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ORIGINAL RESEARCH

Retreatment of Previously Embolized Cerebral Aneurysms: The Risk of Further Coil Embolization Does Not Negate the Advantage of the Initial Embolization

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BACKGROUND AND PURPOSE: A significant minority of aneurysms treated by endovascular means undergo additional subsequent therapy to treat aneurysm recurrence. Our study was undertaken to determine the risk of additional coil embolization of aneurysms recurring following endovascular therapy.

MATERIALS AND METHODS: Patients were identified during a 10-year period from prospectively collated data bases at 2 different neuroscience institutions. Patient outcome was obtained from the data bases or the patient's neurosurgical records. Occlusion grade was assessed at the time of treatment and at follow-up angiography as complete, near-complete, or incomplete.

RESULTS: Of a total of 1834 aneurysms in 1631 patients, 100 aneurysms in 99 patients treated between January 1996 and December 2005 required additional coiling because of an enlarging remnant and subtotal occlusion. This comprised 6% of the patients treated and 8% of the total followed. Thromboembolic events complicated 3 retreatment procedures, but all 3 patients remain independent. Ninety-five patients were followed for 8–103 months (mean, 42.3 months) by conventional or MR angiography.

CONCLUSION: Coil embolization of aneurysm recurrences has a low complication rate and leads to satisfactory occlusion in most cases. The risk from additional coil embolization does not negate the advantage of the initial embolization.

Coiling of ruptured intracranial aneurysms achieves an absolute reduction in death or dependence at 1 year of 7.4% and a relative risk reduction of 23.9% when compared with neurosurgical clipping.[1] The main concern is the durability of endovascular treatment. Aneurysm recurrence is potentially disadvantageous. Our knowledge of the long-term natural history of a coiled aneurysm remnant is incomplete. Rebleeding, though uncommon, is well recognized.[2-5] Our aim was to determine the complication rate of additional coil embolization in previously coiled aneurysms with unruptured remnants. Because the rupture risk from aneurysm recurrences is very low, it is essential that retreatment be effective and carry only a small additional burden of morbidity.

Materials and Methods

Patients were identified from prospectively collated and on-going data bases on endovascular aneurysm treatment, commenced in January 1996 at 2 different neuroscience institutions. Patient outcome was obtained from the data bases or the patient's neurosurgical records.

During a 10-year period (January 1996 to December 2005), a total of 1834 aneurysms in 1631 patients was treated at these centers by coil embolization. Most of the coils used were bare platinum alone, with just >10% of the patients being treated with bioactive coils or a combination of bioactive and bare platinum coils. Patients who were treated with Onyx (ev3, Irvine, Calif) were excluded from the study. One thousand five hundred seventeen aneurysms were ruptured and 317 were unruptured. Of those patients who presented with subarachnoid hemorrhage (SAH), 76% of aneurysms were World Federation of Neurologic Surgeons grades 1 and 2. At treatment, 56% of aneurysms were completely occluded, 37% had a neck remnant, and 7% were subtotally occluded.

Follow-up angiography was performed in 1233 patients (76%) with 1284 aneurysms (70%). Follow-up was performed by conventional angiography during the early years of the study, moving toward MR angiography in the later years. Of these, 141 aneurysms (11%) demonstrated subtotal occlusion. One hundred aneurysms in 99 patients have been recoiled. This study deals exclusively with the latter cohort of patients.

Of the 41 patients (with 41 aneurysms) who were not retreated with coils in the study period, 1 patient sustained a fatal rebleed after 11 months; 6 underwent surgical clipping without recoiling; and in the remaining 34 patients, retreatment has not been performed because of patient age, clinical status, or anticipated procedure-related difficulties based on vascular anatomy.

Three hundred ninety-eight patients (24%) did not have follow-up angiography. Of those, 161 patients died before interval angiography. After unsuccessful coiling, we clipped 38 aneurysms in the acute phase. The cause of death before follow-up was as follows: 94 patients because of SAH and complications, 10 as a result of surgical procedures, 21 from endovascular procedural complications, 12 from recurrent SAH, and 24 from unrelated causes.

In our original cohort of 1631 patients, rebleeding occurred in 18 patients (1%), 12 within 1 month and 6 later. Four of the latter rebled during the first year (6 weeks and 2, 7, and 11 months), 1 at 3 years, and 1 at 7 years.

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Results

Of the 1233 patients (76%) with follow-up angiography, 100 (8%) aneurysms in 99 patients (59 women, 40 men; 20–85 years of age) received further embolization because interval angiography demonstrated an enlarging remnant and subtotal sac obliteration. Ninety-three aneurysms had previously ruptured (6% of ruptured aneurysms), and 7 were unruptured (2% of unruptured aneurysms). The patients underwent further coil embolization 7–102 months after the initial treatment (mean, 19.9 months). Although 23 aneurysms (23%) were completely occluded at the initial treatment, 12 (12%) had subtotal occlusion, and the remaining 65 (65%) had a neck remnant. None were completely occluded at the time of the first follow-up angiogram. Fifteen were initially observed and treated as late as 102 months after initial coiling because subsequent follow-up showed an enlarging remnant. One retreatment of an anterior communicating aneurysm failed at 8 months, but retreatment became subsequently possible with the use of newer catheters (63 months after initial coiling). One wide-necked small basilar termination aneurysm was not retreated until 53 months because the patient did not attend follow-up.

The location of the recoiled aneurysms was anterior communicating ($n = 27$), posterior communicating ($n = 25$), basilar ($n = 12$, two associated with fenestrations), middle cerebral ($n = 12$), terminal internal carotid ($n = 9$), carotid paraophthalmic ($n = 5$), posterior inferior cerebellar (PICA) ($n = 4$), superior hypophyseal ($n = 3$), anterior choroidal ($n = 2$), and posterior cerebral ($n = 1$) arteries.

Sixty-two aneurysms were small (<10 mm), 12 with wide necks; 36 aneurysms were large (>10 mm), 32 with wide necks (>4 mm); and 2 were giant aneurysms. The percentage of small aneurysms with small necks receiving further coiling was 3%; small wide-necked aneurysms, 3%; large small-necked aneurysms, 7%; and large wide-necked aneurysms, 21%.

Of the 99 patients who had further coil embolization, 7 had multiple procedures. The total number of procedures was 111. Four were stent-assisted.

Clinically significant complications (as defined by a complication resulting in permanent neurologic deficit or death) from thromboembolic events occurred in 3 patients (3%) (compare with 3% thromboembolic events at the time of primary treatment). Two patients with left middle cerebral artery aneurysms were dysphasic and had memory difficulties, and 1 patient with a right anterior choroidal aneurysm had poor concentration and mild-to-moderate cognitive deficits relating to memory difficulties. All remain independent. One patient developed a small asymptomatic anterior cerebral artery infarct after retreatment of a paraophthalmic aneurysm. There were no procedural ruptures (compare with 5% procedural ruptures at the time of primary treatment).

Four patients were not followed, either because further treatment was not thought to be an option ($n = 2$) or because they did not attend follow-up ($n = 2$). Follow-up for the remaining 95 patients (96 aneurysms) ranged from 8 to 103 months (mean, 42.3 months). It was by conventional angiography in the earlier years, moving toward MR angiography in the later years of the study.

Of the retreated aneurysms that were followed, 75 (78%) had stable satisfactory angiographic appearances (complete or near-complete occlusion) and there has been no rebleeding (follow-up for 24–103 months; mean, 50.5 months; median, 44.5 months). Eleven (11%) who are still under surveillance (8–30 months; mean, 14 months; median, 10 months) show no significant recurrence so far, but longer follow-up is required to assess stability.

Ten of the 95 retreated patients (11%) had a second recurrence. Four had further endovascular treatment. Two patients with re-recurrent giant posterior communicating artery aneurysms and 1 with a re-recurrent carotid paraophthalmic aneurysm were subsequently treated with stents and high-attenuation Onyx (one had a good outcome and stable complete occlusion and the other was dysphasic due to a guidewire perforation of an M3 artery and hematoma formation). Another with a PICA recurrence was treated with balloon occlusion of the ipsilateral vertebral artery. One patient required further treatment. In 5 other patients, the recoiled remnant was not stable and the patients opted for neurosurgery with good outcome.

Discussion

The complication rate following recoiling of aneurysms ranged from 0% to 11% in previous series.[6-11] Some of these series included patients who had undergone repeated coiling following aneurysm rerupture or as part of a multistage treatment. Our series excluded these patients to determine the risk associated with elective treatment of unruptured aneurysm recurrences.

Of 20 aneurysm recoiling procedures in the series of Park et al,[8] 4 had thromboembolic complications, 2 (10%) resulting in neurologic deficit. This contrasts starkly with our experience and that of other published series, which have reported low rates of complication associated with additional coiling.[6,7] Despite the fact that the series of Henkes et al [9] included a great proportion of large and giant aneurysms in 495 retreatments, only 3.2% of patients had a permanent neurologic deficit and there was 1 death. The series of van Rooij and Sluzewski [7] also included a large proportion of reopened large or giant aneurysms, but they had no complications in 23 retreatments. In the series of Kang et al,[10] there were no complications in 32 recoiled aneurysms.

Our study demonstrates that this additional treatment is associated with a low complication risk and results in satisfactory stable occlusion in most patients. This is a selected group in whom safe retreatment should be predictable. We did not encounter aneurysmal rupture, probably because much of the dome was already well protected by coils. The thromboembolic risk was the same as that for the initial treatment.

Our retreatment rate of 8% is similar to that of 4.7%–10% quoted currently in the literature.[4-6,12,13] The International Subarachnoid Aneurysm Trial (ISAT)[1] reports that 66% of aneurysms were completely occluded, 26% had a neck remnant, and 8% showed incomplete occlusion at the first follow-up. Our cohort of patients differed from that in the ISAT trial in that it included both ruptured and unruptured aneurysms.

Neurosurgery does not always result in complete obliteration. In ISAT, 42% of clipped aneurysms underwent postclip angiography, and in this selected population, 12% had a neck remnant and 6% of aneurysms were incompletely occluded. Other surgical series report 4% completely unclipped and 4%

incompletely clipped aneurysms,[14] and Feuerberg et al[15] found 3.8% incidence of aneurysm rests after clipping and reported a 3.7% incidence of rebleeding in these patients. Successful coil embolization of surgical remnants is, of course, also described[16,17] and was also our experience (unpublished observations by Renowden and McConachie; 2007).

Our decision to retreat those aneurysms with an enlarging remnant and/or incomplete occlusion was made because of the reported increased risk of further hemorrhage associated with unstable remnants and incompletely occluded aneurysms.[2,3] The incidence of rebleeding in recurrent aneurysms is 7.9% in comparison with 0.4% in stable occlusions.[3] In a large meta-analysis, 12 of 90 aneurysms that were subtotally occluded rebled, compared with 2 of 254 aneurysms with complete or near-complete occlusion.[2] Additionally, in 1 series of 105 aneurysms with complete or near-complete occlusion, no further rebleeding occurred during a mean follow-up period of 41.2 months.[12]

The rebleed rate after endovascular therapy quoted in ISAT[1] was 0.2% per patient year with a follow-up from 1 to 8 years (mean, 4 years). In the Cerebral Aneurysm Rerupture After Treatment (CARAT) study, the rehemorrhage rate in the coiled group was 1.3/100 patient years, and no rehemorrhage occurred after 2 years.[18] In the series of Sluzewski et al,[5] the incidence of late rebleeding was 1.27%, with a mortality rate of 0.76%. They recorded an annual risk of late rebleeding of 0.32%, with risk factors including large aneurysm size, initial incomplete aneurysm occlusion, and incomplete occlusion at 6-month follow-up. Their median period of follow-up was 51.5 months. The incidence of late rebleeding reported elsewhere of 1.1–1.3%[3,4] is similar to our own (0.5%).

Aneurysm retreatment inevitably incurs some risk. Given what is known concerning the rerupture rate of aneurysm recurrences, the risk of retreatment must be very low to improve patient outcomes. Our study shows that recoiling carries a 3% risk of minor permanent neurologic deficit, which does not offset the benefit of coiling versus clipping demonstrated in the ISAT trial. However, further investigation is required, preferably by means of a randomized controlled trial, to evaluate whether there is a benefit from treatment of aneurysm recurrences.

Recanalization occurs more frequently in large aneurysms (>10 mm), with large necks (>4 mm) and incomplete occlusion at initial treatment.[4] Small aneurysms with small necks are, however, by no means exempt from recanalization. Dense aneurysm packing is an important factor in reducing recanalization, and coils should occupy at least 25% of the aneurysm volume to reduce the risk.[6,19] We pack densely until no more coils can be safely introduced into the aneurysm.

Raymond et al[4] noted that recurrence occurs more frequently in previously ruptured aneurysms, perhaps reflecting a biologic difference between the 2 groups. Six percent of ruptured aneurysms were recoiled in this series in comparison with 2% of unruptured aneurysms.

Most important, the first follow-up angiogram often performed at approximately 6 months is not sufficient to detect all aneurysms that may require additional coiling. Although most were detected and retreated after the initial angiogram, 15 were retreated following later angiograms because the neck remnant progressively enlarged. Nine of the 15 were treated after their second follow-up at approximately 2 years, but the remaining 6 required later treatment, 1 as late as 102 months after initial coiling. Progressive neck remnant enlargement has been demonstrated in 14.8% of aneurysms in the first year after treatment.[13]

Raymond et al[4] have also reported progressive deterioration with reopening of aneurysms that were angiographically occluded at 6 months. None of the aneurysms in our series of patients who went on to receive additional coiling were completely occluded at 6 months, but 1 patient who presented with a rebleed from the same aneurysm at 7 years had complete angiographic occlusion at 2 years. Raymond et al found major recurrences in 20.7% at a mean of 16.48 ± 15.93 months. Nearly half were retreated with coils and half of these showed a second recurrence after a mean follow-up of 15.56 ± 18.43 months. The authors detected 46.9% of all recurrences by 6 months and 96.9% by 36 months.

In ISAT,[1] 2 aneurysms that were completely occluded at 6 months reruptured.

We routinely perform follow-up angiography at 3–6 months. Intra-arterial angiography was used until 2004, but we now follow patients by using MR angiography source data, multiplanar reconstructions, and maximum intensity projections or surface-rendered images. When the aneurysm is completely occluded, we perform an additional follow-up study after a further 18–24 months. If a small remnant is seen at 3–6 months, MR angiography is arranged at 12 months. If the aneurysm is then stable, a further study is arranged 2 years after that. If an enlarging remnant is demonstrated, retreatment is considered. The patients are followed to ensure 2 consecutive years of angiographic stability. Most significant recurrences should therefore be detected by using this protocol. Gallas et al[13] reported that 96% of aneurysms completely occluded at 1 year remained stable, with a mean follow-up period of 36 months. They also reported that no patient with a completely occluded aneurysm at 2 years demonstrated recanalization at 3 years. It is currently debatable for how long these patients should be followed. A case could be made for delayed imaging at 10 years, but the numbers of investigations would be prohibitively large and the yield of significant recurrences very small after stability had been demonstrated for 2 years.

Conclusion

In conclusion, the rupture risk from aneurysm recurrences is very low; therefore, it is essential that retreatment be effective and carry a small additional burden of morbidity. In our series, most retreated patients had stable satisfactory angiographic appearances and there was no case of rebleeding. The risk of additional treatment in this small subgroup of patients with previously coiled aneurysms was 3%. Although this does not offset the benefit of coiling versus clipping, further investigation is required to assess whether patient outcomes benefit from treating aneurysm recurrences.

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