89 Middle Cerebral Artery Bifurcation Aneurysm: Incidental Tandem Aneurysms of the Middle Cerebral Artery; Periprocedural Rupture of a Temporal Artery Aneurysm During Coil Insertion; Sealing of the Rupture Site and Parent Vessel Occlusion with nBCA; Subsequent Coil Occlusion of an MCA Bifurcation Aneurysm Assisted by a pCONUS1 HPC Device Under Mono-antiaggregation with ASA Only

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Abstract

A 39-year-old female patient was referred to a neurologist by her general practitioner for the work-up of headache. The performed MRI/MRA examination revealed two tandem aneurysms of the right middle cerebral artery (MCA): the first aneurysm arose from the first temporal branch of the MCA measuring 3 mm, the second aneurysm was located at the MCA bifurcation with a diameter of 6 mm. In accordance with the patient's wishes endovascular treatment of both aneurysms was planned. During coiling of the smaller aneurysm, a coil loop ruptured the aneurysm wall and the extravasation did not resolve with temporary balloon occlusion of the M1/M2 segment. Therefore, the aneurysm and its parent artery were occluded with nBCA injection under balloon protection, which resulted in instantaneous hemostasis. The resulting right temporal lobe infarct remained asymptomatic. The second aneurysm was treated 3 weeks later by pCONUS1 HPC assisted coil occlusion under ASA monotherapy. A follow-up DSA 3 months later confirmed the satisfactory occlusion of both aneurysms. The management of periprocedural aneurysm rupture and the intracranial use of coated stent derivatives with reduced thrombogenicity are the main topics of this chapter.

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Keywords

Middle cerebral artery · Tandem aneurysms · Periprocedural aneurysm rupture · nBCA · Coil occlusion · pCONUS1 HPC · Mono-Antiaggregation · ASA

Patient

A 39-year-old female presented with headaches. Apart from a 21 pack-year smoking history, her medical history was unremarkable.

Diagnostic Imaging

MRI, MRA, and DSA showed tandem aneurysms of the right MCA. The proximal aneurysm (fundus diameter 3 mm) was located at the origin of the first temporal branch; the distal aneurysm (fundus diameter 6 mm) was located at the MCA bifurcation (Fig. 1).

Treatment Strategy

The aim of the treatment was to prevent aneurysm rupture. Microsurgical clipping was recommended and offered but rejected by the patient. Coil occlusion of both aneurysms was the medical team's second choice but was the patient's preferred strategy. Endovascular intervention was scheduled with the intention of treating both aneurysms in a single session.

Treatment

Procedure #1, 25.06.2018*:* endovascular coil occlusion of an incidental small aneurysm of the right MCA, arising from the first temporal branch; perforation of the aneurysm wall by a coil loop, occlusion of both the aneurysm and the parent artery with balloon-protected nBCA injection

Anesthesia: general anesthesia; 3× 500 mg thiopental (Trapanal, Nycomed) IV, 6× 4 μg desmopressin (Minirin, Ferring) IV

Premedication: 1× 500 mg ASA (Aspirin, Bayer Vital) PO and 1× 30 mg prasugrel (Efient, Daiichi Sankyo) PO 5 days before the treatment, followed by 1× 100 mg ASA PO daily and 1× 10 mg prasugrel PO daily; response tests on the morning of the procedure: Multiplate (Roche Diagnostics) (ARU): ADP 5, ASPI 11, TRAP 105; VerifyNow (Accumetrics): ARU 455, P2Y12: 100% inhibition; dual platelet function inhibition

Access: right common femoral artery; *sheath:* 8F (Terumo); *guide catheter:* 8F Guider Softip (Boston Scientific); *microcatheters:* Excelsior SL-10 (Stryker) for the coil, Marathon (Medtronic) for nBCA; *microguidewires:* Synchro2 0.014″ 200 cm (Stryker) for Excelsior SL-10, Mirage 0.008″ (Medtronic) for Marathon

Implant: 1× coil: Axium 3D 2/6 (Medtronic)

Balloon: Scepter XC 4/11 (MicroVention)

Liquid embolic agent: nBCA (Glubran2, GEM), ethiodized oil (Lipiodol, Guerbet). 1:1, 0.2 cc injected

Course of treatment: via the 8F guide catheter, an Excelsior SL-10 microcatheter was inserted into the right M1 segment, and the aneurysm sac, arising from the first temporal branch, was catheterized. A 2/6 mm 3D coil was gently inserted into the aneurysm sac. The coil was repositioned several times before a stable position was achieved. During these maneuvers, the tip of the microcatheter remained at the ostium of the aneurysm. No undue force was required or applied. During the coil deployment under roadmap imaging, the last loop of the coil was seen to protrude anteriorly, directly through the aneurysm wall. Contrast medium injection of the right ICA via the guide catheter showed massive extravasation from the aneurysm. The coil was detached and a Scepter balloon catheter was inserted into the right M1/M2 segment and gently inflated. During this phase of the procedure, the blood pressure was lowered to a target systolic value of 120 mmHg and the sedation was deepened. Desmopressin was given to counteract the ASA effect on the platelet function. After several cycles of balloon inflation and deflation, the extravasation decreased but did not cease, as demonstrated on repeated DSA runs. The tip of a Marathon catheter was therefore inserted into the

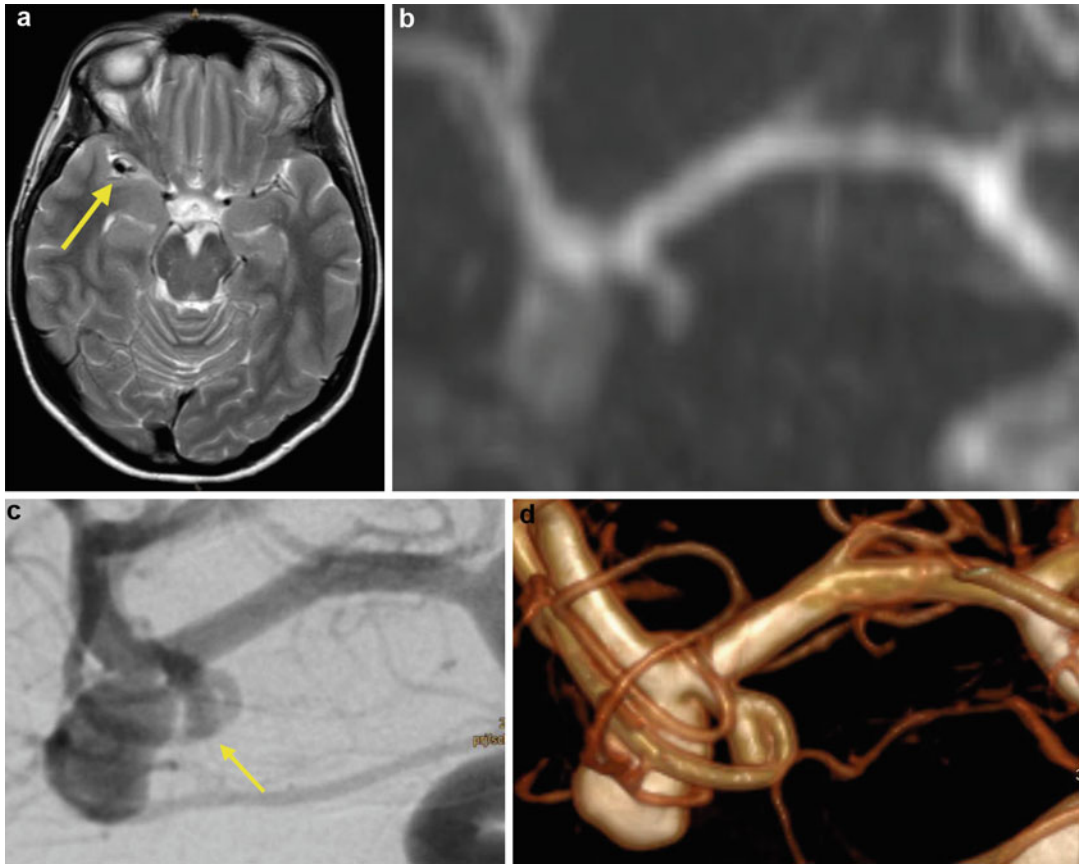


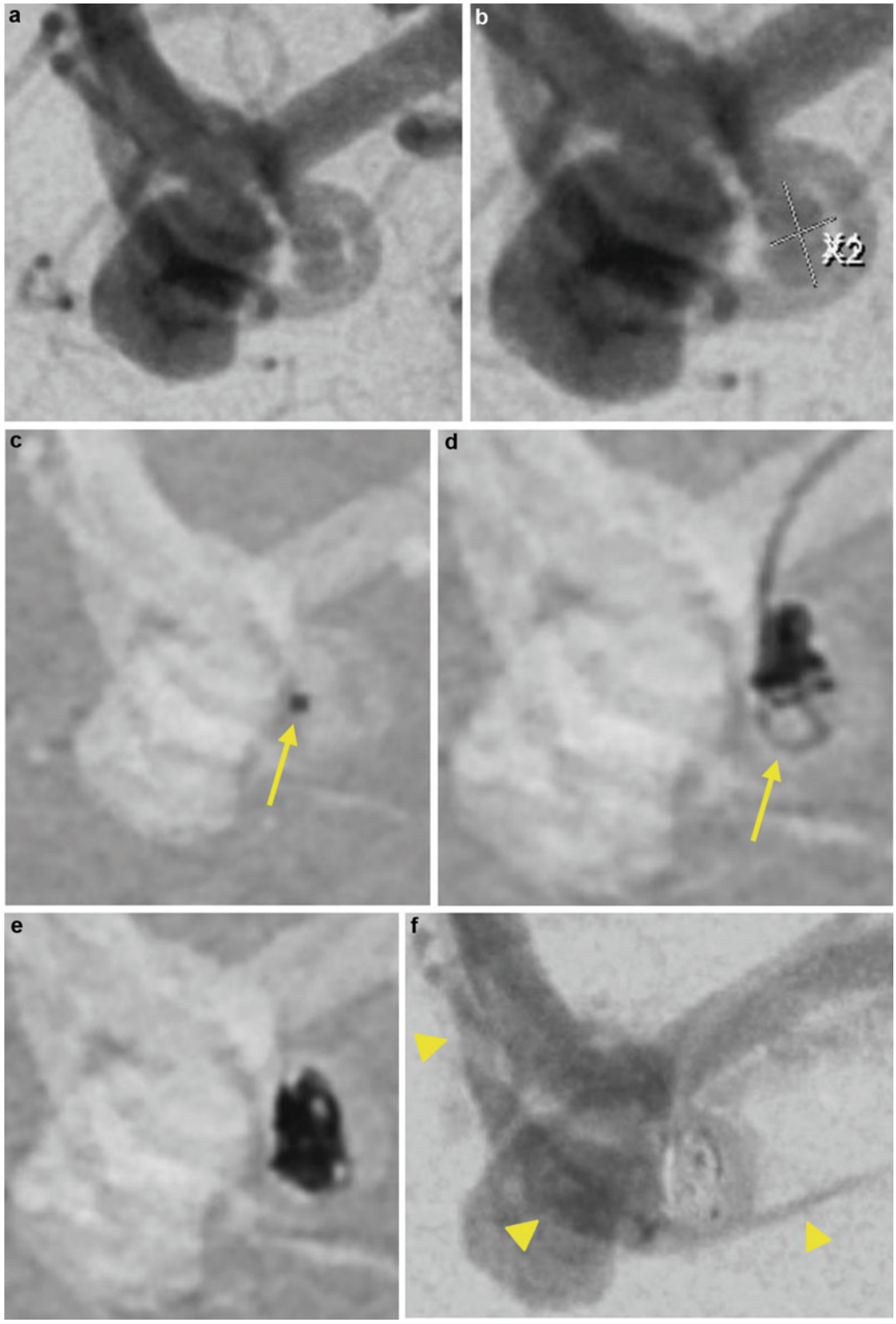
Fig. 1 Diagnostic imaging demonstrating incidental tandem aneurysms of the right MCA. T2WI MRI shows an aneurysm of the right MCA bifurcation (arrow (**a**)). TOF MRA (**b**), 2D DSA (arrow (**c**)), and 3D reconstruction of a rotational DSA (**d**) show an additional aneurysm at the first temporal branch of the right MCA

sac of the ruptured aneurysm, between the coil loops, and a Glubran2/Lipiodol 1:1 solution was prepared. The balloon in the MCA was deflated and 40% glucose was injected via the Marathon catheter, deflation of the balloon allowed the glucose solution to distribute freely. Under fluoroscopy at 30 frames/s, the dead space of the Marathon catheter (0.23 ml) was filled with the Glubran2/Lipiodol solution. The Scepter balloon was then inflated. With a DSA run with 6 frames/s and maximum image magnification, Glubran2/Lipiodol was slowly injected into the aneurysm sac. A small volume of glue escaped into the subarachnoid space; the remainder solidified in the aneurysm sac and the adjacent temporal branch, without reaching the proximal extent of the balloon. The balloon stayed intact and was slowly deflated. The subsequent injection of contrast into the right ICA confirmed the occlusion of the previously ruptured small aneurysm together with the adjacent temporal branch. The distal aneurysm arising from the MCA bifurcation remained intact and there was no NBCA embolization to the cortical branches or the proximal right MCA (Fig. 2).

Duration: 1st–24th run: 133 min; fluoroscopy time: 41 min

Complications: coil-perforation of the previously unruptured right MCA aneurysm, which prompted the occlusion of the aneurysm sac and the parent artery with nBCA

Post medication: Intravenous nimodipine (Nimotop S, Bayer Vital) as 0.2 mg/ml diluted solution for 15 days, the initial infusion rate was 2 mg/h and was thereafter ranged between 1 and 1.5 mg/h according to the required dose



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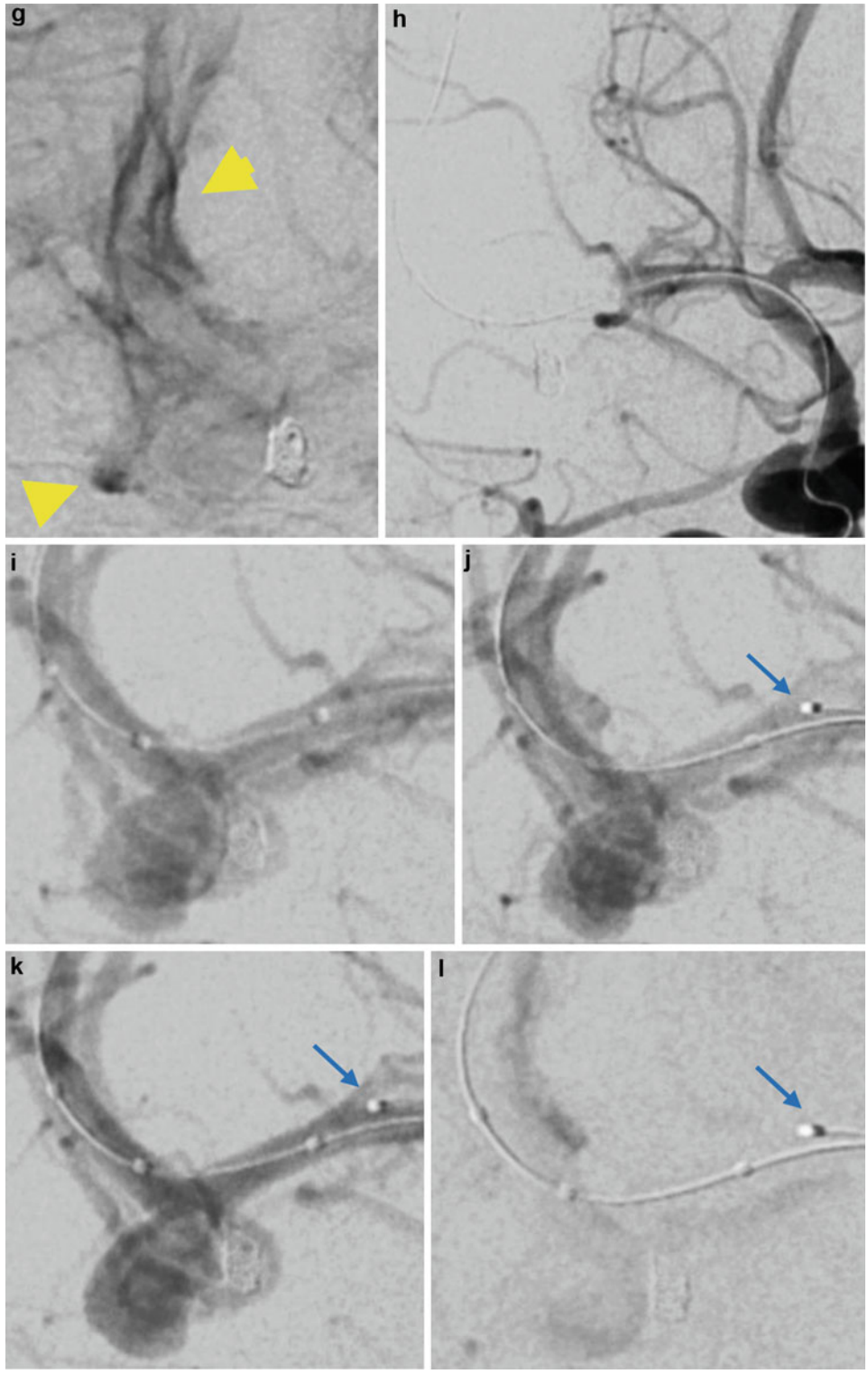

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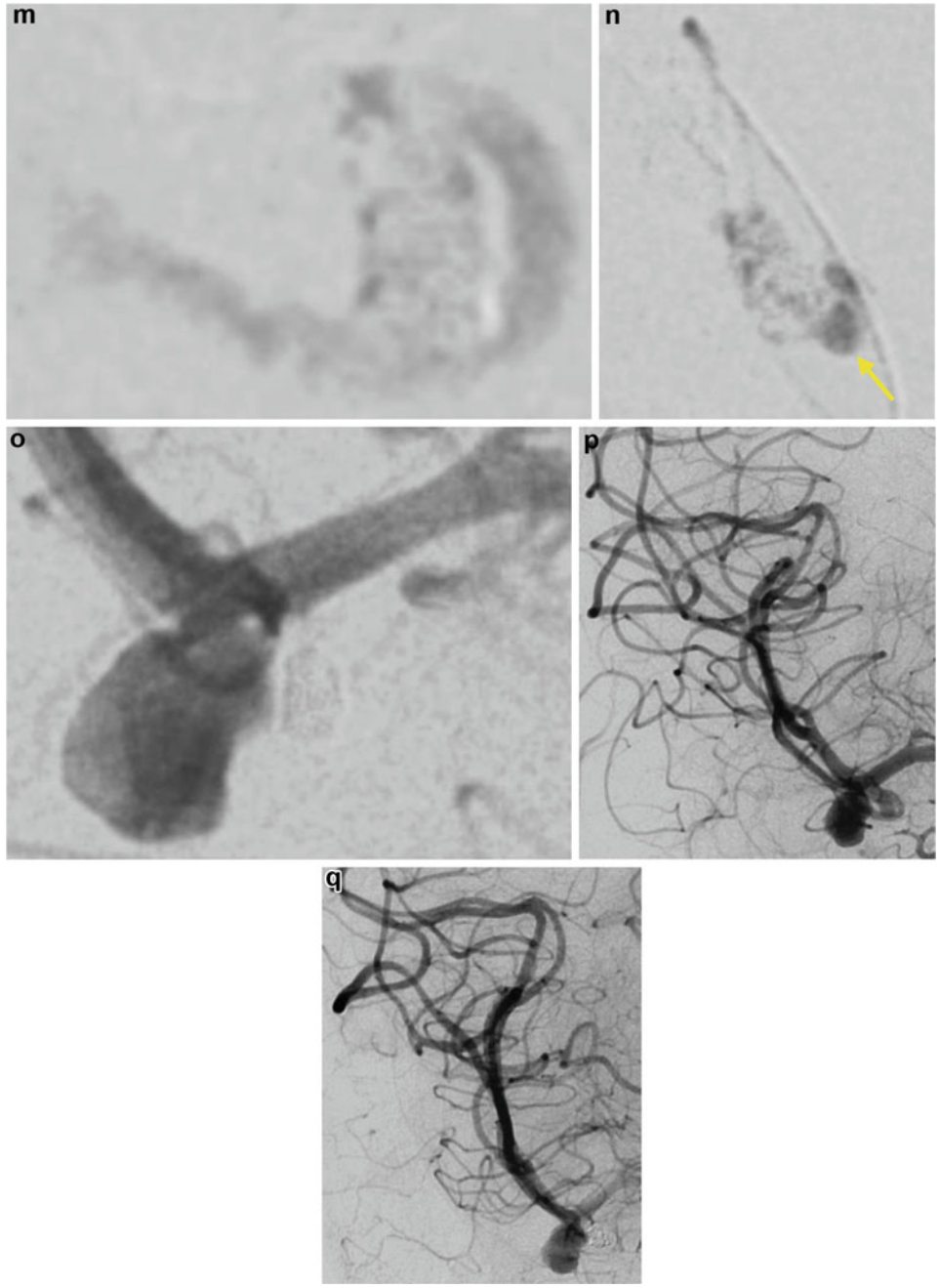


Fig. 2 Endovascular coil occlusion of a small incidental aneurysm of the first temporal branch of the right MCA, with intraprocedural aneurysm rupture. The procedure commenced with the identification of a suitable working projection (**a**), measurement of aneurysm depth (3.2 mm) and width (2 mm) (**b**), and the insertion of a microcatheter (arrow (**c**)). An Axium 3D 2/6 coil was slowly introduced into the aneurysm sac and appeared appropriately sized and deployed well within the aneurysm sac. Manipulation of the coil was performed in order to achieve better apposition of the coil loops. During this process a single coil loop was noted beyond the contour of the aneurysm sac, as visualized by the road map (arrow (**d**)). The coil was then completely introduced (**e**). Contrast injection of the right ICA revealed active extravasation from the aneurysm (arrowheads; 12:12 p.m. (**f**, **g**)). A Scepter balloon was instantaneously inserted into the right M2/M1 segment and inflated in order to stop the extravasation (12:16 p.m. (**h**)). The following contrast injections of the right ICA with the balloon temporarily deflated showed

of catecholamines to maintain a normotensive systemic blood pressure

Clinical Outcome

The patient complained of a moderate headache immediately after the intervention which lasted until the loth post-procedural day. Apart from nuchal rigidity, her neurological status remained otherwise unremarkable.

Follow-Up Examinations

CT performed immediately following the procedure showed contrast medium and blood in the subarachnoid space and a hypodensity of the right temporal lobe. The following day, CT demonstrated an established right temporal lobe infarct, corresponding to the territory of the occluded temporal branch. DSA 11 days later showed minimal vasospasm and confirmed the wide neck of the aneurysm arising from the MCA bifurcation (Fig. 3).

Treatment Strategy

The untreated right MCA bifurcation aneurysm remained a potential source of SAH. The patient, now anxious after the SAH, requested early treatment for this aneurysm but still rejected a microsurgical approach. The wide neck of the aneurysm made it unlikely that it could be successfully treated with coil occlusion without an assist device. The recent partial temporal lobe infarct was considered to be a contraindication to dual antiplatelet therapy, which would have been required for any stent or flow diverter implantation. The use of the low-thrombogenicity pCONUS1 HPC bifurcation device under mono-antiaggregation was considered to be a reasonable option.

Treatment

Procedure #2, 16.07.2018: endovascular coil occlusion of a wide-necked aneurysm of the right MCA bifurcation using a pCONUS1 HPC under mono-antiaggregation

Anesthesia: general anesthesia; 1× 3000 IU unfractionated heparin (Heparin Natrium, B. Braun) IV, 1× 1 mg glyceroltrinitrate (Nitrolingual infus., G. Pohl Boskamp), 1× 500 mg thiopental (Trapanal, Nycomed) IV, 1× 4 mg eptifibatide (Integrilin, GlaxoSmithKline) IA and 1× 5 mg eptifibatide IV

Premedication: 2× 100 mg ASA PO daily (1-0-1) for the 3 days prior to the procedure; 15.7.2018: Multiplate (AUC): ADP 31, ASPI 0, TRAP 51; VerifyNow: ARU 520, P2Y12. 2% inhibition, significant ASA antiplatelet effect

17.07.2018: Multiplate (AUC): ADP 77, ASPI 24, TRAP 155; VerifyNow:ARU 432, P2Y12 0% inhibition, significant ASA antiplatelet effect

19.07.2018: Multiplate (AUC): ADP 115, ASPI 21, TRAP 150; VerifyNow:ARU 484, P2Y12 0% inhibition, significant ASA antiplatelet effect

Fig. 2 (continued) continued extravasation (12:21 p.m. (**i**); 12:27 p.m. (**j**); 12:37 p.m. (**k**, **l**)). Meanwhile a Marathon catheter had been inserted into the right M1 segment (blue arrows). In order to interrupt the ongoing extravasation from the perforated aneurysm, the balloon was kept deflated, the aneurysm was catheterized with a Marathon catheter and the balloon was gently inflated. Using maximum magnification and DSA with 6 frames/s Glubran2/Lipiodol was injected very slowly. The solidification of the liquid embolic agent was observed in oblique projections. In a 25° left anterior oblique view (12:41 p.m. (**m**)), the cast of the aneurysm and of the temporal branch was visualized. The 65° right anterior oblique view (**n**) demonstrated the extravasation of the glue from the anterior aspect of the aneurysm (arrow), at the site of the presumed coil perforation. The balloon was deflated and removed after the Marathon catheter had been withdrawn. The injection of the right ICA (12:42 p.m. (**o**)) confirmed the occlusion of the perforated aneurysm and of the adjacent temporal branch. A comparison of the right ICA contrast injection in posterior-anterior projection pre (**p**) and post (**q**) illustrates the extent of the temporal lobe devascularization

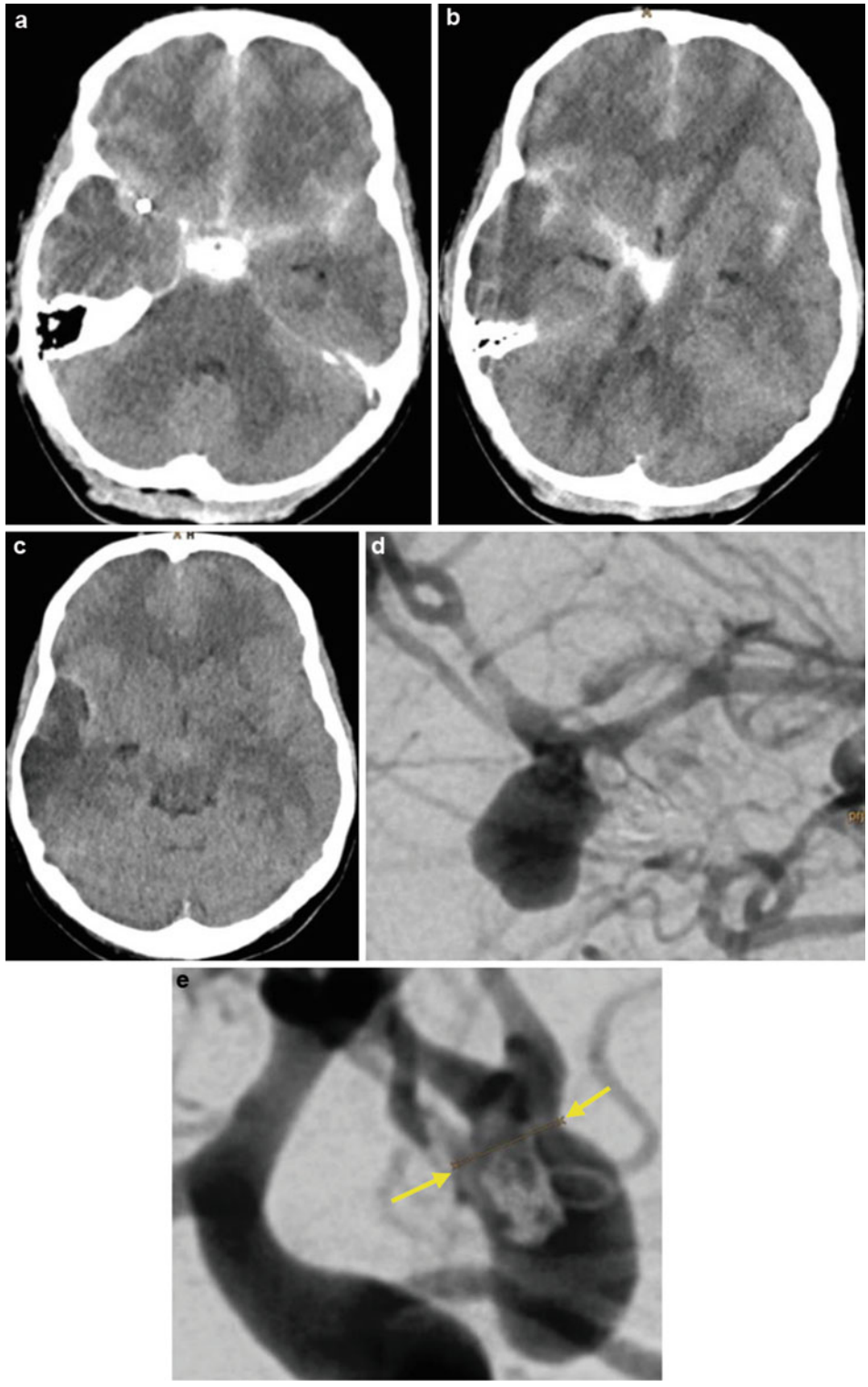


Fig. 3 (continued)

Access: right common femoral artery; *sheath:* 8F (Terumo); *guide catheter:* 7F Guider Softip (Boston Scientific); *microcatheters:* 1× Excelsior SL-10 (Stryker) (Stryker) for coil insertion, 1× Prowler Select Plus 45° (Cerenovus) for implantation of the bifurcation device; *microguidewire:* 1× pORTAL 0.014″ (phenox)

Implants: 1× bifurcation device: 1× pCONUS1 HPC 4/20/5 (phenox)

6× coils: 1× Target Standard 360° 6/15, 1× Target Soft 360° 5/15, 1× Target Ultra 360° 3/10, 2× Target Helical Nano 3/6 (both removed), 1× Target Helical Nano 2/6

Course of treatment: DSA with injection of the right ICA confirmed the persistent occlusion of the proximal aneurysm and its parent artery. The distal aneurysm at the MCA bifurcation was unchanged. The post-hemorrhagic vasospasm had resolved. The Prowler Select Plus microcatheter was introduced into the sac of the MCA bifurcation aneurysm. A pCONUS1 HPC with 5 mm petal wingspan was deployed in the middle of the aneurysm sac. Once the four petals were fully opened, the entire device was retracted under fluoroscopic guidance until the petals were covering the ostium of the aneurysm. In this position, the device was deployed completely, with the stent shaft fixing the implant in the M1 segment. The pCONUS1 HPC remained undetached. An Excelsior SL-10 microcatheter was then inserted into the aneurysm through the pCONUS1 HPC petals and the aforementioned four coils were deployed to occlude the aneurysm. Thereafter, the bifurcation device was electrolytically detached. During the following few minutes, concentric thrombus formation on the stent shaft was observed. In accordance with previous experience, a body-weight calculated dose of eptifibatide was administered both IA and IV. Within minutes, the thrombus disappeared and the aneurysm remained occluded (Fig. 4).

Duration: 1st–34th run: 174 min; fluoroscopy time: 62 min

Complications: temporary, non-occlusive thrombus formation, which resolved after eptifibatide injection IV and IA and remained asymptomatic

Post medication: 2× 100 mg ASA PO daily for life; Multiplate on 19.07.2018 (ARU): ADP 115, ASPI 21, TRAP 150; VerifyNow on 19.07.2018: ARU 484, P2Y12 0%, both tests indicating an adequate platelet function inhibition by ASA

Clinical Outcome

The patient awoke from the general anesthesia without a neurological deficit and was discharged home 4 days after this treatment without any neurological impairment (mRS 0).

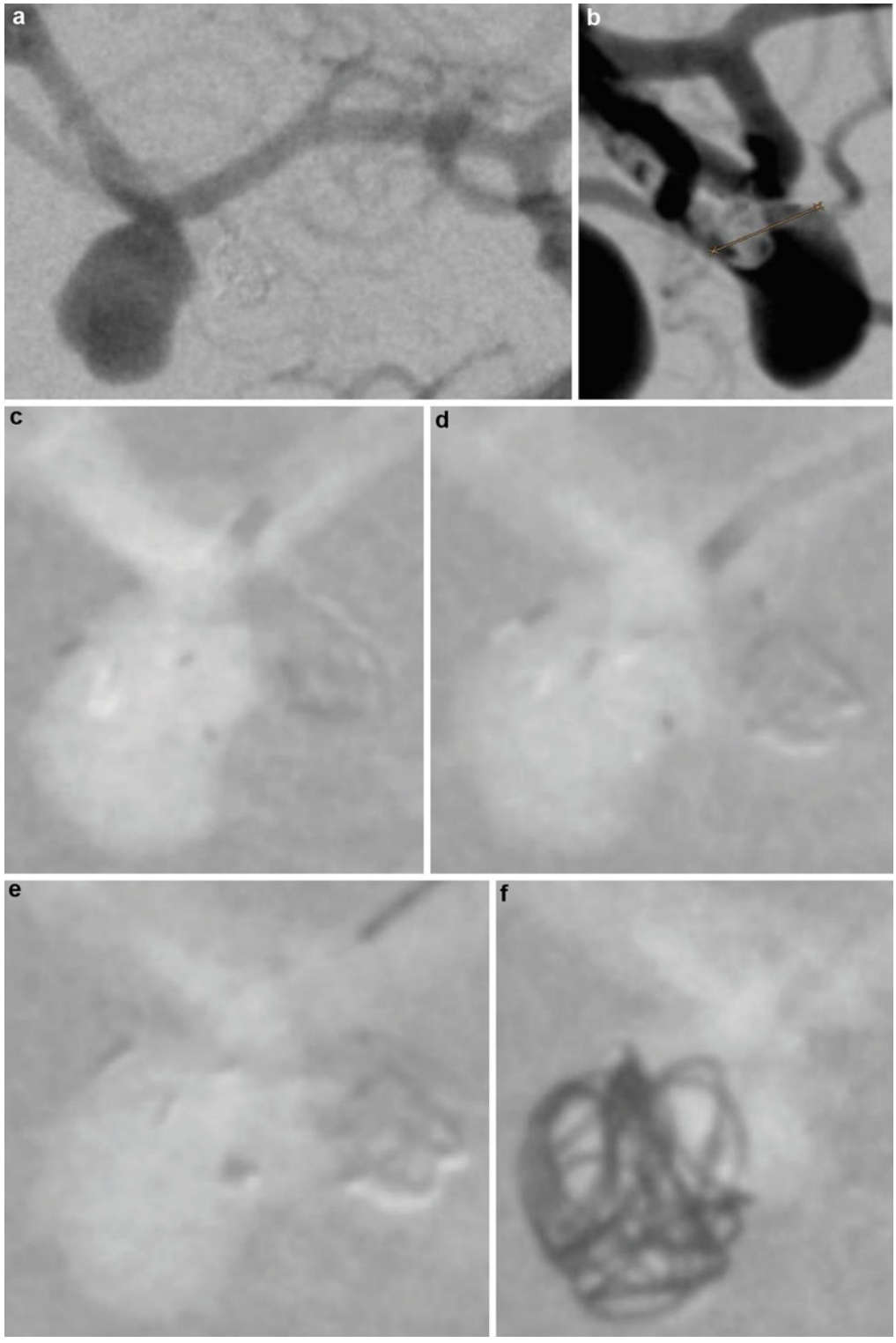
Follow-Up Examinations

MRI was performed on the following day and was – apart from the preexisting partial right temporal lobe infarct – unremarkable. A follow-up DSA was performed 3 months after the second treatment session and confirmed the complete occlusion of the first temporal branch of the right MCA and its aneurysm and stable occlusion of the right MCA bifurcation aneurysm with a minor neck remnant still perfused. There was no stenosis associated with the shaft of the pCONUS1 HPC (Fig. 5).

Discussion

Periprocedural aneurysm rupture is a serious complication. An incidence in the range between 1% and 8% during aneurysms coiling has been

Fig. 3 CT immediately following the procedure shows contrast medium and blood in the subarachnoid space and subtle hypodensity of the right temporal lobe (**a**, **b**). On the following day, blood is already clearing from the basal cisterns and there is an area of established infarction in the right temporal lobe (**c**). DSA on day 11 confirmed persistent occlusion of the aneurysm and minor post-hemorrhagic vasospasm (**d**). A straight lateral projection demonstrates the wide neck of the right MCA bifurcation aneurysm (arrows (**e**))



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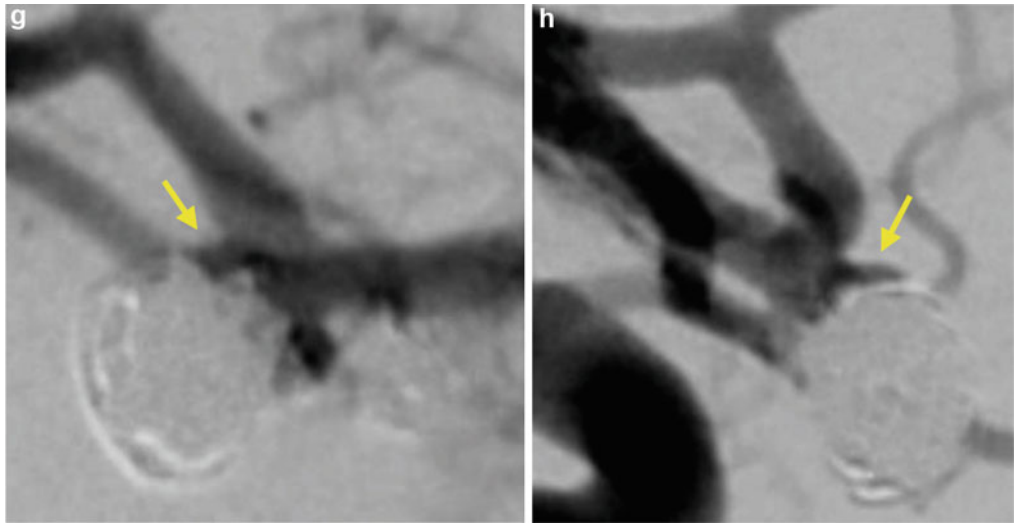

Fig. 4 pCONUS1 HPC assisted coil occlusion of an unruptured wide-necked aneurysm of the right MCA bifurcation. A suitable working projection was chosen (posterior-anterior view (**a**), lateral view (**b**)). A pCONUS1 HPC 4/20/5 (i.e., four petals, no articulation between petals and shaft, 4 mm shaft diameter, 20 mm shaft length, 5 mm petal wingspan; HPC: hydrophilic surface coating for reduced thrombogenicity) was deployed proximal to the equator of the aneurysm (**c**). From there, the petals were opened and the shaft, still undeployed, gently pulled back to a more proximal position in order to achieve a final position at the neck of the aneurysm (**d**). After the complete deployment of the stent shaft, the aneurysm fundus was catheterized with a microcatheter (**e**). Coil occlusion was started with a 6 mm diameter 3D coil (**f**). A minor neck remnant of the aneurysm was accepted in order not to risk compromising the MCA bifurcation (arrows (**g**, **h**))

reported, with either the microguidewire, the microcatheter, or the coils as the perforation device (Ahn et al. 2017: 8%; Brisman et al. 2008: 1%; Choi et al. 2017: 1.2%; Doerfler et al. 2001: 3%; Kawabata et al. 2018: 1.4%). Predisposing factors are previous rupture, elongated proximal vessels, small aneurysm size, and anterior communicating artery aneurysm (Kawabata et al. 2018; Schuette et al. 2011). The most frequently applied strategy to treat the extravasation is proceeding with coil deployment. Alternatively, temporary balloon occlusion may work and is frequently quoted as one of the advantages of balloon remodeling (Ahn et al. 2017; Kawabata et al. 2018). nBCA injection requires significant experience for safe and effective usage but has the advantage of instantaneous sealing of the rupture site. Microsurgical clipping is certainly the last resort (Kawabata et al. 2018). The clinical sequelae of aneurysm rupture largely depend on the individual circumstances. If the rupture site is small and rapid sealing is achieved, the prognosis is usually good. Massive and/or continued extravasation will cause an increase in intracranial pressure and may result in a reduction in cerebral perfusion. The published fatality rates of periprocedural aneurysm rupture are variable and ranges between 0% and 20% (Brisman et al. 2008: 0%; Choi et al. 2017: 0%; Doerfler et al. 2001: 20%; Kawabata et al. 2018: 0.15%).

pCONUS is an assist device for the coil occlusion of wide-necked bifurcation aneurysms (Aguilar-Pérez et al. 2014). It has also been used in acutely ruptured aneurysms (Pérez et al. 2017). The uncoated version of this device has a thrombogenic surface and can only be implanted under dual platelet function inhibition, as it is the case for all currently available intracranial stents. By December 2018, according to phenox more than 2000 pCONUS devices had been implanted. pHPC is a hydrophilic surface coating, which reduces the thrombogenicity of nitinol vascular implants (Lenz-Habijan et al. 2018). Clinical experience thus far has shown that pCONUS HPC can be safely used in patients under ASA monotherapy. This may increase the safety of

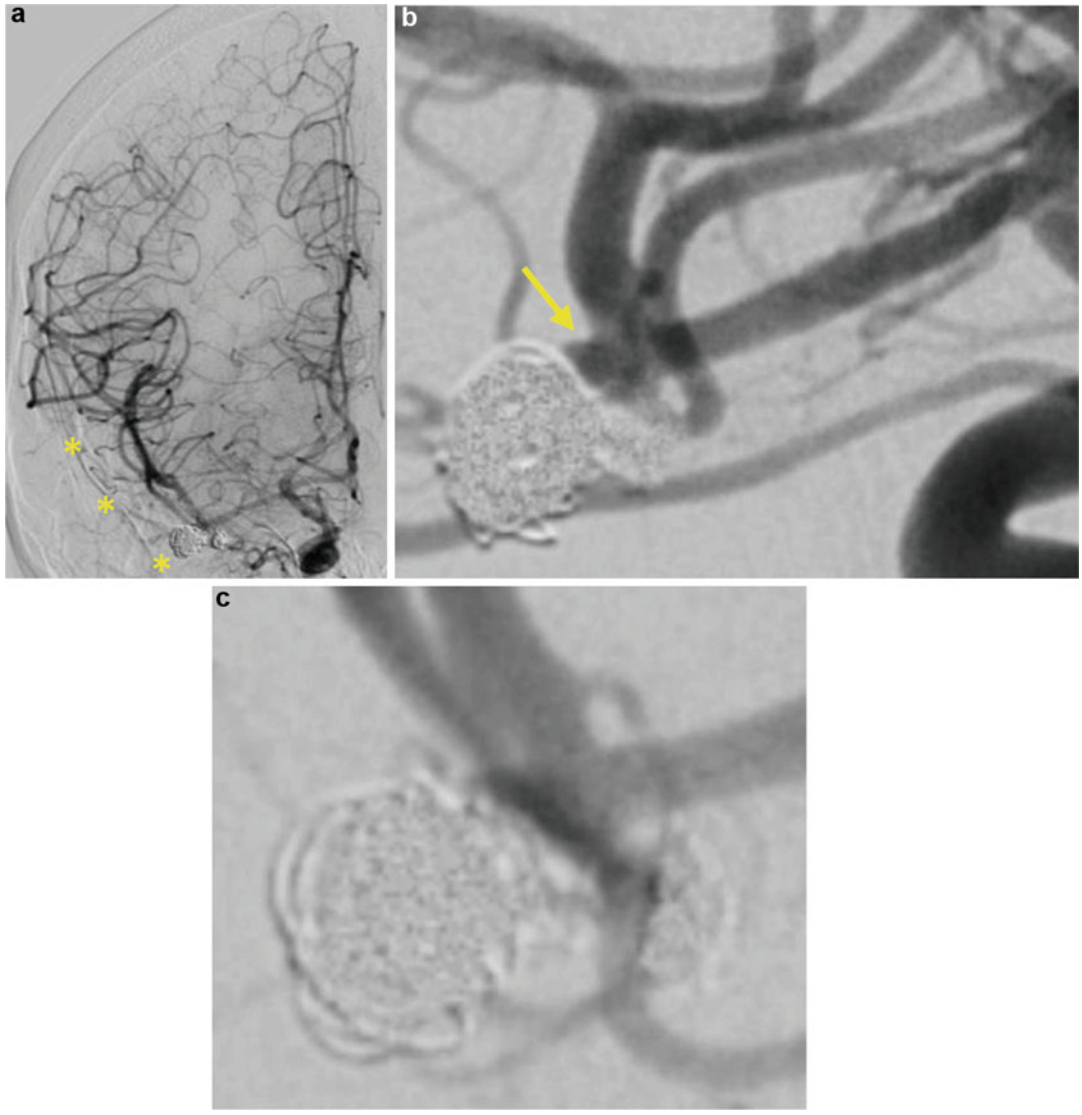

Fig. 5 Follow-up DSA 3 months after the treatment of a wide-necked unruptured aneurysm of the right MCA bifurcation using a pCONUS1 HPC und ASA monotherapy. The first aneurysm was previously occluded with a coil and nBCA, together with its parent artery. The MCA bifurcation aneurysm is occluded apart from a minor neck remnant and the efferent arteries of the MCA are fully patent. The overview (posterior-anterior projection (**a**)) demonstrates the non-opacified temporal branches (asterisks). The reconstruction of the MCA bifurcation with the neck remnant of the aneurysm (arrow) is shown in magnified oblique projections (**b**, **c**)

the endovascular procedures concerned, since "dual antiplatelet therapy" (DAPT) has been found to be associated with a significant risk of hemorrhagic complications (Grodecki et al. 2018). Interestingly, some studies suggested that the regular administration of ASA alone in patients with aneurysmal SAH might decrease the incidence of delayed cerebral ischemia without increasing the risk of bleeding events (Darkwah Oppong et al. 2018). SAH is known to cause platelet activation (Frontera et al. 2017; Ramchand et al. 2016) and could explain why increased doses of ASA are required after SAH. We assess the adequate dosage by

repeatedMultiplate, VerifyNow, and PFA-100 tests. During the acute phase immediately following SAH, we prefer the intravenous route over oral administration for ASA, since the enteral absorption may by disturbed (Soppi et al. 2007). Minor thrombus formation during stent-assisted coiling, as encountered in this case, is not infrequent and may result from different pathological mechanisms (e.g., thrombus displacement from the coil loops, poor wall apposition of the stent). Eptifibatide administration (either IV or IA), although an off-label use, is accepted as a safe and efficient way to remove such thrombus (Ramakrishnan et al. 2013).

Therapeutic Alternatives

Balloon Remodeling
Flow Diversion
Microsurgical Clipping
Parent Vessel Occlusion
Stent-Assisted Coiling

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