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Findings in 21 Patients with a Basilar Tip Aneurysm Treated with GDCs

Patient/ Age (y)/Sex	Clinical Finding	Hunt-Hess Grade	Aneurysm Size*	Coil Length (cm)	Occlusion (%)	Complications [†]	Angiographic Follow-up (mo) [‡]	Outcome [§]
1/44/F	Incidental finding	0	Small	26	100	None	45	Excellent
2/49/F	Mass effect	0	Small	24	90	None	26	Excellent
3/57/M	Mass effect	0	Large	65	90	Occlusion of right PCA	26	Fair
4/46/F	Incidental finding	0	Small	18	100	None	18	Excellent
5/75/F	Incidental finding	0	Small	58	100	None	6	Excellent
6/60/M	Subarachnoid hemorrhage	I	Large	110	90	None	18	Excellent
7/42/M	Subarachnoid hemorrhage	I	Small	28	100	None	6	Excellent
8/56/F	Subarachnoid hemorrhage	I	Small	8	100	None	NA	Excellent
9/31/M	Subarachnoid hemorrhage	II	Small	48	100	Occlusion of left PCA	46	Excellent
10/46/F	Subarachnoid hemorrhage	II	Small	8	90	None	25	Excellent
11/50/F	Subarachnoid hemorrhage	II	Small	45	100	Occlusion of left PCA	24	Excellent
12/64/F	Subarachnoid hemorrhage	II	Small	43	100	None	16	Excellent
13/38/F	Subarachnoid hemorrhage	III	Large	84	100	None	48	Excellent
14/34/M	Subarachnoid hemorrhage	III	Small	40	90	None	47	Excellent
15/43/M	Subarachnoid hemorrhage	III	Giant	185	100	Occlusion of PCA	30	Good
16/52/F	Subarachnoid hemorrhage	III	Giant	172	100	None	25	Excellent
17/47/F	Subarachnoid hemorrhage	III	Large	100	100	None	15	Good
18/58/M	Subarachnoid hemorrhage	IV	Small	60	90	None	42	Good
19/67/M	Subarachnoid hemorrhage	IV	Small	20	100	None	6	Good
20/56/F	Subarachnoid hemorrhage	V	Small	70	100	Occlusion of left PCA	NA	Dead
21/47/F	Subarachnoid hemorrhage	V	Small	16	90	None	24	Good

* Small aneurysm had a diameter of less than 12 mm; large aneurysm diameter was 12–25 mm; giant aneurysm was 25 mm in diameter or larger.

[†] PCA = posterior cerebral artery.

[‡] NA = not available.

[§] A modified Glasgow scale was used to report outcome: excellent = neurologically intact with no detectable deficit; good = mild deficit; fair = marked hemiparesis, aphasia, or other deficit; poor = comatose.

arachnoid hemorrhage underwent endovascular treatment within 4 days of the onset of symptoms. The Hunt and Hess grading system was used to classify the subarachnoid hemorrhage as grade I in three patients, as grade II in four patients, as grade III in five patients, as grade IV in two patients, and as grade V in two patients.

The aneurysm was small (less than 12 mm in diameter) in 15 patients, large (12–25 mm in diameter) in four patients, and giant (more than 25 mm in diameter) in two patients (Table). The aneurysm in nine patients had a narrow neck (4-mm diameter or smaller); in twelve patients, the aneurysm had a wide neck (larger than 4 mm in diameter). In all patients, the clinical diagnosis of subarachnoid hemorrhage was confirmed with computed tomographic (CT) findings (Fig 2a), and the diagnosis of basilar tip aneurysm was confirmed with findings from four-vessel angiography (Figs 1a, 1b, 2b, 2c, 3b, 3c). Magnetic resonance (MR) images, MR angiograms (Fig 3a), and/or CT angiograms were obtained in all patients who did not have a subarachnoid hemorrhage.

The study protocol included angiographic follow-up at 6 months and 1, 2 (Fig 3f), and 4 years after treatment. The clinical follow-up ranged from 1 month to 4 years. Outcome in patients was classified on the basis of a modified Glasgow scale (23): excellent (neurologically intact), good (mild deficit), fair (marked neurologic deficit), poor (comatose), and dead.

Interventional Procedure

Thirteen procedures were performed with local anesthesia. Sedative and/or analgesic drugs were also administered if deemed necessary. General anesthesia was

used in eight patients, who were either in poor medical condition or uncooperative. Heparin (Heparin Immuno; Immuno, Vienna, Austria) (5,000 IU) was administered intravenously for the purpose of systemic anticoagulation.

Initially, intraarterial digital subtraction angiograms of the cerebral vessels were obtained by using a 6-F catheter (Simmons II or Headhunter; Cordis, Miami, Fla) inserted through a transfemoral 6-F introducer sheath. Computer-assisted measurement of the aneurysm was performed to select the appropriate size of GDC. Subsequently, the diagnostic catheter was exchanged for a 6-F guide catheter (Balt, Paris, France) placed in the cervical segment of the dominant vertebral artery. Superselective catheter placement in the aneurysm was accomplished coaxially with a Tracker-18 GDC microcatheter (Target Therapeutics, Fremont, Calif). The coaxial system was continuously flushed with a solution of saline and heparin (1,000 IU heparin per 500 mL normal saline) to prevent thrombus formation between the two catheters. The negotiation of the aneurysm was accomplished with a platinum-tipped 0.016-inch steerable guide wire (Taper; Target Therapeutics). Roadmapping was helpful during this part of the procedure and was used in all cases. Care was taken not to touch the wall of the dome of the aneurysm with the tip of either the guide wire or the microcatheter.

A various number (range, 1–14; mean, 3) of GDCs (Target Therapeutics) of various sizes (2–10 mm in diameter, 8–40 cm in length) were implanted by using a previously described technique (19,22–24). The synthesis and physical properties of GDCs have been described (28) in detail elsewhere. GDC implantation was started

with coils that had the largest diameter in relation of the size of the aneurysm. Care was taken to place the first coil in a basket-like configuration in the aneurysm (Fig 1c). Further embolization was performed with smaller coils to fill the remaining cavity (Fig 1d) until control angiograms showed the aneurysm densely packed with GDCs (Figs 1e, 1f, 2d, 2e, 3d, 3e). After placement and before electrolytic detachment of each GDC, a control angiogram was obtained with hand injection of iodixanol (Visipaque; Nycomed, Oslo, Norway) through the guide catheter to confirm the correct site and location of the coil, as well as to demonstrate the patency of the adjacent arteries.

The percentage of occlusion initially achieved was determined on angiograms, with 100% indicative of complete occlusion of the aneurysm. Complete occlusion was defined as occlusion of the aneurysmal sac and neck; 90% occlusion was defined as an occlusion of the aneurysmal sac, with a small, residual open part of the neck.

RESULTS

Superselective catheter placement in the aneurysm with the GDC microcatheter and GDC embolization were technically possible in all 21 (100%) patients. The clinical examination findings, therapeutic results, and complications (if any) are summarized in the Table.

An initial 100% occlusion of the aneurysm was achieved in 14 (67%) patients. Nine of these patients had an aneurysm with a small neck, whereas

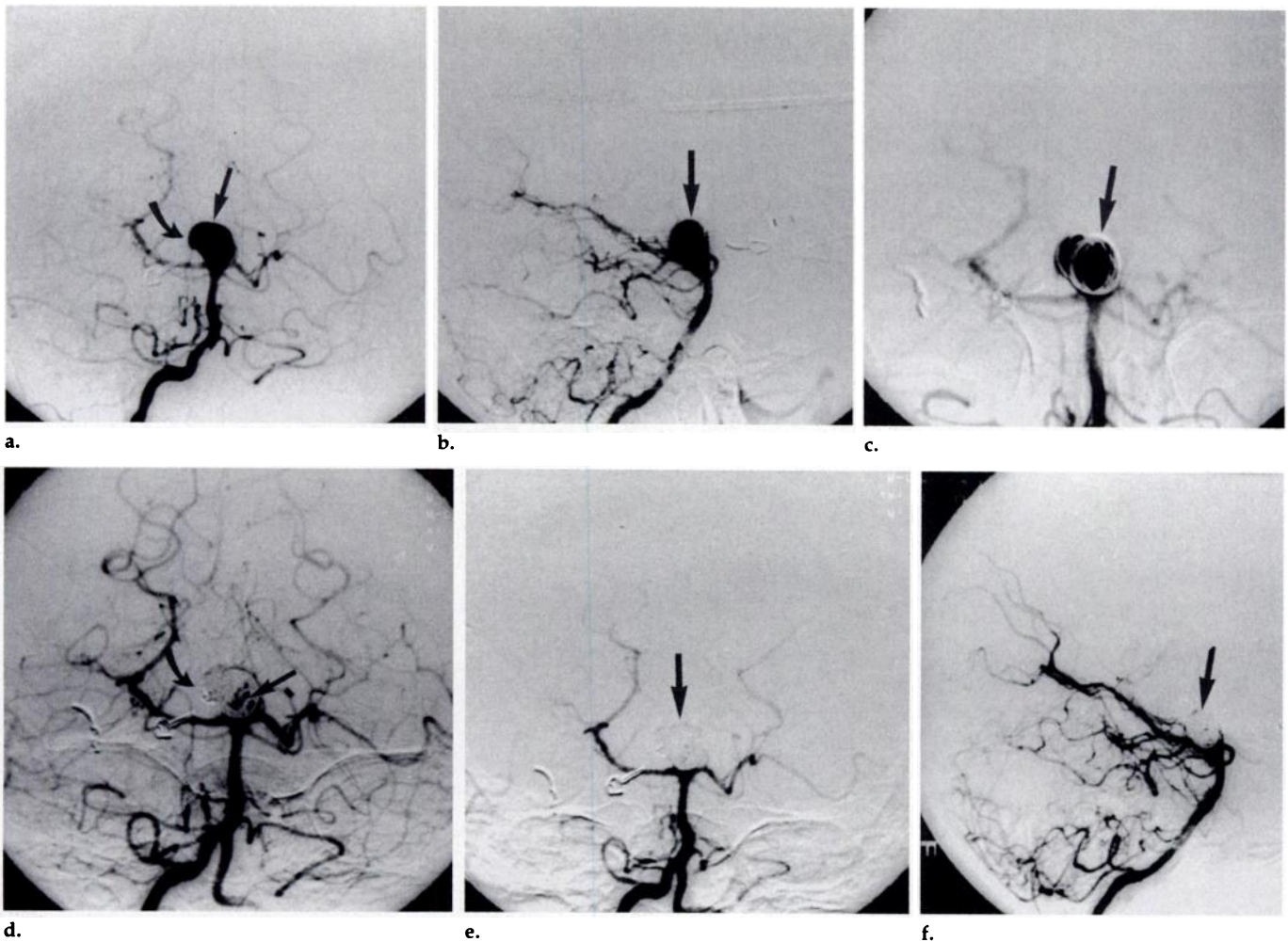


Figure 1. Vertebral angiograms show the sequence of steps in the use of GDCs to occlude a large basilar tip aneurysm. (a) Frontal and (b) lateral projections show a large basilar tip aneurysm (straight arrow) with an outpouching of the right dome of the aneurysm (curved arrow in a). (c) Frontal projection shows the aneurysm (arrow) after delivery of the large-diameter first coil, which acts as a frame for the subsequent smaller-diameter coils. (d) Frontal projection shows incomplete occlusion of the aneurysm. The outpouching (curved arrow) is completely occluded at this point, but the central part of the aneurysm (straight arrow) is still perfused. (e, f) Postembolization vertebral angiograms obtained in the (e) frontal and (f) lateral projections show complete occlusion of the aneurysm with GDCs (arrow).

five patients had an aneurysm with a wide neck. In the remaining seven (33%) patients, all of whom had an aneurysm with a wide neck, 90% occlusion of the aneurysm was achieved at initial treatment. In three of these patients, 6-month follow-up angiograms showed that the remnant of the aneurysmal neck had increased in size owing to compaction of the coils. The aneurysm itself remained the same; that is, coil compaction resulted in a recurrence without a change in morphology of the original aneurysm. Repeated treatment was necessary in cases of recurrence. The aneurysm in two of these patients was large; the third patient had a small aneurysm. In the other four patients with a small aneurysm that was 90% occluded after initial treatment, the residual filling was unchanged at follow-up and was considered to be too small for repeated embolization. There was no

change in the occlusion at 6-month follow-up angiography in 12 (86%) of the 14 patients with a completely occluded aneurysm after initial treatment. One of the two remaining patients died 2 months after the embolization and the second patient, with an initial 100% occlusion, was treated too recently to have undergone 6-month angiographic follow-up at the time this article was written. In 12 patients, who underwent angiographic follow-up at 24–48 months (mean, 34 months), the occlusion was unchanged. In the patients who underwent repeated treatment, occlusion of the aneurysm remained stable at angiographic follow-up at 18–47 months (mean, 30 months).

In clinical terms, repeated bleeding was prevented in all 16 patients with a ruptured aneurysm. Fourteen of these patients were followed up with angiography at 6–48 months (mean, 25

months). The patient who died 2 months after treatment had no symptoms of repeated bleeding. In the patient who was treated recently, there were no clinical findings of repeated bleeding. The patients with signs of a mass effect ($n = 2$) and those without symptoms ($n = 3$) were followed up at 6–45 months (mean, 24 months); none had signs of hemorrhage at follow-up. In the 11 patients with a Hunt and Hess grade II–IV subarachnoid hemorrhage, the aneurysm showed improvement at the 6-month follow-up. The clinical outcome was excellent in seven patients and good in four patients. Three patients with an initial Hunt and Hess grade I had an excellent clinical outcome at the 6-month follow-up. Of the two patients with a grade V hemorrhage, one had a good outcome at follow-up, and the other died of pulmonary complications 2 months after the embolization. Of the

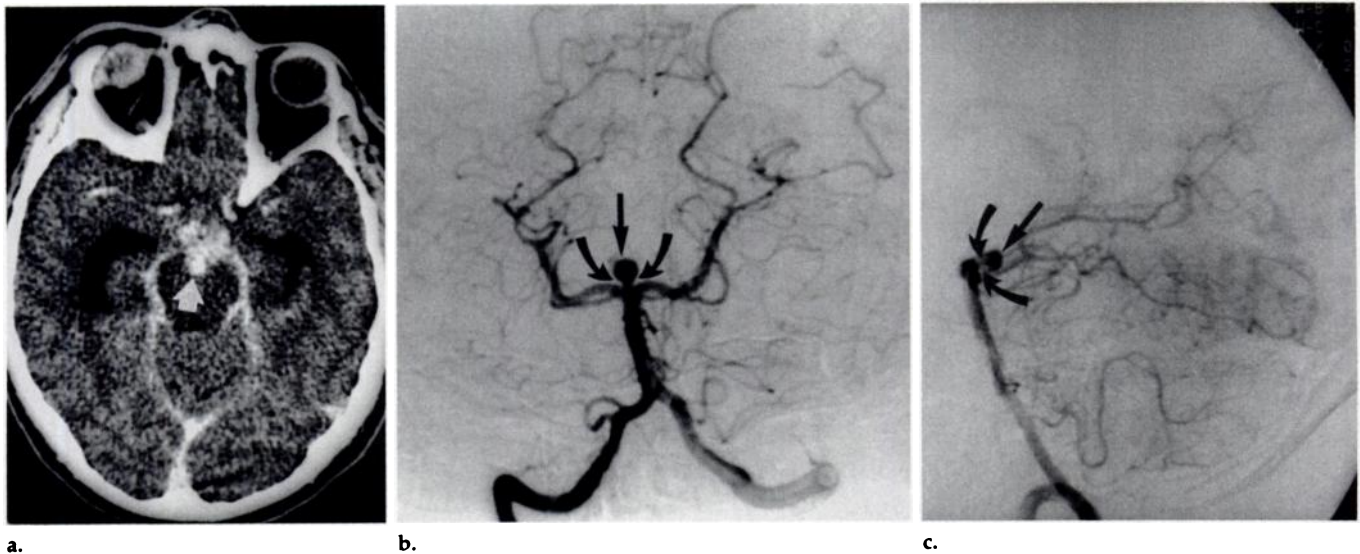


Figure 2. Ruptured basilar tip aneurysm. (a) Axial CT scan shows subarachnoid hemorrhage and the aneurysm (arrow). (b, c) Vertebral angiograms obtained in the (b) frontal and (c) lateral projections show a small basilar tip aneurysm (straight arrow) with a well-defined neck (curved arrows). (d, e) Postembolization vertebral angiograms obtained in the (d) frontal and (e) lateral projections show complete occlusion of the aneurysm with GDCs (arrow).

two patients with sixth nerve palsy, one had an improved outcome, and the other, who had a large aneurysm accompanied by headache and vertigo, had a worsened outcome with a neurologic deficit. Outcome in the three asymptomatic patients, in whom the aneurysm was detected incidentally, remained unchanged.

There were postoperative and therapy-related complications in five patients, namely, occlusion of one of the PCAs after treatment. In one patient, the PCA was reopened by means of intraarterial fibrinolytic therapy; however, a permanent neurologic deficit resulted. In another patient, a transient neurologic deficit resulted, but the 6-month clinical outcome was good. In a third patient, there was flow reduction in one PCA because the GDCs caused partial compromise of the origin of the PCA. The patient was clinically asymptomatic, and normal perfusion of the formerly compromised PCA was evident at the 6-month follow-up. The other patients were clinically asymptomatic; the PCA had normal perfusion by way of the anterior circulation through the posterior communicating artery. The overall morbidity and mortality rate was 5% (one patient) and 5% (one patient), respectively. There was 0% mortality at 30 days after performance of the procedure.

DISCUSSION

Vertebrobasilar aneurysms account for 5%–15% of all intracranial aneurysms (5). Basilar tip aneurysms are the most common type (51%) of aneurysm in the posterior circulation (29,30). Aneurysms of the posterior circulation, particularly basilar tip aneurysms, are difficult to treat surgically and result in high morbidity and mortality rates (1–7,31). Hence, several endovascular techniques have gained acceptance as an alternative therapy in patients who have this aneurysm. Higashida et al (10–13,15) have reported results in large series of patients who underwent detachable balloon embolization for treatment of intracranial aneurysms. However, such balloons do not adapt to the irregular shape of the aneurysm, thereby causing stress on the aneurysm wall during balloon inflation and resulting in a relatively high risk of aneurysm rupture. Another shortcoming is the possible displacement of the balloon

after detachment, which can result in occlusion of parent vessels (13,15). Therefore, only patients with an inoperable basilar tip aneurysm or who were otherwise unable to undergo surgery were selected for endovascular balloon embolization.

With the development of steerable microcatheter guide-wire systems, superselective catheter placement in an aneurysm and delivery of microcoils have become possible. The nontraumatic placement of the tip of the microcatheter in the aneurysm and the implantation of microcoils should eliminate the complications that occur with the use of detachable balloons, such as rupture of the aneurysm.

Casasco et al (17) reported a large series of 71 cases of aneurysm treated with platinum-fiber microcoils. An incomplete occlusion was reported in 11 (15%) of the 71 cases. Two of these patients died because of a repeated hemorrhage. In six patients, there were ischemic complications; in four patients, there was

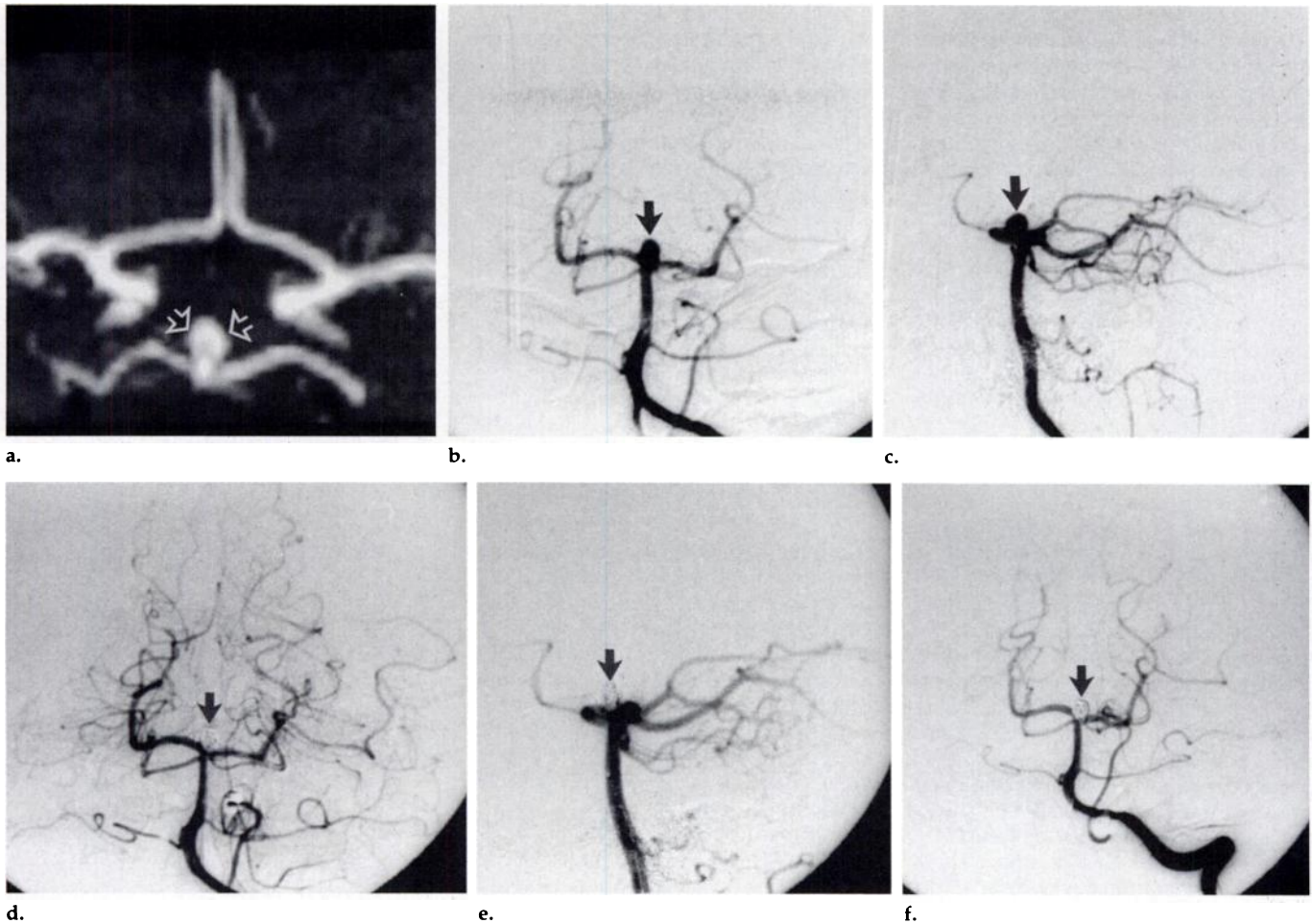


Figure 3. Nonruptured basilar tip aneurysm. (a) MR angiogram shows the basilar tip aneurysm (arrows). (b, c) Vertebral angiograms obtained in the (b) frontal and (c) lateral projections show a small, wide-necked basilar tip aneurysm (arrow). (d, e) Postembolization vertebral angiograms obtained in the (d) frontal and (e) lateral projections show complete occlusion of the aneurysm with GDCs (arrow). (f) Frontal angiographic projection obtained at 2-year follow-up shows persistent occlusion of the aneurysm (arrow).

occlusion of the parent vessel. These two types of complications were the result of the fact that these microcoils are non-detachable, which seems to cause problems especially in the treatment of a wide-necked aneurysm. When conventional microcoils are used, ischemic complications can result after inadvertent placement of the last coil. Conversely, the attempt to avoid inadvertent placement can result in incomplete occlusion of the aneurysm.

With the development of the GDC, the disadvantages of nondetachable microcoils and detachable balloons can be minimized (32). Controlled delivery is the most important advantage of the GDC: The coil is detached only when the correct position is demonstrated at angiography. In case of inadvertent placement, the GDC can be withdrawn and reinserted. A further advantage is the flexibility and softness of the coils, which enables the filling of outpouchings in the aneurysm and minimizes the risk of rupture. Additionally, during electrolytic detachment of the GDC, electrothrombosis occurs adjacent to the coil, which accelerates the occlusion.

Implantation was started with a GDC with the largest diameter relative to the size of the aneurysm to achieve a basket-like configuration and to bridge the aneurysm neck with a mesh of coils. The remaining cavity was filled with smaller-diameter coils, which were placed in the network of the first coil; this placement prevented bulging into the parent artery.

Problems with GDC implantation can occur because of anatomic features of the aneurysm. Specifically, a wide aneurysmal neck and/or an aneurysm in which the normal branch arteries originate near the neck or are incorporated in the aneurysm can cause difficulties (to the point of impossibility) in the tight packing of the aneurysm. In these circumstances, there is a risk that the coils will bulge into the parent artery or compromise the adjacent origin of the parent artery, and only loose packing and a sometimes incomplete occlusion of the aneurysm can be achieved. Consequently, complete occlusion is possible in a larger percentage of small-necked aneurysms than wide-necked aneurysms (33). A further complication is the

development of a remnant aneurysmal neck caused by compaction of the coils due to arterial flow.

Guglielmi et al (22) reported initial 100% occlusion in two cases of a small-necked aneurysm and in one case of a wide-necked aneurysm in their series of 23 cases of basilar bifurcation aneurysm. A 98% occlusion was achieved in two cases of wide-necked aneurysm, and a 95% occlusion was achieved in three cases of a wide-necked aneurysm and in two cases of a small-necked aneurysm. In three cases of a wide-necked aneurysm, more than one embolization was necessary. McDougall et al (27) reported an initial complete occlusion with GDCs in seven of 33 (21%) cases of basilar tip aneurysm. Six patients required repeated treatment because of partial recanalization. In three of these patients, the repeated treatment was successful. Bavinski et al (26) reported 100% occlusion in seven (33%) of 13 patients. In one case, repeated treatment was performed. All of these previous studies, however, involved a selected group of patients.

Unlike in the studies cited in the preceding paragraph, we performed endo-

vascular treatment in a nonselected population of patients with a basilar tip aneurysm; therefore a comparison of our results with those of surgical series (1-7,31) may be more valid. In our series of 21 patients with a basilar tip aneurysm, an initially complete occlusion was achieved in 14 (67%) patients, and 90% occlusion was achieved in seven (33%) patients. In other studies (22,26,27,33), the highest percentage of complete occlusions was reported in patients with a small-necked aneurysm. Because of recurrence of partial perfusion of the aneurysmal neck after 6 months, repeated treatment was necessary in three of the patients in our series.

The goal of any treatment for an intracranial aneurysm is to avoid bleeding, to prevent repeated bleeding in a ruptured aneurysm, and to improve neurologic symptoms due to mass effect in a patient with an unruptured aneurysm. In 16 of 21 patients, a basilar tip aneurysm caused subarachnoid hemorrhage before treatment. There was no repeated hemorrhage after treatment, which suggests that an incomplete occlusion (in five patients with a ruptured aneurysm, an initial 90% occlusion was achieved) may protect the aneurysm against repeated rupture (22,23,26,34). Two patients in our series presented with symptoms due to mass effect. Clinical improvement of the symptoms was observed in one of these patients; however, GDC embolization resulted in protection against bleeding in both patients. Three other asymptomatic patients, whose aneurysms were found incidentally, were treated successfully to prevent rupture.

Another disadvantage in treating patients with a wide-necked basilar tip aneurysm is the risk of compromising an adjacent origin of the PCA. The cause for occlusion of the PCA can be either mechanical compression of the origin at an attempted tight packing of the aneurysm or thrombus formation when the intraaneurysmal thrombus shifts to the origin of the parent vessel. The occlusion of one PCA was the most important complication in our series. Occlusion of a PCA occurred in five (24%) patients, and only one of these patients had worsened clinical symptoms intraoperatively; therefore, intraarterial fibrinolytic therapy was started immediately. Despite successful reopening of the artery, the patient developed a permanent neurologic deficit. Guglielmi et al (22) reported one complication (permanent hemianopsia) in a patient with a wide-necked basilar bifurcation aneurysm with bilateral occlusion of the PCAs. In their series of patients with a posterior circulation aneurysm, the

morbidity and mortality rates were both 7%. McDougall et al (27) reported one patient with a repeated hemorrhage after treatment and thrombosis of the distal part of the basilar artery and of the P-1 segment of the PCA, which resulted in a permanent neurologic deficit. In one patient, the coil migrated into the P-1 segment of the PCA but did not compromise the parent artery.

In summary, occlusion by means of endovascular coils is a promising alternative therapy in patients with an intracranial aneurysm that should not be treated with surgical clipping because of increased risk to the patient. Surgical clipping of a basilar bifurcation aneurysm is difficult and is associated with high morbidity and mortality rates. Our midterm results indicate that occlusion with GDCs is a less invasive and safe alternative therapeutic method for the treatment of patients with such an aneurysm and that this method should be used preferentially. Moreover, this endovascular approach is not only less invasive than other procedures, but it is also associated with a shorter period of hospitalization. In addition, patients with a poor medical condition can be treated. Long-term follow-up studies, however, are needed before the present results can be confirmed. ■

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