Surgical management continues to be the mainstay of treatment for hemorrhagic mass lesions of the brain, whether traumatic, spontaneous, or iatrogenic. Certain malformations that cause cerebral bleeding, such as aneurysms or fistulas, are now often treated endovascularly. Cranial bleeding, however, such as EDHs, SDHs, and intracerebral hematomas, still requires surgery if there is a significant mass effect. Open surgery affords the surgeon the ability to both remove the clot and control any ruptured or damaged vessels.

An interesting treatment for traumatic EDH was recently reported by Suzuki and colleagues. They described emergency embolization of the meningeal vessels in a series of patients with traumatic injuries, obviating the need for surgery. This approach has not gained much attention among neurosurgeons, perhaps because it was reported in a radiology journal. In addition, the generally accepted endovascular practice of systemic anticoagulation at the time of intervention seems counterintuitive in patients with traumatic injuries. The concept of stopping the bleeding by repairing the injured vessel, however, is an attractive one. This type of treatment has not been described previously in the neurosurgical literature.

In the present study, a patient is described with troublesome postoperative epidural bleeding who responded well to an endovascular treatment to achieve hemostasis in the MMA branches.

## Case Report

This 40-year-old man presented with severe headaches. A CT scan of his head revealed a large SDH on the left side. There was no reported history of trauma or a bleeding diathesis. The patient had, however, also recently suffered 2 simple motor seizures that fit with the location of the clot. Surgery was performed and good evacuation of the SDH was achieved. Epidural hemostasis was difficult due to diffuse oozing in several areas from branches of the MMA. A combination of bipolar coagulation, dural tacking sutures, and hemostatic products was used to obtain what seemed to be good hemostasis in this area. A CT scan of the head obtained on the following day, however, revealed a large EDH under the bone flap (Fig. 1). Although the patient still had only a headache, there was a significant mass effect and we decided to return the patient to the operating room. Numerous points of bleeding in the dura mater were again identified. Intravenous desmopressin acetate (0.3 µg/kg) was administered, and an even more concentrated effort to achieve surgical epidural hemostasis was made. When the surgical bed looked dry, the wound was closed.
A CT scan obtained after the second operation showed that the EDH under the bone flap was gone (Fig. 2) but that a new EDH of significant size was located anterior to the bone flap (Fig. 3). A hematologist was consulted, and a complete workup was ordered, including tests of prothrombin time, activated partial thromboplastin time, factor VIII, von Willibrand antigen, and bleeding time, all of which were within normal limits. Repeated testing performed 1 month later, after any possible effect of the desmopressin acetate had worn off, again yielded normal results.

When the second EDH was found, the decision was made to attempt to control the bleeding by endovascular means. The patient was taken to the angiosuite. Under systemic heparinization to prevent catheter-induced thromboembolic events, the left external carotid artery was selected with a guiding catheter, and a microcatheter was directed into the MMA. Selective angiography of a branch of this vessel (Fig. 4) demonstrated 2 areas of extravasation near the site of the EDH. The branches

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Fig. 1. Head CT scan demonstrating a postoperative left EDH under the bone flap (subdural drain is visible).

Fig. 2. Head CT scan showing resolution of the original EDH after the second operation (subdural drain is visible).

Fig. 3. Head CT scan after the second operation showing a new EDH anterior and inferior to the bone flap (subdural drain is visible).

Fig. 4. Selective angiogram of the left MMA demonstrating extravasation of contrast material (black arrows).
were embolized with particles 250–350 μm in diameter until flow stasis was achieved (Fig. 5). The heparin was reversed with protamine sulfate at the end of the procedure, and the patient made an uneventful recovery.

Discussion

A neurosurgical opinion should always be sought regarding the management of EDH. Not all patients need surgery, but some patients initially selected for observation only will experience deterioration of their condition. One group found that posttraumatic EDHs enlarged in 23% of patients who received nonoperative management of their EDHs. In another series, in 64.9% of such patients serial enlargement of EDHs was demonstrated on CT scans. Not all of these enlarging EDHs require surgical evacuation, but the authors of another series showed that 32% of patients with small EDHs being managed expectantly eventually required surgery. It is difficult to predict which EDHs deemed observable will eventually require surgery. Risk factors identified for eventual evacuation of conservatively managed EDHs include the presence of a skull fracture traversing a meningeal artery, vein, or major dural sinus, and an initial CT scan obtained within 6 hours of the traumatic event. Hamilton and Wallace reported a series of 48 consecutive patients with EDH, 18 of whom underwent conservative management of their EDHs and only 1 of whom required subsequent surgery. All 18 patients had clots <1.5 cm in diameter with minimal midline shift (mean 1.8 mm). The authors argued that surgeons should be hesitant to allow conservative treatment of EDHs containing areas of lucency, which suggest active hemorrhage, or those associated with radiological evidence of uncal herniation.

Perhaps the repair of injured meningeal vessels would decrease the number of patients who require surgery for EDH; prophylactic embolization of the dural arteries in the area of the EDH should achieve this end. If there is a strong suspicion of bleeding in a certain branch, based on fracture and clot location, then selective angiography in the area may be warranted with embolization if anything treatable is found, provided that surgical clot evacuation is not necessary.

The case presented here resulted from frustration over an inability to achieve good surgical hemostasis. There was also the problem with incision planning for another craniotomy, this one anterior to the original operation. The solution was elegant and simple, and may provide impetus for an endovascular approach in selected patients with posttraumatic EDHs.

Fans of the science fiction television and movie series Star Trek may recall a scene in the movie Star Trek IV: The Voyage Home in which a surgeon repairs the MMA in a comatose crew member suffering from an EDH without making an incision, thus saving him from open surgery to remove the clot. The crew member then wakes up from his coma very rapidly, somewhat implausibly given the high likelihood of a mass lesion in this clinical setting. However, the attraction of not having to perform a craniotomy is evident.

The future, as portrayed in a science fiction movie 20 years ago, has arrived. Angiography and possible endovascular treatment should be considered as adjuncts to treatment in a subset of patients with EDHs who do not require surgery for clot evacuation, but in whom there is still believed to be a danger of deterioration.

Disclaimer

The author reports no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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