Endovascular Coiling of Intracranial Aneurysms in Elderly Patients: Report of 205 Treated Aneurysms

**BACKGROUND:** More elderly patients are presenting with intracranial aneurysms. Many are poor surgical candidates and often undergo endovascular treatment. 

**OBJECTIVE:** We present our experience with embolization in elderly patients.

**METHODS:** We performed a retrospective review of a prospective database of elderly patients treated with coil embolization for intracranial aneurysms.

**RESULTS:** In a period of 16 years, 205 aneurysms were treated in 196 individuals (age range, 70–96 years; mean age, 77.3 years), including 159 females (average follow-up, 16.2 months). Ninety-seven patients presented with unruptured aneurysms, and 99 patients presented after subarachnoid hemorrhage; the diagnosis was confirmed by computed tomographic scan or lumbar puncture. Complete occlusion was achieved in 53 aneurysms (26%), with a neck remnant in 127 (62%), incomplete occlusion in 13 (6%), and 12 unsuccessful attempts. Postembolization, 89.3% of patients were neurologically intact or unchanged, whereas 8.7% had new deficits. Four patients died. By modified Rankin Scale score, at last clinical evaluation, 128 patients (65%) had a good outcome. Follow-up angiograms were available for 113 aneurysms; they revealed that 62% were unchanged, 21% were further thrombosed, and 17% had recanalized. Three aneurysms ruptured after treatment during follow-up. Rupture was not associated with incomplete occlusion or neck remnant results (P = .6). Twenty-five aneurysms required reembolization. Reembolization was not associated with new deficits or death (odds ratio, 0.56; 95% confidence interval, 0.19–1.58; P = .27).

**CONCLUSION:** Coil embolization of intracranial aneurysms is safe and effective in the elderly. Preembolization clinical condition strongly correlates with clinical outcome. Incomplete embolizations are not associated with a higher rerupture risk. Additional embolization does not affect the clinical results.

**KEY WORDS:** Aneurysm, Coiling, Elderly, Embolization, Endovascular

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with patients treated with clipping. Additionally, many more patients required retreatment for rupture, residual filling, or recanalization of the aneurysm after coiling. The impact of cumulative risk of multiple procedures over time is uncertain, but it theoretically could negatively influence the long-term outcome in these patients, particularly for younger patients, who may require many decades of aneurysm protection.

Although these findings indicate that surgical clipping is a more durable treatment for younger patients, resulting in better long-term outcomes, the logical implication for elderly patients is that a less durable treatment option may be an acceptable therapeutic approach. Determining the effects of a less durable treatment option in this demographic and evaluating its impact on the long-term outcome is of great importance. It seems possible that a less invasive approach, particularly in those patients with multiple comorbidities who are poor surgical candidates, may be reasonable. The risks of rebleeding and recanalization, prominent in younger patients, may be less important in elderly patients.

Coupled with the fact that older patients have a higher risk of adverse outcomes with surgical treatment compared with endovascular treatment, coil embolization may be the preferred treatment option for elderly patients. However, there are relatively few series that have assessed the outcomes of coil embolization exclusively in the elderly population. We present our experience with endovascular coil embolization in a series of 196 elderly patients (>70 years of age), which, to our knowledge, is the largest series currently in the literature.

PATIENTS AND METHODS

All patients with aneurysms treated by endovascular techniques at University of California, Los Angeles, Medical Center have been prospectively entered into an endovascular coiling database. This database was used to identify all patients 70 years of age or older with aneurysms treated by coil embolization in the past 16 years. A small number of early patients did not have complete medical records information and therefore were excluded from this analysis. We performed a retrospective review of medical records in these elderly patients with aneurysms. Our Institutional Review Board approved the review of medical records.

Risk factors and predictive factors for outcomes and adverse events were statistically analyzed by the creation of 2 x 2 tables for odds ratio (OR) and Fisher’s exact test calculation for dichotomous variables. Continuous variables (age) were compared using the Mann-Whitney test.

RESULTS

Patients and Aneurysms

In a 16-year period, 205 aneurysms were treated in 196 individuals, who ranged in age from 70 to 96 years (mean age, 77.3 years); the group included 159 women and 37 men. The average clinical follow-up was 16.2 months (standard deviation, 25 months).

At presentation, 99 patients presented acutely after SAH attributable to aneurysm rupture. The diagnosis of SAH was typically confirmed by computed tomographic scan. In the rare cases that the computed tomographic scan was negative but the clinical history was strongly suggestive of SAH, lumbar puncture was used to confirm the diagnosis. Ninety-seven patients presented with unruptured aneurysms (Table 1). There were 118 small (<10 mm), 64 large (≥10 mm), and 23 giant (≥25 mm) aneurysms. There were 75 aneurysms with small necks and 130 with wide necks (dome-to-neck ratio, >2) (Table 2). Aneurysm location was in the anterior circulation in 164 cases and in the posterior circulation in 41 cases (Table 3).

For 5 aneurysms in 5 patients, a Neuroform stent (Boston Scientific/Target, Fremont, CA) was placed during the initial treatment to facilitate coil embolization of wide-necked aneurysms. An additional 5 aneurysms, which recanalized after initial treatment, were reembolized with the aid of Neuroform stent placement.

Clinical Results

The angiographic results are reported for the total number of aneurysms (n = 205). Complete angiographic occlusion was achieved in 53 of 205 aneurysms (26%). A neck remnant was left in 127 of 205 aneurysms (62%), and 13 of 205 aneurysms (6%) had an incomplete occlusion. Unsuccessful attempts occurred in 12 aneurysms (Table 4).

Clinical results are reported for the total number of patients (n = 196). Immediately posttreatment, 89.3% patients (175 of 196 patients) were neurologically intact or unchanged from their
preprocedure condition, whereas 8.7% (17 of 196 patients) had new deficits. Four patients died in the acute period (1 patient who presented with grade 2 SAH and 3 patients with a poor initial clinical grade). By modified Rankin Scale (mRS) criteria (Table 5), at last clinical evaluation, 128 of 196 patients (65%) had a good outcome (mRS score, ≤2). Of patients who were at least 80 years of age, 59% (33 of 56 patients) had good outcome at last evaluation, compared with 68% (95 of 140 patients) under the age of 80 years ($P = .25$).

Because of the wide mobility of the patients referred to our hospital for care, long-term local angiographic follow-up was not available for many patients; this is one of the limitations of this retrospective analysis. Follow-up angiograms were available for 113 aneurysms at an average of 14 months (range, 1–95 months). At last follow-up, 62% (70 of 113 aneurysms) were unchanged; 21% (24 of 113 aneurysms) that previously had a neck remnant or incomplete occlusion further thrombosed; and 17% (19 of 113 aneurysms) recanalized (Table 6). Aneurysms with a complete occlusion had a recanalization rate of 7% (2 of 28 aneurysms) vs 20% (17 of 85 aneurysms) for those with incomplete occlusion or neck remnants (OR, 3.25; 95% confidence interval, 0.65–21.92; $P = .15$). As expected, those with an incomplete embolization had the highest rate of recanalization (25%).

Three treated aneurysms ruptured during follow-up (2 were in patients with SAH, and 1 was an incidentally found aneurysm). The ruptures occurred at 10 days, 1 month, and 8 months after embolization. Rupture after treatment was not significantly associated with incomplete or neck remnant results ($P = .6$). However, all 3 ruptures occurred in patients with neck remnants. The rate of rupture after embolization was therefore 2% (3 of 140 cases) in aneurysms with incomplete or neck remnant results and 0% in patients with complete occlusion. Of note, 73 patients with SAH had incomplete occlusion or a neck remnant, and all of them had their blood pressure liberalized or actively pressed as part of vasospasm prophylaxis and treatment. Only 1 of these patients (1.4%) experienced rerupture in the acute postembolization period. Patients who experienced ruptures posttreatment were, on average, older (average age, 83 years) than those who did not have a rupture (average age, 77 years) ($P = .05$). No other signif-

| TABLE 3. Aneurysm Locations$^a$ |
|---------------------------------|
| Aneurysm Location               | No. of Aneurysms |
|---------------------------------|------------------|
| Anterior circulation            | 164              |
| Cavernous ICA                   | 7                |
| Paraclinoid ICA and ophthalmic artery | 30             |
| Posterior communicating artery  | 61               |
| Anterior choroidal artery       | 2                |
| ICA bifurcation                 | 6                |
| Anterior cerebral artery        | 1                |
| Anterior communicating artery   | 45               |
| MCA bifurcation                 | 9                |
| Other MCA artery aneurysms      | 3                |
| Posterior circulation           | 41               |
| Vertebral artery                | 3                |
| Posteroinferior cerebellar artery | 3               |
| Superior cerebellar artery      | 5                |
| Posterior cerebral artery       | 3                |
| Basilar trunk                   | 2                |
| Basilar tip                     | 24               |
| Trigeminal artery               | 1                |

$^a$ ICA, internal carotid artery; MCA, middle cerebral artery. n = 205 aneurysms.

| TABLE 4. Anatomic Result of Embolization$^a$ |
|---------------------------------------------|
| Result                                       | No. of Aneurysms |
|---------------------------------------------|------------------|
| Unsuccessful attempt                         | 12               |
| Complete occlusion                           | 53 (26%)         |
| Neck remnant                                 | 127 (62%)        |
| Incomplete occlusion                         | 13 (6%)          |

$^a$ n = 205 aneurysms.

| TABLE 5. Modified Rankin Scale |
|-------------------------------|
| Score | Description |
|-------|-------------|
| 0     | No symptoms at all |
| 1     | No significant disability despite symptoms; able to carry out all usual duties and activities |
| 2     | Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance |
| 3     | Moderate disability; requiring some help, but able to walk without assistance |
| 4     | Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance |
| 5     | Severe disability; bedridden, incontinent, and requiring constant nursing care and attention |
| 6     | Dead         |

| TABLE 6. Treated Aneurysms With Long-term Angiogram Follow-up (n = 113) |
|---------------------------------------------------------------|
| Result                     | No. of Aneurysms |
|------------------------------|------------------|
| Unchanged                  | 70 (62%)         |
| Further thrombosis          | 24 (21%)         |
| Recanalized                 | 19 (17%)         |

(24 of 113 aneurysms)
significant risk factors (Table 7) could be identified to predict rupture after treatment, although there were trends toward more frequent ruptures in men and in larger aneurysms ($P = .089$, and $P = .075$, respectively).

Twenty-five aneurysms (13% of those with embolization performed) required reembolization owing to incomplete embolization or recanalization. However, patients who required additional endovascular treatment did not have a higher rate of poor outcomes at last follow-up than those who did not require additional endovascular treatment (OR, 0.56; 95% confidence interval, 0.19–1.58; $P = .27$). The mean follow-up for patients who required reembolization was 24 months (range, 1–78 months).

Comparison of Patients With Ruptured and Unruptured Aneurysms

Ninety-nine patients presented with SAH secondary to aneurysm rupture (Table 8). Ninety-seven patients presented with unruptured aneurysms. Most patients with unruptured aneurysms presented either incidentally or because of symptoms related to mass effect of the aneurysm (most commonly, cranial nerve dysfunction). Whereas 80% of the patients with SAH (79 of 99 patients) had small (<10 mm) aneurysms, only 34% of the patients without SAH (33 of 97 patients) had small aneurysms ($P < .0001$) (Table 2). The decision to treat small, unruptured aneurysms was generally made if the patient had a personal or family history of SAH, if the aneurysm had shown an increase in size on serial angiograms, if the morphology of the aneurysm was concerning (for example, the presence of a bleb or "nipple" [Fig. 1]), or if the aneurysm was otherwise symptomatic owing to mass effect. Wide-necked aneurysms were more common in patients without SAH (76% [74 of 97 patients], compared with 51.5% [51 of 99 patients] in those with SAH; $P = .0004$).

The results of embolization were similar between patients with ruptured and unruptured aneurysms; complete embolization was accomplished in 28% of patients with unruptured aneurysms (27 of 97 patients) and in 22% of those with ruptured aneurysms (22 of 99 patients) ($P = .32$). Despite the similar rates of complete embolization results, in those patients for whom a follow-up angiogram was available, recanalization was more common in patients without a history of rupture (24% [14 of 59], compared with 10% in patients with rupture [5 of 49 patients]; OR, 2.74; 95% confidence interval, 0.82–9.60; $P = .08$). The requirement for further embolization was similar between the 2 groups (14% unruptured [14 of 97 patients] and 11% ruptured [11 of 99 patients]; $P = .5$). Rupture of aneurysms after embolization occurred in 3 patients overall (1 with a previous rupture [1%] and 2 treated after SAH [2%]; $P = 1.0$).

There was no statistically significant difference in the rate of new neurologic deficits in patients with unruptured aneurysms (6% [6 of 97 patients]) vs those with rupture (11% [11 of 99 patients]; $P = .2$). Aneurysm perforation did not occur in any patients treated for unruptured aneurysms, whereas it occurred in 5 patients after SAH ($P = .06$). There were no procedure-related deaths in the treatment of unruptured aneurysms, whereas there were 2 deaths after embolization of ruptured aneurysms ($P = .5$).

Overall, as expected, the rate of good outcomes (mRS score, ≤2) was higher in patients who presented unruptured (91% [88 of 97 patients]) compared with those who presented after SAH (40% [40 of 90 patients]; $P < .0001$). Of the 9% of patients with unruptured aneurysms who had a poor outcome (mRS score, >2), most poor function was related to preexisting deficits or comorbidities. Only 2 of these patients had a deterioration related to the aneurysm embolization, and, as mentioned previously, 1 patient died because of rupture of the aneurysm several months after embolization.

### TABLE 7. Risk Factor Analysis for Aneurysm Rupture After Treatment

| Risk Factor             | Rupture (n = 3) | No Rupture | $P$ Value |
|-------------------------|-----------------|------------|-----------|
| Age, average, y         | 83              | 77         | .05       |
| Male                    | 67%             | 18%        | .089      |
| Posterior circulation   | 33%             | 20%        | .5        |
| Large/giant size        | 100%            | 42%        | .075      |
| Wide neck               | 67%             | 63%        | 1.0       |
| Subarachnoid hemorrhage | 67%             | 50%        | .6        |

### TABLE 8. Comparison of Patients With Ruptured Vs Unruptured Aneurysms

| Aneurysms | Unruptured | Ruptured | $P$ Value |
|-----------|------------|----------|-----------|
| Patients  | 97         | 99       |           |
| Posterior circulation | 18 (19%) | 22 (22%) | .6        |
| Small aneurysms (<10 mm) | 33 (34%) | 79 (80%) | <.0001    |
| Wide neck | 74 (76%)  | 51 (51.5%) | .0004    |
| Embolization result (by patient) |          |          |           |
| Complete   | 27 (28%)  | 22 (22%)  | .32       |
| Neck remnant or incomplete | 63 (65%) | 73 (73%)  |           |
| Unsuccessful attempts | 7 (7%)    | 4 (4%)    |           |
| Follow-up angio (n = 108) |          |          |           |
| Recanalization | 14 (24%) | 5 (10%)   | .08       |
| No change or thrombosis | 45 (76%) | 44 (90%)  |           |
| Additional embolization | 14 (14%) | 11 (11%)  | .5        |
| Rupture after embolization | 1 (1%)  | 2 (2%)    | 1.0       |
| Complications |          |          |           |
| New neurologic deficit | 6 (6%) | 11 (11%)  | .2        |
| Aneurysm perforation | 0  | 5 (5%)    | .06       |
| Procedure-related death | 0 | 2 (2%)    | .5        |
| Good outcome (mRS ≤2) | 88 (91%) | 40 (40%)  | <.0001    |

*Angio, angiography; mRS, modified Rankin Scale score.*
Complications

A new neurologic deficit after embolization occurred in 17 of 196 patients (8.7%). In most of these (12 patients), deficits were associated with embolic or ischemic events, including 11 patients with arm weakness, hemiparesis, and/or hemineglect. One patient with ischemia had a deterioration of mental status. Five patients (2.6%) had aneurysm perforation; 4 of these patients had a new neurologic deficit (included in the 17 patients above), primarily deterioration of mental status, and 1 patient developed hemiparesis. There were 2 procedure-related deaths. One patient had thrombosis of the internal carotid artery and intracranial hemorrhage after urokinase intra-arterial injection. The other patient developed a massive retroperitoneal hemorrhage after the procedure (Table 9).

DISCUSSION

Previous Studies

Since their introduction, endovascular technologies have evolved into one of the most important management options for intracranial aneurysms, and the techniques have been shown to be generally safe and effective.9-11 Technologic advances have “pushed the envelope” to make the techniques more durable and more applicable to complex types of aneurysms.12-14

The largest prospective clinical trial to date comparing coil- ing and surgical clipping was the ISAT.4,15,16 Although the ISAT showed that initial treatment of cerebral aneurysms with coil embolization was better tolerated than surgical clipping, the trial has been the object of scrutiny for its methodology.4,15,16 In particular, the study only randomized those patients who were deemed suitable candidates for either coiling or clipping. Additional follow-up of the patients treated in ISAT has revealed several interesting things. First, although coil embolization was initially better tolerated, with lower morbidity and mortality, 17.4% of patients who underwent coiling required retreatment for rupture or residual or recurrent aneurysm filling, compared with only 3.8% treated surgically.7 About half of these patients were re-treated early, and half were re-treated late, with a mean time to retreatment of 20.7 months. Retreatments continued to be required throughout the follow-up period. After surgery, most retreatments were early (mean, 5.7 months). By hazard ratio, late retreatment was 6.9 times more likely after endovascular treatment and was most common with younger age, larger lumen size, and incomplete initial occlusion.

The difference between clipping and coiling in the ISAT patients in terms of long-term outcome was further explored in terms of late rebleeding rates.6 This analysis showed better long-term protection and longer predicted life expectancy for younger patients (<40 years of age) treated by surgical clipping. From the combination of these factors, retreatment and late rebleeding seem to indicate that surgical clipping is favorable in selected younger patients. This raises the question whether the converse is true: should elderly patients, with higher initial surgical risk and a shorter life expectancy, be preferentially treated by coil embolization to avoid the up-front surgical risk? Although a less durable treatment, coil embolization is better tolerated in the short term, carrying less anesthesia and acute treatment risk. In older patients, the durability of the aneurysm treatment may be less important, and the cumulative risk of retreatment and/or rebleeding may not overturn the initial benefits of coiling.

Although no study has prospectively addressed this question, there have been several small series of elderly patients reported (Table 10). The largest prior series in the literature is the subgroup analysis of elderly patients treated in ISAT.17 This series compared 138 elderly (age, >70 years) patients treated endovascularly with 140 elderly patients treated surgically. There was a slightly higher rate of good outcomes (independent living) in the coil group (60.1% vs 56.1%). This difference was more profound in internal carotid artery and posterior communicating artery aneurysms (72% vs
52%; \( P < .05 \)). However, the outcomes favored surgery for middle cerebral artery (MCA) aneurysms (45.5% vs 86.7%; \( P < .05 \)). The study also found a lower rate of posttreatment epilepsy in patients treated endovascularly (0.7%) compared with those who underwent surgery (12.9%; \( P < .001 \)). Although this series supplies convincing evidence that coiling in elderly patients is safe and generally effective, it is subject to the same criticism as the ISAT in general, in that all of these patients were deemed suitable for both surgery and coiling before randomization. It therefore may underestimate the benefit of coiling in the general elderly population, as it does not include those patients who are clearly poor surgical candidates. It may further underestimate the difference by including a relatively large number of MCA aneurysms (22 aneurysms) in the coiling group. In our series, all coiled patients were included, including patients in poor medical condition who were clearly poor surgical candidates. Additionally, we treated only 9 MCA bifurcation aneurysms, as many of the lesions in this location were considered to be more appropriately treated with surgical clipping. The present utilization of 3-dimensional digital angiography identifies a population of patients with MCA aneurysms that can be safely treated with good immediate and long-term anatomic and clinical outcomes.

Other series of coil embolization in elderly patients in the literature have included 68 patients reported by Lubicz et al., 63 patients reported by Cai et al., and 52 patients reported by Sedat et al. Although general rates of good outcomes have varied depending on the make-up of the presenting clinical conditions (ruptured vs unruptured, good vs poor grade, etc), it has been generally shown that endovascular treatment in the elderly is safe and effective. As we have shown in our series as well, the rate of poor outcomes is considerably worse in patients who initially present in poor clinical grade, regardless of the treatment.

Regarding rerupture risk, Cai et al. reported 2 aneurysms (3% of 65 coiled aneurysms) that reruptured after treatment. Lubicz et al. and Sedat et al. had no reruptures. The elderly series from the ISAT did not comment on rerupture. Our rate of 3 reruptured aneurysms (1.55% of 193 successfully embolized aneurysms) was comparable to these previously reported rates as well as to the overall rate of 3% rehemorrhage after endovascular treatment in the entire ISAT population.

Seventeen percent of patients treated in the series published by Cai et al. required retreatment for recurrent aneurysm filling. Our series is comparable, with 13% of patients requiring retreatment. The ISAT reported an overall retreatment rate of 17.4%. However, there was an increased rate of retreatment in younger patients.

**Approach to Treating Elderly Patients With Aneurysms**

At our institution, we prefer to use endovascular coil embolization for elderly patients presenting with intracranial aneurysms, particularly those with medical comorbidities. As we have stated, we feel that the risk of retreatment and rebleeding during the shorter life expectancy of these patients is likely less than in young patients. Therefore, we have favored the treatment that is safest and most noninvasive up-front, with less procedure-related morbidity and mortality.

We maintain the same technical principles applied to coil embolization of patients of any age, aiming for complete embolization whenever possible. The typically more tortuous circulation of elderly patients and the frequent presence of wide-neck aneurysms make the navigation and stability of catheters and microcatheters more challenging and make it more difficult to achieve complete embolization. This also explains the elevated number of unsuccessful attempts we are reporting.

In patients who present after SAH, our primary goal is to safely protect the rupture site, if one can be identified, as well as the inflow zone. Beyond this, if complete embolization can be safely accomplished, it is attempted. However, we tend to avoid unnecessarily aggressive maneuvers in this setting once the aneurysm is partially protected. For rupture cases, we generally use only soft and ultrasoft coils. Our goal is to prevent immediate rerupture risk while minimizing the risk for perforation and worsening of the clinical condition. Although this approach may lead to a less durable result, we feel that if the aneurysm morphology is not favorable, the added risk of attempting a complete occlusion is not justified in the acute period. Whereas, in a younger patient, an incomplete occlusion or neck remnant may present significant

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**TABLE 10. Reported Findings in Elderly Patients**

| Series                          | No. of patients | Ruptured or unruptured | Neurologic deterioration | Reruptures | Retreatment |
|--------------------------------|-----------------|------------------------|--------------------------|------------|-------------|
| Ryttefors et al, 2008 (ISAT Subgroup) | 138             | R                      | 11.4%                    | 0          | 17.4%       |
| Lubicz et al, 2004              | 68              | R                      | 2.9%                     | 3%         | 7.3%        |
| Cai et al, 2005                 | 63              | R + U                  | 9%                       | 0          | 17%         |
| Sedat et al, 2002               | 52              | R + U                  | 4.2%                     | 0          | 5.7%        |
| Current Study                   | 196             | R                      | 8%                       | 1.6%       | 13%         |

* R, ruptured; U, unruptured.
problems over time, the same anatomic result may very well provide adequate protection in the nearer term. In patients with incidental aneurysms, we tend to be more aggressive. We more frequently use standard and firm coils for framing, followed by softer coils for filling, attempting a more complete and durable embolization. We feel that this approach has served our elderly patients well, as can be seen from the outcomes of this series.

CONCLUSIONS

Coil embolization of intracranial aneurysms in elderly patients is a safe and effective treatment option, avoiding the up-front risk of surgical treatment, particularly in those patients with medical comorbidities. Despite the navigation difficulties and unfavorable aneurysm morphology leading to a higher rate of partial embolizations, the rate of rerupture and retreatment was no higher than in general series of coiled aneurysms. Retreatment in this patient population did not correlate with worse outcomes. Preembolization clinical condition and age both strongly correlated with clinical outcome. Although this retrospective study cannot answer all questions, such as the comparison of coiling to clipping in the elderly, it adds to the growing literature that supports endovascular treatment in these patients as safe and effective.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENT

This is a retrospective review of a prospectively gathered database of elderly patients with intracranial aneurysms treated by coil embolization. Similar series have been published in the past, including the subgroup analysis of elderly patients treated in the International Subarachnoid Aneurysm Trial1 and the series by Sedat et al.2 However, this is, to date, the largest series of its kind, and as such is of interest, especially as increasing numbers of elderly patients present with intracranial aneurysms, and the debate continues regarding the best method of treatment for these patients. For unruptured aneurysms in this age group, controversy remains regarding whom to treat and whom to observe. The authors conclusively demonstrate that endovascular coiling is a safe and effective option for the treatment of ruptured and unruptured aneurysms in elderly patients. However, a significant limitation of the study is the large number of aneurysms (113 of 205 aneurysms) that were unavailable for follow-up.

An interesting point to note is that the incomplete embolization of aneurysms was not associated with a higher rerupture risk and that additional embolization did not affect clinical results. This is an important point with regard to the treatment of ruptured aneurysms in elderly patients, in whom the goal for treatment in the setting of acute subarach-
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noid hemorrhage may be to protect the aneurysm from rerupture and not necessarily to achieve complete embolization; especially because, as the authors note, elderly patients typically have more tortuous vessels that are more difficult to navigate, and it is more difficult to stabilize microcatheters in these vessels during embolization. However, as a caveat, complete obliteration should be achieved whenever it can be safely done. It is also important to note that no increased periprocedural morbidity or mortality was associated with retreatment procedures. In this age group, we have also favored endovascular treatment for ruptured aneurysms whenever safe and feasible. We also prefer magnetic resonance angiography for follow-up imaging to reduce potential risk. We continue to struggle with which asymptomatic unruptured aneurysms to treat in this age group. If treatment risks decline further in the future, it may become reasonable to offer treatment to more patients in this age group with asymptomatic unruptured aneurysms.

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1. Ryttlefors M, Enblad P, Kerr RS, Molyneux AJ. International subarachnoid aneurysm trial of neurosurgical clipping versus endovascular coiling: subgroup analysis of 278 elderly patients. Stroke. 2008;39(10):2720-2726.

2. Sedat J, Dib M, Lonjon M, et al. Endovascular treatment of ruptured intracranial aneurysms in patients aged 65 years and older: follow-up of 52 patients after 1 year. Stroke. 2002;33(11):2620-2625.

The prisoner's dilemma is a fundamental problem in game theory that demonstrates why two people might not cooperate even if it is in both their best interests to do so. Merrill Flood and Melvin Dresher working at RAND in 1950 originally framed it. Albert W. Tucker formalized the game with prison sentence payoffs and gave it the “prisoner's dilemma” name (Poundstone, 1992).

In its classical form, the prisoner's dilemma (“PD”) is presented as follows:

Two suspects are arrested by the police. The police have insufficient evidence for a conviction, and, having separated both prisoners, visit each of them to offer the same deal. If one testifies (defects from the other) for the prosecution against the other and the other remains silent (cooperates with the other), the betrayer goes free and the silent accomplice receives the full 10-year sentence. If both remain silent, both prisoners are sentenced to only six months in jail for a minor charge. If each betrays the other, each receives a five-year sentence. Each prisoner must choose to betray the other or to remain silent. Each one is assured that the other would not know about the betrayal before the end of the investigation. How should the prisoners act?