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A ruptured blister aneurysm of the A1 segment of the anterior cerebral artery with communicating hydrocephalus: a case report with histo-pathological and genetic predisposition

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Informed consent: the No Objection certificate/permission for publication was sought from the family members of the deceased patient.
Abstract
Background: Cerebral arteries experience aneurysms more commonly than systemic arteries. This case report discusses a blister aneurysm that affected the anterior cerebral artery's A1 segment. The histological and genetic background is related to the aneurysm's unique presentation.

Case description: The blister aneurysm ruptured, leading to interventricular and basal subarachnoid hemorrhage. A right sided fronto-temporo-parietal decompressive craniotomy was performed to explore it, along which clipping operation was performed. A communicative hydrocephalus develops after the craniectomy for which a right parietal VP shunt was conducted that underwent malfunction. The patient succumbed due to septic shock after 4 months of VP shunt revision surgery.

Discussion: Different forms of cerebral aneurysms were analyzed, with regards to their histopathological characteristics and underlying anatomical basis of their formation. Finally, the genetic propensity of all the aneurysm was explained. There was an interventricular and basal subarachnoid hemorrhage because of the blister aneurysm's rupture. To explore it, a fronto-temporo-parietal decompressive craniotomy on the right side was done, along with a clipping operation. After the craniectomy, a right parietal VP shunt was performed, however it malfunctioned, leading to a communicative hydrocephalus. After undergoing VP shunt revision surgery for 4 months, the patient passed away from septic shock.

Conclusions: The common types of cerebral aneurysms (saccular, fusiform, mycotic and blister) and the anatomical basis of their occurrence are reviewed in-depth in the histopathological and genetic literature.

Introduction
The dorsomedial wall of the supra-clinoid portion of the internal carotid artery is frequently affected by blister aneurysms (BA), which make up 1% of intracranial aneurysms [1]. They stand out for their hemispherical shape and thin walls [2,3,4]. They are treated differently than saccular aneurysms due to their morphological and histological differences, which makes surgical exploration and routine clipping riskier [2,3,4]. Here, we present a case of a blister aneurysm of the A1 segment of the anterior cerebral artery (ACA) that manifested as post-craniotomy communicating hydrocephalus, diffuse basal subarachnoid hemorrhage (SAH), intraventricular hemorrhage (IVH), and fatal septic shock. As far as we know, there hasn't yet been a report of a case this complex. Along with discussing its embryological and anatomical basis, blister aneurysms' histological comparison to those of other aneurysm types is also covered.

Case report
Ethical considerations
This article is a case report and ethical approval was not sought from the Institutional Ethical Committee. The research review board and the Institutional Ethical Committee were however intimated about the publication of this report. The No Objection certificate/permission for publication was sought from the family members of the deceased patient. (Copy attached)

Presentation
A 48-year-old man was brought to the emergency unit after coughing, gastric upset, vomited twice, and losing consciousness unexpectedly. A blister aneurysm (0.44 mm x 1.29 mm) in A1 segment of the right anterior cerebral artery's was noticed via cerebral angiography. The entire left internal carotid artery was blocked, while the ophthalmic artery only had slight fullness as shown in Fig. 1.

The aneurysm clipping was performed. A modified Fisher Grade IV, WFNS Grade-V subarachnoid hemorrhage (SAH) measuring 51 x 35 mm in the right inferior frontal lobe and extending into the ventricular system was identified on brain CT scan as shown in Fig. 2, and Fig. 3.

There was a slight intraventricular bleeding present. There was widespread subarachnoid bleeding across the cerebral sulci and basal cisterns. No evident abnormality was visible on the chest X-ray. External ventricular drain (EVD) was left in place during right-sided Fronto-Temporo-Parietal (FTP) craniectomy with intracranial hemorrhage (ICH) evacuation. A communicative hydrocephalus develops after the craniectomy. There was a right parietal VP shunt. Right frontotemporal, right anterior basal ganglia, and bilateral superior frontal parietal cortex regions all showed acute infarcts after craniotomy, according to magnetic resonance imaging (MRI) of the brain as shown in Fig. 3.

The patient made a full recovery and was released after achieving hemodynamic stability. The patient started having shunt malfunction four months after being released, and eventually passed away from septic shock.

Treatment
Using ‘?’ question mark-shaped incision, a right-sided fronto-temporo-parietal decompressive craniectomy was carried out. The cranium was approached from the side, and a stellate-pattern durotomy was performed. Right side A1 was traced medially to identify an aneurysm, and both A1s were used to take proximal control. The use of temporary clips lasted for around 15 minutes. The Huebner recurrent artery was preserved, and a permanent curved clip was placed in the aneurysm's neck. The YASARGIL curved aneurysm clip (9 mm x 1) is made of titanium. A ventricular drain was placed and anchored externally to help with ICH evacuation after the wound was healed in layers.
The right parietal VP shunt procedure was performed using a curvilinear incision at the right parietal occipital area and a medium pressure Chabra VP shunt after the patient acquired Post Craniectomy communicative hydrocephalus. At Frazier's point, the right side, a burr hole was made in the muscle. Distal end of shunt tunnelling was inserted. The ventricle end was placed and secured at the 110 point. A VP shunt malfunctioned four months later. The following day's CT scan of the brain indicated Sinking skin flap syndrome, which suggests excessive draining. A revision of the programmable VP shunt was performed. After restoring the flap level and achieving hemodynamic stability, the patient was discharged.

**Postoperative course**
After clipping surgery, the patient was awake, alert, and hemodynamically stable. After 48 hours of a stable condition, the patient was released after the VP shunt was successfully implanted. Four months later, the VP shunt failed. A shunt revision was performed, and the patient was sent home after being determined to be hemodynamically stable.

**Discussion**
Blister aneurysms rarely may also affect the anterior communicating artery and basilar artery in addition to the Internal carotid artery [5].

**Histo-pathological basis of cerebral aneurysms**
Internal elastic lamina (IEL) disintegration, irregular luminal intimal surface, myo-intimal hyperplasia, disorganized muscular media, hypo-cellularization, and inflammatory cell infiltration are pathogenically suggestive of intracranial aneurysms. **Table 1** shows the comparative analysis of histo-pathological features of common types of cerebral aneurysms.

**Anatomical basis of cerebral aneurysms**
Because they are composed of muscle, the cerebral arteries differ from systemic (elastic) arteries in that they have a thinner adventitia and a more developed IEL. Systemic arteries also include more elastic fibres than muscle arteries do. They lack an external elastic lamina and a vasa vasorum. The vasa vasorum, a network of microvasculature across the tunica adventitia, supports nutritive and drainage processes by eliminating metabolic waste from the arterial vessel walls and delivering oxygen. The pathophysiology of atherosclerosis, aneurysms, and vasculitis may be passively influenced by the vasa-vasorum transfer of several inflammatory mediators [13].
Intramural hematoma is caused by repeated bleeding from the vasa vasorum into the tunica adventitia; it gradually disappears. This causes inflammation in the vessel wall and the release of growth factors, which encourages the proliferation and thinning of the vessel wall and the development of aneurysms [14].

The location/position of the intracranial artery circulation affects the development of a cerebral aneurysm. The cerebral artery branching sites offer a sensitive region for the establishment and growth of brain aneurysms [15,16] because of high intravascular turbulence and aberrant arterial wall shear stress caused by IEL fenestrations and tunica media loss.

**Genetic basis of cerebral aneurysms:**

The hypothesis that there is a significant hereditary component to the development of cerebral aneurysms is raised by a genetic predisposition to these lesions. At least five vulnerable loci have been discovered through linkage studies (1p34.3-36.13, 4q32, 7q11, 19q13, and Xp22). A meta-analysis of all the major genome-wide association studies that included sizable populations (8q11, 9p21, 4q31.23, 12q22, 20p12, 2q33, and 7q13) revealed several risk loci to be consistent [17,18]. However, expression profiling studies of aneurysm formation have revealed the genes involved in cell proliferation, adhesion, migration, extracellular matrix interaction, and general inflammatory and pathogenic response [17].

The risk of having an intracranial aneurysm is further increased by associated Monogenic Disorders like Loeys Dietz syndrome (TGFBR1, TGFBR2, SMAD2, SMAD3), Microcephalic/Majewski’s Osteodysplastic Primordial Dwarfism, type II (PCNT), autosomal dominant polycystic kidney disease (PKD1, PHD2), neurofibromatosis type-IV Ehlers-Danlos syndrome (vascular type) (COL3A1), and Marfan syndrome (FBN1) [19,20]

Meta-analyses have linked SOX17, which has been identified as a highly frequent gene in studies of intracranial aneurysms [21], in this context. The vessel wall remodelling gene 9p21/CDKN2, which is involved, has drawn the most interest and has the strongest connection. Although the research on EDNRA and SOX17 has not been as detailed as that on CDKN2, they are two other possible genes that might be implicated in the emergence of IAs [22].

**Declaration of patient consent**

The authors certify to having obtained all relevant patient consent papers. The patient(s) have given their agreement for his photos and other clinical information to be published in the journal by filling out the form. The patient’s relatives are aware that their names and initials will not be published, and that while every effort will be taken to keep their identities hidden, anonymity cannot be guaranteed.
References


Fig. 1

Fig. 1: Cerebral angiography showing the aneurysm in the A1 segment of the anterior cerebral artery.
Fig 2: Brain CT showing the foci’s of subarachnoid hemorrhage and interventricular hemorrhage and craniotomy being conducted.

Fig 3: Brain CT showing the intracranial hemorrhage and dilated ventricular horns.

Fig 4: Brain MRI Right frontotemporal, right anterior basal ganglia, and bilateral superior frontal parietal cortex regions all showed acute infarcts after craniotomy.
Table 1: Comparative analysis of common types of Cerebral Aneurysms based on histo-pathological findings

<table>
<thead>
<tr>
<th>Sl. no</th>
<th>Type of Cerebral Aneurysm</th>
<th>Histo-pathological findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Saccular</td>
<td>Intima-media-adventitia layers are normal and there is no internal elastic lamina [6]. Numerous disordered mural cells (fibroblasts, myofibroblasts, and vascular smooth muscle cells) [6, 7] The endothelial layer that lines the luminal surface is frequently organized erratically [6,7]. Endothelial cells have discernible spaces between them [6,7].</td>
</tr>
<tr>
<td>2</td>
<td>Fusiform/dissecting</td>
<td>With or without noticeably thickening of the intima, there is focal loss of the internal elastic lamina along a portion of the vessel wall [8].</td>
</tr>
<tr>
<td>3</td>
<td>Mycotic</td>
<td>Transmural inflammation, necrosis, and thrombosis in varying degrees [9]. Most of the time, tissue samples exhibit bacterial staining [10].</td>
</tr>
<tr>
<td>4</td>
<td>Pseudo</td>
<td>‘Proteoglycans are heavily deposited in the pseudoaneurysm wall, along with a noticeable buildup of endothelial and smooth muscle cells. The tissue stresses produced by the artery pressures close to the pseudoaneurysm wall are probably responsible for this reaction [11].</td>
</tr>
<tr>
<td>5</td>
<td>Blister</td>
<td>Focal wall defects lacking the typical collagenous layer and covered only by a thin layer of adventitia and fibrous tissue [12].</td>
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