our cases

Case no	Age/sex	Preop grade*	Interval from injury to presentation	Clinical presentation	Location of aneurysm	Treatment	Outcome
1	26/M	II	21 D	SAH	ICA	Crevasse clipping	Excellent
2	22/M	III	15 D	SAH, ICH	ICA	Neck clipping	Poor
3	33/F	II	28 D	SAH, ICH	ACoA	Neck clipping	Good
4	19/M	/	50 D	Epistaxia	CS	Trapping	Excellent
5	25/M	I	7 D	SAH	ICA	Neck clipping	Excellent
6	40/F	II	30 D	SAH	ICA	Crevasse clipping	Good
7	30/F	/	35 D	Epistaxia	CS	Trapping	Death
8	36/M	/	14 D	Epistaxia	CS	Trapping	Excellent
9	28/M	/	21 D	Epistaxia	CS	Trapping	Excellent
10	21/M	I	25 D	SAH	ICA	Neck clipping	Excellent
11	31/M	I	82 D	SAH, ICH	ACA	Neck clipping	Excellent
12	35/M	III	10 D	SAH	ICA	Crevasse Clipping	Poor

*According to the classification of Hunt-hess. SAH - Subarachnoid hemorrhage, ICH - Intracerebral hematoma, ICA - Internal carotid artery, ACoA - Anterior communicating artery, CS - Cavernous sinus (segment)

Figure 1: A 40-year-old female patient was sent to the hospital for "sudden headache one month after head trauma". Her DSA showed right internal carotid aneurysm with a typical "cucurbit-like" or "blister-like" shape (arrow)

The MRI, which was performed in seven patients, revealed round or irregular lesions with flow-void signal in the center and mixed signal on the periphery. Moreover, the lesion size seen on the MRI was much bigger than when seen on the DSA.

Surgical management

We used the interhemispheric fissure approach in one patient with anterior cerebral aneurysm and the pterion approach for others. Four traumatic pseudoaneurysms in the cavernous sinus underwent trapping of the internal carotid artery (ligation of the common carotid artery and clipping of the supraclinoid carotid artery) after taking Matas test (carotid artery compression) for more than two weeks and being proved by DSA that there was adequate compensation from collateral hemispheric blood flow. Others underwent "neck reinforcement and clipping" or "crevasse clipping", which is described below.

After the dura matter was opened, we tore the arachnoid membrane, drained the CSF or took a ventriculostomy if hydrocephalus was present. All this was done for maximal exposure of the parent artery and minimal brain retraction. When facing a mass of blood blot or organized matter with artery pulsation [Figure 2], we were alert that the matter we faced might be a pseudoaneurysm. We gradually exposed the proximal and distal parts of the parent artery by separating the arachnoid membrane from the artery without touching the aneurysm directly. Then the thickened arachnoid membrane was converged around the aneurysm neck to reinforce the "weak neck" of this false aneurysm. The clip was applied to clamp the aneurysm neck with all this matter around. When a pseudoaneurysm avulsed from the parent artery, quick temporary blockage on both sides of the parent artery was necessary to reduce blood loss and the rupture position on this parent artery was exposed [Figure 3]. The "mini clip" was applied to clamp the crevasse paralleling the axial direction of the parent artery in case of too much lumen compromise [Figure 4]. If the neck or crevasse was located on the opposite part where we could not see directly, an encircling clip was applied. Then the blood flow in the vessels was measured after removal of the temporary clips. And the clip was adjusted under the monitoring of perioperative Doppler to guarantee enough blood flow in the parent artery.

Results

Eight aneurysm samples were taken for pathologic examinations, which revealed a lot of recent blood clots in all samples and a little fibrous tissue in some samples, without elastic or smooth muscle tissue [Figure 5].

Nine patients of these were excellent (no deficit) or good (some deficit but independent) and two patients were poor (dependent) when they were discharged. One patient with a cavernous segment pseudoaneurysm died of postoperative cerebral infarction. This patient was bleeding all the time, which could not be controlled by nasal cavity plugging and carotid artery compression, during the period of Matas test for preparation. We

Figure 2: A pulsating blood blot was observed when the aneurysm was exposed (black arrow)

Figure 3: The pseudoaneurysm avulsed from the parent artery and a crevasse (black arrow) on the bifurcation of the internal carotid artery (ICA) and the posterior communicating artery (PComA) was left

Figure 4: A "mini clip" was applied to clamp the crevasse paralleling the axial direction of the parent artery in case of too much lumen compromise

performed an emergency operation on this patient and trapped the right carotid artery. Though the bleeding was controlled, the patient suffered right hemisphere infarction proved by postoperative CT one day after

Figure 5: The pathologic picture of pseudoaneurysm wall of this patient showed there were no three layers of normal artery wall and revealed fibrous tissue without elastic or smooth muscle tissue

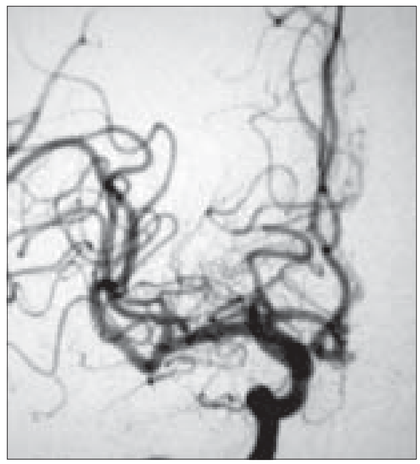

Figure 6: Postoperative DSA (eight months later) showed the aneurysm obliterated, no residues appeared and the parent artery was kept intact

surgery. The outcomes of the other three patients with cavernous segment pseudoaneurysms were excellent without any neurological deficit after enough Matas test. The two patients with poor outcome suffered one side limbs paralysis for local ischemic regions in the ganglia areas which were proved by CT.

Nine patients underwent follow-up (range: three months to seven years) and rebleeding was not seen in them. Seven patients performed DSA or CTA examinations, which revealed that aneurysms were obliterated, no residues appeared and parent arteries were kept intact [Figure 6].

Discussion

Traumatic intracranial pseudoaneurysms are rare, occurring in fewer than 1% of patients with cerebral aneurysms.[4] These aneurysms may present in a variety of ways, but are typically associated with an acute episode of delayed intracranial hemorrhage with an average time from initial trauma to aneurysm hemorrhage of approximately 21 days.[5] The treatment of this kind of aneurysm is difficult and is associated with a high morbidity. This high morbidity is secondary to current poor understanding of this kind of aneurysm, uncertain preoperative diagnosis and a high incidence of aneurysm avulsion during operation. Most importantly, it is relative to a high risk of loss of patency of parent vessels, either intentionally or as a consequence of the treatment.[6]

Etiology consideration

Skull base fracture is likely to stab and tear the arteries near the cranial base and give rise to the aneurysms of ICA in the cavernous sinus, para-clinoid or supraclinoid segments, which are the main locations of traumatic intracranial aneurysms. And the aneurysms in those locations in our group were 10 in 12 patients (83%). Gunshot wounds cause the aneurysm anywhere around the trajectory.[7] We find that whether a traumatic pesudoaneurysm forms or not has nothing to do with the severity of trauma. Almost all pseudoaneurysms in our group were caused by mild or moderate head injuries, not by severe or critical head injuries according to the GCS scores. And it was reported that the movement of cerebral falx would also cause the pseudoaneurysm by cutting the pericallosal artery under the external force. With more per nasal endoscope therapies and endovascular intervention used, more iatrogenic pseudoaneurysms were seen.[8,9]

Whether craniotomy surgeries will help to cause intracranial aneurysms has not been known by now, though there was a case report that a traumatic pericallosal aneurysm was caused by a transcallosal surgery.[10] But non-complete debridement and controlling bleeding not so well in the operation are important factors for inducing pseudoaneurysms in peripheral vessels.[9] In our group, only one patient with an anterior communicating aneurysm had a history of surgery when she suffered the head injury.

Preoperative diagnosis

Traumatic intracranial pseudoaneurysms arise from the segments of ICA near the skull base, which are not the common locations, such as bifurcation of arteries, where congenital aneurysms grow. As to the gender and age distribution, traumatic intracranial pseudoaneurysms are seen more in young males. It may be related to a high trauma incidence in these people.

Making an exact preoperative diagnosis of traumatic intracranial pseudoaneurysms is difficult, but if we consider the probability of pseudoaneurysms and do some preparations for it before the operation, we could reduce the surgical risk a lot. So while evaluating an aneurysm we need to consider the probability of a pseudoaneurysm when several factors as below appear: (1) history of head trauma, especially skull base fracture, per nasal endoscopic therapy or intravascular intervention recently; (2) young male patients; (3) typical "cucurbit-like" or "blister-like" aneurysms which are located near the skull base on DSA. Taking MRI for suspected patients with pseudoaneurysms is useful, because MRI could show the wall of aneurysms clearly. For patients with DSA negative but highly being suspected traumatic pseudoaneurysms, they would be requested to perform DSA again one to two months later, because the aneurysm cavity is very small at first and easily covered by a lot of thrombotic matter.[5]

Surgical techniques considered

Without real neck and sac wall, the dissection and preparation of the aneurismal sac for clipping involves an extremely high risk of perioperative rupture.[9] Moreover, it is difficult to gain proximal control of the parent artery because its location is always near the skull base. So, to secure these properly in surgery, perioperative hemodynamics testing techniques, demanding surgeons with exceptional skills and an experienced team are needed.

Avoiding too much compromise of parent arteries and maintaining sufficient blood flow is the key to achieving a good surgical outcome. Though we checked blood flow again and again to make sure it was good during the operation, two patients in our group still suffered from one side limbs paralysis after operations for local cerebral ischemia. More research on the changes of perioperative and postoperative cerebral blood flow is needed. It is necessary to take "Matas test" for the patients considered wrapping of ICA and we also recommend that it is acceptable way to take a preoperative "Matas test" for all highly suspected traumatic intracranial pseudoaneurysms. A taking "Matas test" before operation could increase the brain tolerance for ischemia and reduce the risk of postoperative infarction, though its validity and safety is still being debated.[11] According to our observations, all patients who performed enough "Matas test" did not appear any cerebral ischemic symptom and no accident of aneurysm rupture happened during the period of the carotid artery compression. Moreover, it helps to control epistaxis of cavernous segment pseudoaneurysms. So "Matas test" is valuable in the treatment of these aneurysms, and has its feasibility in the developing countries for its easily going.

The extracranial-intracranial bypass is another good option for this complex aneurysm. It could provide adequate blood flow to the distal parts of the arteries even when the proximal part of the parent artery is obstructed. As to endovascular techniques for the treatment of this kind of aneurysm, embolizing the pseudoaneurysm directly is highly risky because of the false sac and will arouse bleeding readily during intervention. And we only used it on the proximal artery occlusion to take the place of surgical trapping for cavernous segment aneurysms to avoid craniotomy.[12] A good news is the use of vascular covered stent, which was reported to have been used in the treatment of such false aneurysms.[7]

Conclusions

The surgical treatment of traumatic intracranial pseudoaneurysms is risky and difficult and individualized surgical option is necessary. Understanding the compensation of intracranial blood circulation, preoperative "Matas test" if it is necessary, perioperative hemodynamics testing and the application of revascularization techniques, will help reduce surgical risk and achieve a good surgical outcome.

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