Delayed ipsilateral hemorrhage following aneurysm treatment with flow diverter


Over the last few years, endovascular treatment has been the first-line treatment for ruptured and unruptured intracranial aneurysms, with satisfying anatomical and clinical results. Nevertheless, treatment of wide-necked and fusiform aneurysms remains difficult with standard endovascular treatment (coil embolization), and recanalization remains an issue after coiling of large and giant aneurysms. Although the use of flow diverters in these subgroups of aneurysms has demonstrated encouraging results, cases of delayed IPH after flow-diverter placement have been described with potential serious clinical worsening.

In this context, Hu et al. performed 3 post mortem histopathological analyses of brain sections from 3 patients who suffered fatal delayed IPH. Microscopic and spectroscopic analyses revealed the presence of polyvinylpyrrolidone (PVP) occluding the small vessels in the area of bleeding in 2 of the 3 patients. As outlined by the authors, this finding is a cause for serious concern not only with respect to aneurysm treatment with flow diverters but for the entire field of neurointerventional procedures, as PVP is a commonly used coating on a variety of interventional devices. Thus, the etiopathogenesis of delayed IPH has to be analyzed in light of these new findings.

The authors report an incidence of delayed IPH of 4.1%, which is very close to what we reported in our recent case series (5.7%). As suggested by the authors, it is difficult to consider delayed IPH as hemorrhagic transformation of a thromboembolic ischemic lesion in the absence of large territories of acute stroke on pathological examination of the brain tissue. We recently reported similar findings in 2 cases of delayed IPH in which post-flow-diverter treatment MRI studies (a few hours or days before IPH) showing no ischemic lesion in the area where the IPH occurred (Fig. 1). In fact, as outlined by the authors, the occurrence of small silent thromboembolic events is usual after aneurysm coiling, however no cases of delayed IPH have been reported. PVP is known to compose the outer coat of many devices, but the relation between the presence of PVP in the small vessels of the hemorrhagic area and the occurrence of delayed IPH is not clear. Endovascular procedures are usually performed with devices made with PVP, but delayed IPH occurred only with flow-diverter utilization.

The histological findings reported by the authors are relatively disappointing, revealing filamentous, nonbiological material occluding the lumen of vessels of about 100 μm in diameter, which was depicted as PVP by Fourier transform infrared (FTIR) spectroscopy. Neither inflammatory reaction nor granulomas were observed in the histological specimens. However, as granulomas have been reported after PVP emboli in the cardiology literature, the authors suggest a potential role for the weakening and disruption of the vasculature created by the foreign body reaction in the arterial wall in the occurrence of delayed IPH. Also histological specimens revealed attenuation of the tunica media of postcapillary venules with extravasated erythrocytes suggesting a rise in venule pressure and a potential venous mechanism for delayed IPH.

Other potential mechanisms have been advocated, in-

![Fig. 1. Pretreatment angiography (lateral view angiogram, A) revealed a left saccular aneurysm. Axial FLAIR MRI (B) performed 1 day after the procedure showed no postprocedural complications (no intracranial bleeding or ischemic complications). Two days later, the patient presented with hemiparesis and mydriasis. CT (C) revealed a left frontal hematoma with subarachnoid hemorrhage, inducing a mass effect treated surgically. CT was performed after surgery (D). Lateral view angiogram (E) obtained 10 months after the surgery showed a complete aneurysm occlusion with no stenosis of the parent artery.](image-url)
cluding the deleterious effect of dual antiplatelet therapy and flow modification due to flow-diverter placement. Dual antiplatelet therapy is usually administered for stent-assisted coiling, but the rate of hemorrhagic complications is not as high as for flow-diverter placement. In their comprehensive literature survey on stent-supported coiling, Shapiro et al. observed a 2.2% rate of hemorrhagic complications, but these complications were not precisely described and are probably not all delayed IPH.1 Cruz et al. hypothesize that the reconstruction of arteries with the flow-diverter device could reduce vascular compliance and change the blood pressure waveform, generating a larger pulse pressure and increasing the pressure transmitted to the aneurysm and the distal cerebral arteries, which might lead to hemorrhagic complications; this is a potential explanation, but it has not been demonstrated by experimental evidence.1

Surprisingly, Hu et al. did not report any surgical evacuation for the 3 patients with delayed IPH.2 In our series, all patients had surgical evacuation of their hematoma (combined with platelet transfusion) with satisfying clinical outcomes (modified Rankin Scale score 1) for all patients.8 This underscores the value of surgical evacuation of the hematoma in this specific situation even in patients receiving dual antiplatelet therapy.

Delayed IPH is a serious but poorly understood complication after flow-diverter treatment. The pathological series published by Hu et al. suggests new potential mechanisms, including weakening of the arterial wall due to a foreign-body reaction or venous phenomenon. However, neither pathological findings nor previous imaging findings confirm the hypothesis of the hemorrhagic transformation of an ischemic stroke. Dual antiplatelet therapy probably also plays a role in the occurrence of delayed IPH. Given that no single mechanism may explain delayed IPH, a study of a larger series of cases, analyzing the risk factors, should be performed to explain and prevent this kind of complication.

AZZEDINE BENAISSA, M.D.
LAURENT PIEROT, M.D., Ph.D.
Centre Hospitalier Universitaire de Reims
Reims, France

Disclosure
Dr. Pierot is a consultant for Codman, Covidien, MicroVention, Penumbra, and Sequent. Dr. Benaissa reports no conflict of interest.

References
4. Pierot L, Cognard C, Ricolfi F, Anxionnat R: Midterm anatom-