Contents lists available at ScienceDirect

Brain and Spine

journal homepage: www.journals.elsevier.com/brain-and-spine

Unraveling cerebral saccular aneurysm mimics: Case report and review of the literature

Senne Broekx [a,*], Lotte Keulen [b], Tomas Menovsky [a,c]

[a] Department of Neurosurgery, Antwerp University Hospital, 2650, Edegem, Belgium
[b] Department of Pathology, Antwerp University Hospital, 2650, Edegem, Belgium
[c] Faculty of Medicine, Antwerp University, 2650, Edegem, Belgium

ARTICLE INFO

Handling Editor: Dr W Peul

Keywords:
Aneurysm mimics
Middle cerebral artery
Thrombosis
Ischemic stroke
Case report

ABSTRACT

Introduction: Aneurysm mimics, such as an occluded cerebral artery, vascular loops or infundibular dilatations, should be beard in mind when planning a craniotomy for the treatment of an aneurysm. Although ischemic stroke caused by clot migration from an aneurysmal cavity has been described, an ischemic event should raise awareness of potential MCA branch occlusion instead of an aneurysm.
Research question: We provided a scaffold that could be used to differentiate other saccular aneurysm mimics. We explored the current literature concerning ACM segment occlusions initially misdiagnosed as a saccular aneurysm.
Material and methods: We present the case of a 58 year old female who experienced a subarachnoid hemorrhage. CT angiography could not reveal an underlying aneurysm. She had a medical history of right carotid artery occlusion with secondary ischemic stroke and left spastic hemiparesis. An aneurysm of the right MCA was suspected and she was scheduled for explorative craniotomy.
Results: Peroperatively we did not encounter an aneurysm, although a thrombosed branch of the right MCA was noted. The most proximal part of the branch was still patent, mimicking a saccular aneurysm on angiographic records.
Discussion and conclusion: Aneurysm mimics can potentially expose patients to unnecessary exploratory craniotomies in the presumptive diagnosis of a saccular aneurysm. MRI 3D-CISS can be a helpful adjunct, since MRA and DSA are frequently not sufficient. Although ischemic stroke can be caused by clot migration from an aneurysmal cavity, an ischemic event should raise awareness of potential cerebral artery occlusion.

1. Introduction

Aneurysm mimics, such as an occluded cerebral artery, vascular loops or infundibular dilatations, should be beard in mind when planning a craniotomy for the treatment of an aneurysm (Park et al., 2008). Cerebral artery occlusion is mostly caused by atherosclerosis, a congenital atretic artery, cerebral artery dissection or clot migration from an aneurysmal cavity (Park et al., 2008; Komiyama et al., 2001). Although ischemic stroke caused by clot migration from an aneurysmal cavity has been described, an ischemic event or presence of cardiovascular risk factors should raise awareness of potential MCA branch occlusion instead of an aneurysm. Occlusion of cerebral arteries misinterpreted as an aneurysm has been described in previous literature, especially in association with the posterior circulation, although this entity can occur in the anterior circulation as well (Park et al., 2008; Komiyama et al., 2001; Liu et al., 2022; Kawanishi et al., 2003; Pearl et al., 2008; Shibahashi et al., 2012; Takeuchi et al., 2015; Yu et al., 2013). As a primary objective we provided a resumptive scaffold that could be used by other neurosurgeons in order to differentiate between these saccular aneurysm mimics, since MRA and digital subtraction angiography (DSA) are not always able to differentiate between these entities. As a secondary objective, we explored the current literature concerning ACM segment occlusions initially misdiagnosed as a saccular aneurysm.

2. Case presentation

We present the case of a 58 year old female who came to our

* Corresponding author. Department of Neurosurgery, Antwerp University Hospital, Koerweg 20, 3600, Genk, Belgium.
E-mail address: senne.broekx@gmail.com (S. Broekx).

https://doi.org/10.1016/j.bas.2023.101786
Received 10 May 2023; Received in revised form 11 July 2023; Accepted 25 July 2023
Available online 26 July 2023

Neurosurgical attention in September 2022 after experiencing a subarachnoid hemorrhage (SAH). Relevant examination of her medical records showed right carotid artery occlusion with secondary ischemic stroke and left spastic hemiparesis (2020), nicotine (forty packyears) and ethanol abuse (one bottle of wine a day). She was taking salicylic acid 100 mg a day in the context of her ischemic event. Last year, she was admitted multiple times to our emergency department secondary to falls in the context of ethanol abuse.

Clinical examination showed E3M6V4, retrograde amnesia and an agitated state, a left supraorbital bruise, a left central facial palsy and a left spastic hemiparesis. Vital signs were within normal limits. Laboratory findings showed no signs of infection and normoglycemia, although an ethanol intoxication was observed (2.1 g/L).

A conventional brain CT scan showed old ischemic sequellae at the right basal ganglia and right temporal lobe, as well as subarachnoid blood within the left frontoparietal region, Sylvian fissure and quadrigeminal cistern. No intraventricular hemorrhage nor skull fractures were observed (see Fig. 1). Initial CT angiography could not reveal an underlying aneurysm (see Fig. 2).

Since she was found by her family lying on the bathroom floor with signs of ethanol intoxication, a traumatic SAH was initially suspected. The exact trauma mechanism was unclear, however. By means of revision of the initial CT angiographic records and 3D reconstruction images (see Fig. 2) during our cerebrovascular board meeting, an aneurysm of the right MCA bifurcation was suspected and our patient was scheduled for an explorative craniotomy. An endovascular approach was not possible due to internal carotid artery occlusion.

We performed a transsylvian approach through a right pterional minicraniotomy. Peroperatively we did not encounter an aneurysm. Instead, a thrombosed branch of the right MCA was noted (see Fig. 3). The most proximal part of the branch was still patent, mimicking a saccular aneurysm on angiographic records. We performed a resection of the thrombosed branch with clipping of the proximal and distal segments of the arteriotomy. Histopathological examination confirmed a circumferential thrombosed MCA segment with fibrin covering of the tunica intima and preservation of the lamina elastica and tunica media. Liquified blood and atherosclerotic debris evacuated after arteriotomy, leading to a partial patent lumen on histopathological examinations (see Fig. 4). Peroperative and postoperative course was uneventful and no new neurological deficits were encountered.

3. Discussion

3.1. Saccular aneurysm mimimcs

Based on the current literature, we provide a summary of the clinical and radiographical tools and clues that could help in the differentiation between a cerebral artery segment occlusion and a saccular aneurysm, omitting unnecessary exploratory surgery (see Table 1) (Komiyama et al., 2001). As described by many authors, since MRA and DSA visualize intravascular blood flow and the lumen of the cerebral arteries, these investigations are not always sufficient to differentiate both entities (Komiyama et al., 2001; Kawanishi et al., 2003; Pearl et al., 2008; Shibahashi et al., 2012; Lee et al., 2007). However, as described by Pearl et al., recanalization of the blood vessel's lumen on consecutive DSA is self-evidently suggestive of temporary occlusion rather than a saccular

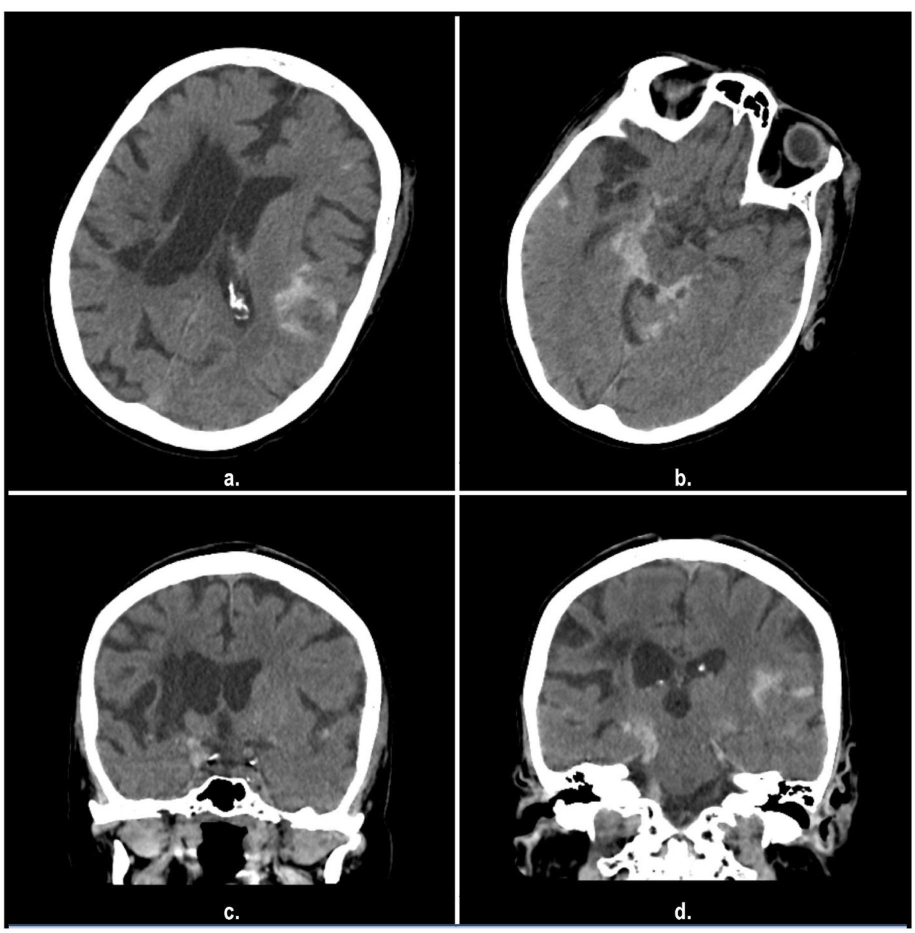

Fig. 1. Conventional brain CT scan showing old ischemic sequellae at the right basal ganglia and right temporal lobe, as well as subarachnoid blood at the left frontoparietal area, as well as in the left Sylvian fissure and within the quadrigeminal cistern. No intraventricular hemorrhage nor skull fractures were observed. a. & b.: conventional CT in axonal plane | c. & d.: conventional CT in coronal plane.

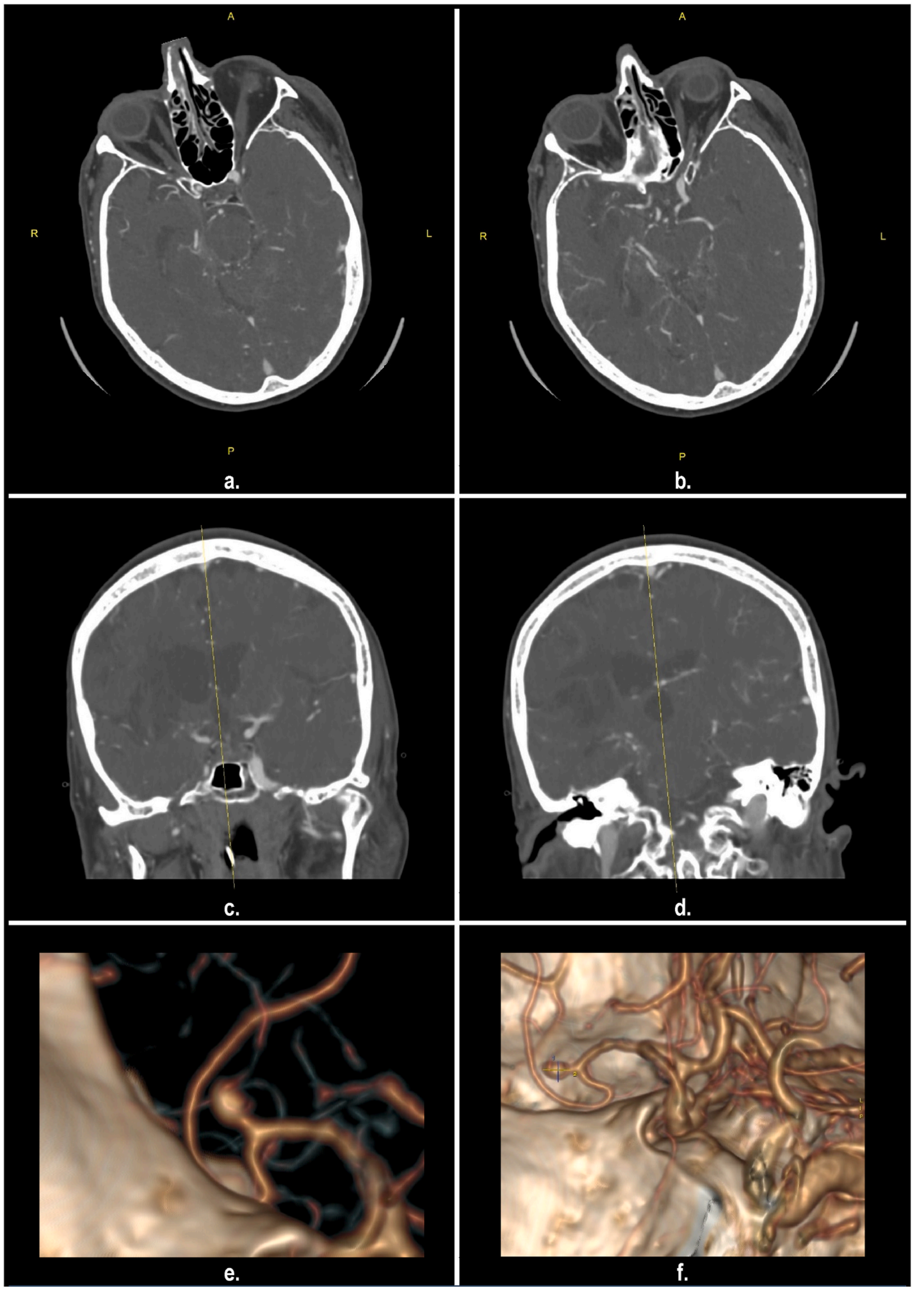

Fig. 2. Brain CT angiography showing no aneurysm could be observed. Second-look observation by vascular board showed a possible MCA bifurcation aneurysm on the right side. a. & b.: CT-angiography in axonal plane | c. & d.: CT-angiography in coronal plane | e. & f.: 3D reconstruction images in which the presumbed aneurysm can be seen.

aneurysm (Pearl et al., 2008). On the other hand, progression of stenosis on consecutive DSA examinations is also suggestive of thrombosis, as was observed by Shibahashi et al. (2012).

The shape of the patent lumen can also help in the differentiation, since in most cases a conical shape is suggestive of chronic vascular occlusion, while a dilated globoid stump is only rarely observed in a thrombosed artery segment (Park et al., 2008). Another way to differentiate both entities is the phenomenon that in most thrombosed MCA branches, the diameter narrows at the fundus of the proximal stump, in contrast to saccular aneurysms.

However, patency of the most proximal segment of a thrombosed MCA branch can mimic a saccular aneurysm on angiographic records (see Fig. 5). MRI with 3D constructive interference in steady state sequences (3D-CISS) can be a useful adjunct for establishing the correct diagnosis (Komiyama et al., 2001; Shibahashi et al., 2012). 3D-CISS provides a high spatial resolution of brain anatomical structures and offers excellent visualization of structures within the cerebrospinal fluid spaces (Komiyama et al., 2001). Furthermore, it can identify structural continuity between the patent segment and the occluded blood vessel (Komiyama et al., 2001). Other MRI sequences include fast imaging employing steady state acquisition (FIESTA) (Shibahashi et al., 2012). However, Park et al. reported that a very thin atretic trunk was not detected on FIESTA sequences, even after explorative craniotomy (Park et al., 2008).

Previous ischemic stroke or patients with risk factors of atherosclerosis should warrant the neurosurgeon of the possibility of thrombosis of a cerebral artery segment, expecially when the location of the suspected aneurysm/occlusion is congruent with the vascular territory of the ischemic region (Yu et al., 2013). However, to make the differentiation between both entities even more complicated, ischemic stroke caused by

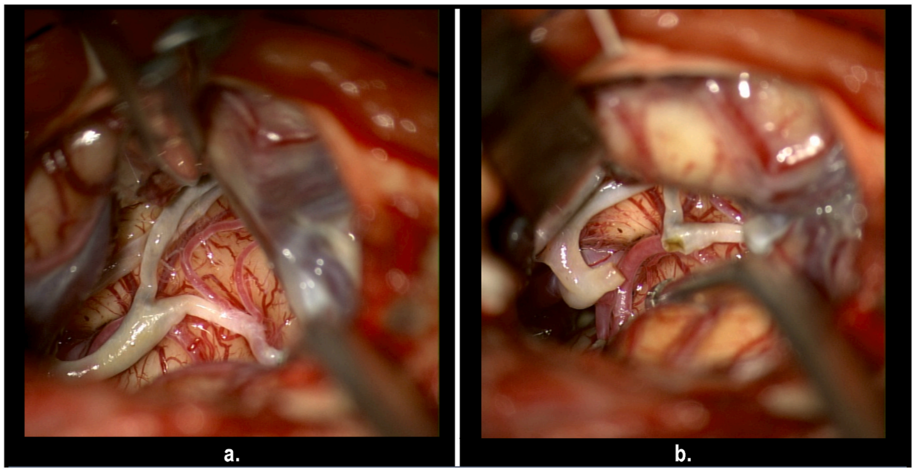

Fig. 3. Figure showing the peroperative findings after pterional craniotomy and transsylvian approach. a: thrombosis and atherosclerotic discoloration of M2 segment and partial thrombosis of bifurcation with patency of proximal stump | b: view after resection of the thrombosed segment with evacuation of atherosclerotic debris prior to clipping of the proximal and distal segments.

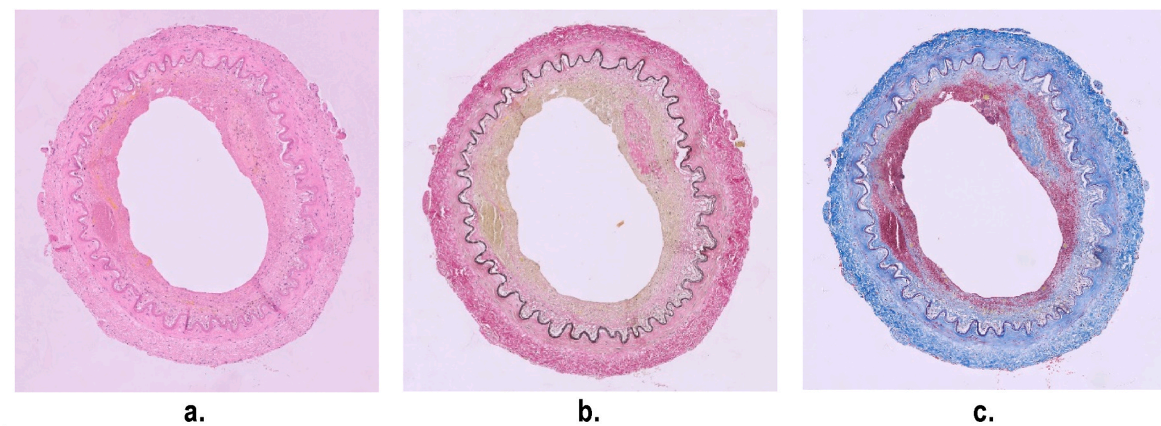

Fig. 4. Histopathological examination showing a thrombosed MCA segment with fibrin covering of the tunica intima and preservation of the lamina elastica and tunica media. A circumferential thrombus with partial organization (right upper kwadrant on histopathological specimens) can be observed. Liquified blood and atherosclerotic debris evacuated after arteriotomy, leading to a partial patent lumen on histopathological examinations. a.: hematoxylin and eosin staining (zoom x10) | b.: elastin staining (zoom x10) | c.: masson trichrome staining (zoom x10).

Table 1
Table showing a resumptive summarization that could be used in the differentiation of saccular cerebral aneurysm mimics.

1	▪ Recanalization on consecutive DSA is suggestive of (temporary) occlusion
2	▪ Progression of stenosis suggestive of occlusion
3	▪ Shape of patent lumen (conical shape suggestive of occlusion, globoid shape suggestive of saccular aneurysm)
4	▪ Narrowing proximal stump diameter at fundus suggestive of occlusion
5	▪ Structural continuity on 3D-CISS is suggestive of occlusion
6	▪ Previous ischemic stroke/risk factors for atherosclerosis suggestive of occlusion
7	▪ Association of immature cerebral arteries (immature PcomA e.g.) are suggestive of infundibular dilatation
8	▪ Intramural hematoma suggestive of cerebral artery dissection
9	▪ Localized moyamoya phenomenon distal to the site of occlusion suggestive of (chronic) occlusion

clot migration from an aneurysmal cavity has been described in previous literature. Pearl et al. formulated that 3.3% of patients with cerebral aneurysms present with symptoms secondary to embolization from an aneurysmal sac, most commonly within the MCA territory (Pearl et al., 2008).

Comparing the vascular anatomy of both sides can be helpful as well (Pearl et al., 2008). For example, the association of immature blood vessels (immature posterior communicating artery e.g.) are suggestive for an infundibular dilatation rather than a saccular aneurysm (Kawanishi et al., 2003). In the case of a MCA trifurcation, a correct diagnosis is even more challenging, since a vascular stump of one of the trunks can

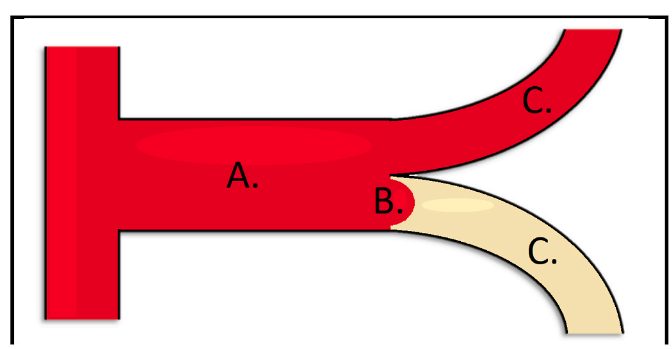

Fig. 5. Schematic representation of the thrombosed ACM segment mimicking a saccular aneurysm. a: patent M1 segment of the MCA | b: patent proximal stump of the M2 segment of the MCA mimicking a saccular aneurysm | c: M2-segment of the MCA.

easily be misdiagnosed as a MCA bifurcation aneurysm, as was the case described by Park and Lee et al. (Park et al., 2008; Yu et al., 2013; Lee et al., 2007). A MCA trifurcation is only present in about 12–29% of anatomical specimens (Park et al., 2008).

An intramural hematoma should warrant for recent cerebral artery dissection (Komiyama et al., 2001). This phenomenon will only be observed in the acute phase of the dissection, however (Komiyama et al., 2001).

A final tool that can be used in the differentiation of cerebral aneurysm mimics is the moyamoya phenomenon, in which progressive occlusion induces the formation of collateral perforating vessels near the stenosis (Park et al., 2008; Shibahashi et al., 2012; Yu et al., 2013). However, this phenomenon will only be seen in chronic occlusive-cerebrovascular disease and will be absent when a cerebral blood vessel is occluded abruptly by a distal thrombus (Park et al., 2008). Therefore, the absence of the moyamoya phenomenon does not rule out a focal occlusion. Furthermore, cerebral aneurysms are frequently encountered in patients with moyamoya disease (Yu et al., 2013). The moyamoya phenomenon is mostly associated with the occlusion of the proximal MCA, unlike moyamoya disease involving mostly the distal internal carotid artery (Park et al., 2008). Therefore, an unusual location of the moyamoya phenomenon may provide a clue to the diagnosis of a vascular stump (Yu et al., 2013).

In contrast to other authors who performed no further surgical intervention after observation of the thrombosed cerebral artery segment, we performed a resection of the thrombosed MCA segment (Komiyama et al., 2001; Kawanishi et al., 2003; Yu et al., 2013). As described by Komiyama et al., we also observed a yellowish discoloration of the occluded segment, caused by atherosclerotic changes within the blood vessel (Komiyama et al., 2001). Park et al. also described a resection of the atretic trunk of a MCA trifurcation (Park et al., 2008). Shibahashi and Lee et al. reported on a STA-MCA-bypass in order to restore vascularization distal to the thrombosed segment, while Yu et al. established a revascularization by means of an encephalomyoarteriosynangiosis (EMAS) (Shibahashi et al., 2012; Yu et al., 2013; Lee et al., 2007).

3.2. Digital subtraction angiography versus magnetic resonance imaging

In order to enhance practical insights in the diagnostic modalities available for the differentation of the diverse group of saccular aneurysm mimics, the main advantages and disadvantages of DSA and MRI/MRA will be briefly discussed. An extensive and detailed description of the working mechanisms of these tools, as well as novel modalities – such as molecular imaging –, are beyond the scope of this review and can be consulted in other reviews (Turan et al., 2018).

MRI/MRA uses a strong magnetic field forcing protons to align within this field in order to produce detailed images of the cerebral vascular anatomy and surrounding brain structures (Turan et al., 2018). This diagnostic modality has the advantage of being a noninvasive tool, without the need of ionizing radiation and iodinated contrast agents (Turan et al., 2018). Earlier meta-analyses have shown that MRA is approximately equivalent to DSA in the detection of intracranial aneurysms, with a sensitivity of 87% and a specificity of 92% (Turan et al., 2018). With advances in the technology of ultrahigh-resolution MRI, the accuracy of this modality will also increase (Turan et al., 2018). MRI provides other benefits as well, such as the evaluation of wall enhancement in order to predict the natural evolution and rupture status of an aneurysm, as well as evaluating wall permeability as a predictor for aneurysm wall stability and the presence of an intramural hematoma (Turan et al., 2018). Furthermore, as already mentioned, 3D-CISS MRI provides a high spatial resolution of surrounding anatomical brain structures, as well as the identification of structural continuity of cerebral blood vessels and therefore the presence of a dead-end artery. The disadvantage of MRI/MRA is the steep decline in sensitivity and increase in false-negative results according to aneurysm size (<5 mm) or location (along the internal carotid artery and anterior communicating artery) (Turan et al., 2018). Furthermore, this diagnostic modality is not always compatible with other medical devices, such as older aneurysm clips (Turan et al., 2018).

DSA uses iodinated contrast agents that are injected in the cerebral vasculature by means of an intravascular catheter, which are detected by a series of x-ray radiations. Due to a higher spatial resolution, it remains the reference standard for imaging the cerebral vasculature (Turan et al., 2018). DSA has the advantage of a higher sensivity and specificity compared to MRI/MRA (Turan et al., 2018). It has proven a higher reliability for smaller (<5 mm) aneurysms (Turan et al., 2018). On the other hand, DSA requires the usage of iodinated contrast agents, as well as ionizing radiation (Turan et al., 2018). Catheter angiography implicates some intrinsic risks, such as iatrogenic stroke, vessel rupture and infection (Turan et al., 2018). Furthermore, DSA is associated with a higher monetary cost for the patient and is only available in specialized health care centers (Turan et al., 2018).

Although DSA remains the gold standard for the preoperative planning and follow-up of patients with a cerebral aneurysm (ruptured or unruptured), MRI 3D-CISS remains the preferred diagnostic tool for the differentiation between saccular aneurysms and cerebral vascular occlusions (Turan et al., 2018).

4. Limitations

There are several limitations which need to be acknowledged. First, due to the fact that only published studies and articles written in English were selected, selection bias was unavoidable. Second, time to follow-up of our patient is rather limited, although this was not the main focus of our review. Third, we did not perform MRA nor DSA examinations, since an aneurysm was suspected based on CT angiographical findings. Finally, although literature reviews are generally accomplished by two authors lege artis, this review was performed by only one author. In retrospect, by analysing the clues suggested in current literature, we should have planned a MRI in order to differentiate between a saccular aneurysm and an artery occlusion. Therefore, in case of an aberrant cerebral vascular anatomy, neurosurgeons should be aware of the potential presence of a dead-end artery. The reliability and generalizability of our case report should be interpreted within the perspective of these aforementioned limitations. However, since our conclusions are based on all available literature concerning this topic, our review forms a useful scaffold covering the most important clinical concepts and practical suggestions in the diagnostic workup of saccular aneurysm mimics.

5. Conclusion

Aneurysm mimics, such as an occluded cerebral artery, vascular loops or infundibular dilatations, can potentially expose patients to unnecessary exploratory craniotomies in the presumptive diagnosis of a saccular aneurysm. Based on clinical and radiographical tools and clues provided in current literature, we provided a resumptive scaffold that could be used by neurosurgeons in the differentiation between a cerebral artery segment occlusion and a saccular aneurysm. MRI 3D-CISS can be a useful adjunct, since MRA and DSA are frequently not sufficient. Although ischemic stroke can be caused by clot migration from an aneurysmal cavity, an ischemic event should raise awareness of potential cerebral artery occlusion.

Ethical approval

For this type of study formal consent is not required.

Funding

No funding was received for this research.

Statement

During this case report, the CARE statement guidelines were followed.

Informed consent

Additional informed consent was obtained from all individual participants for whom identifying information is included in this article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

No acknowledgments.

References

Kawanishi, M., Sakaguchi, I., Miyake, H., 2003. Occlusion of the posterior communicating artery mimicking cerebral aneurysm: case report. Neurol. Res. 25 (5), 543–545.

Komiyama, M., et al., 2001. Distal stump of an occluded intracranial vertebral artery at the vertebrobasilar junction mimicking a basilar artery aneurysm. Acta Neurochir. 143 (10), 1013–1017.

Lee, J.H., et al., 2007. Occlusion of the middle cerebral artery branch mimicking aneurysm. J Korean Neurosurg Soc 42 (5), 413–415.

Liu, Y., et al., 2022. Occlusion of the anterior cerebral artery mimicking a cerebral aneurysm: clinical presentation and literature review. J. Neurol. Surg. Cent. Eur. Neurosurg. 83 (6), 606–610.

Park, J., et al., 2008. Occluded vascular stump mimicking middle cerebral artery bifurcation aneurysm: report of 2 cases. Surg. Neurol. 70 (6), 664–667. ; discussion 667.

Pearl, M.S., Tamargo, R., Gailloud, P., 2008. Middle cerebral artery branch occlusion mimicking a saccular aneurysm on 3D digital subtraction angiography. J. Neurosurg. 109 (6), 1123–1125.

Shibahashi, K., Kimura, T., Morita, A., 2012. Middle cerebral artery atherosclerotic stenosis mimicking a cerebral aneurysm: pitfall in preoperative evaluation of cerebral aneurysms. Br. J. Neurosurg. 26 (3), 406–408.

Takeuchi, S., et al., 2015. Middle cerebral artery branch occlusion mimicking an aneurysm. Asian J Neurosurg 10 (2), 117–118.

Turan, N., et al., 2018. Current perspectives in imaging modalities for the assessment of unruptured intracranial aneurysms: a comparative analysis and review. World Neurosurg 113, 280–292.

Yu, J., Zhang, Y., Wang, H., 2013. Occluded middle cerebral artery vascular stump mimicking aneurysm: case report and review of literature. Pakistan J. Med. Sci. 29 (3), 869–871.