# Counseling patients with cerebral aneurysms

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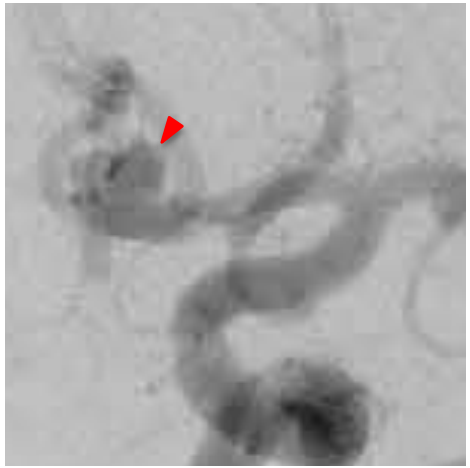
# What constitutes a dangerous cerebral aneurysm?

- Patient age
- Location
- Comorbidities



J Neurosurg 73:18–36, 1990

The International Cooperative Study on the Timing of Aneurysm Surgery

Part 1: Overall management results

NEAL F. KASSELL, M.D., JAMES C. TORNER, PH.D., E. CLARKE HALEY, JR., M.D., JOHN A. JANE, M.D., PH.D., HAROLD P. ADAMS, M.D., GAIL L. KONGABLE, B.S.N., AND PARTICIPANTS

*Department of Neurological Surgery, University of Virginia Health Sciences Center, Charlottesville, Virginia, and Department of Neurology, University of Iowa, Iowa City, Iowa*

TABLE 8

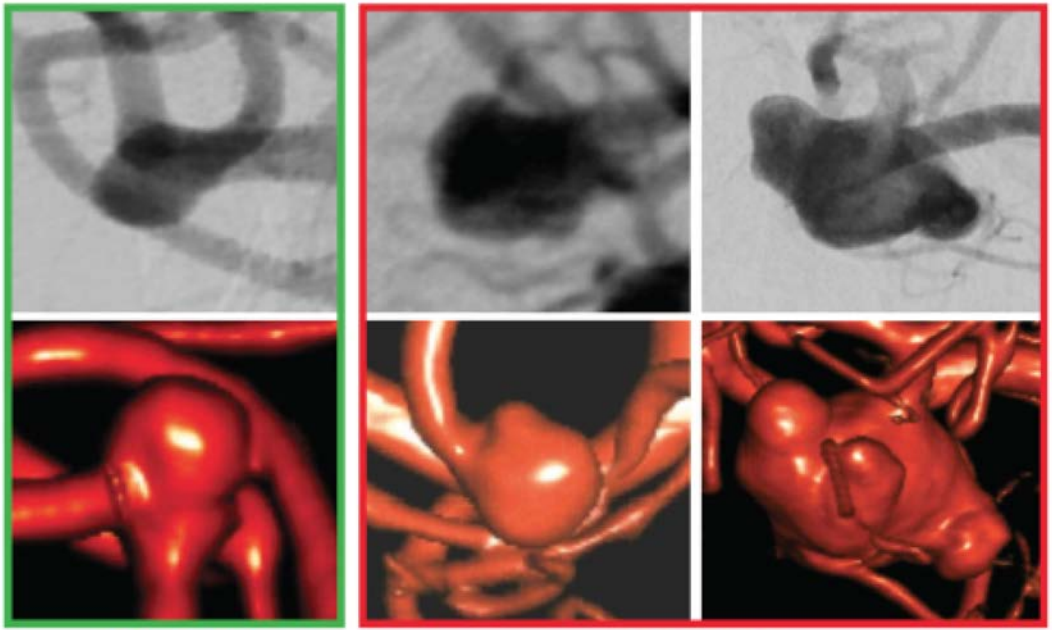
*Ruptured aneurysm size (diameter) and site**

| Aneurysm Site | Small (< 12 mm) | Large (12–24 mm) | Giant (> 24 mm) | Total |
|---|---|---|---|---|
| ICA | 790 (75.2) | 233 (22.2) | 28 (2.7) | 1051 (29.8) |
| MCA | 560 (71.2) | 199 (25.3) | 27 (3.4) | 786 (22.3) |
| ACA | 1158 (84.3) | 207 (15.1) | 9 (0.7) | 1374 (39.0) |
| VB | 203 (76.3) | 58 (21.8) | 5 (1.9) | 266 (7.6) |
| other | 37 (52.9) | 6 (8.6) | 1 (1.4) | 44 (2.0) |
| total | 2748 (78.0) | 703 (20.0) | 70 (2.0) | 3521 (100.0) |

* ICA = internal carotid artery; MCA = middle cerebral artery; ACA = anterior cerebral artery; VB = vertebrobasilar circulation. Numbers in parentheses indicate percentages.

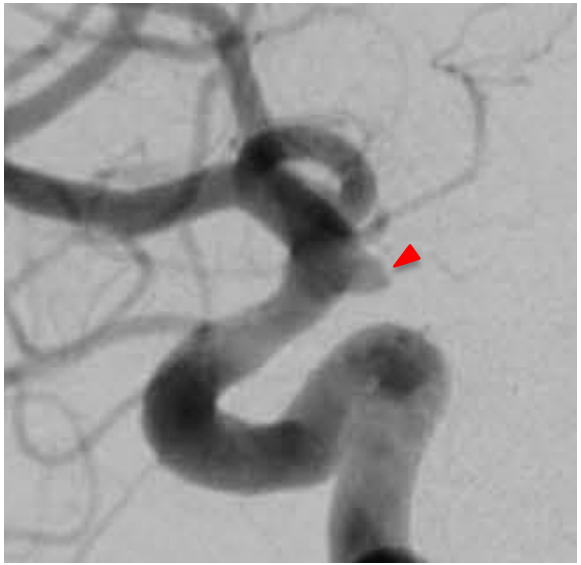
# What constitutes a dangerous cerebral aneurysm?

- Patient age
- Location
- Comorbidities
- Morphology
- Prior SAH
- Gender
- Aneurysm size



# Small unruptured aneurysms – How do you counsel?

- 67F retired school bus driver h/o DM2 (BMI 27) and migraines with incidental bilateral ICA PCoA aneurysms



# Prospective trials suggest low risk of small aneurysm rupture

**Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment**

*International Study of Unruptured Intracranial Aneurysms Investigators**

*Lancet* 2003; **362:** 103–10

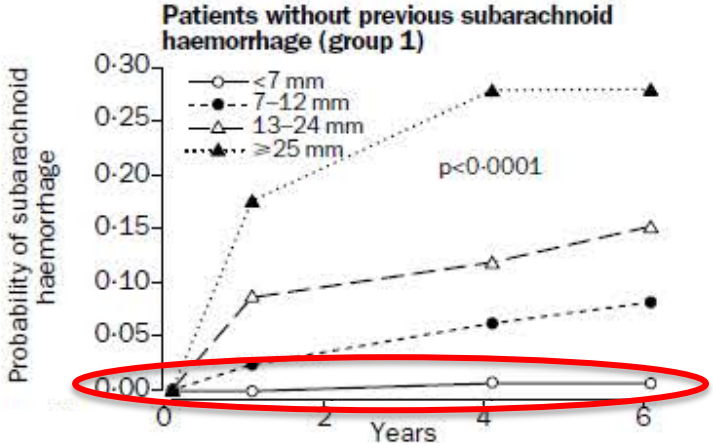
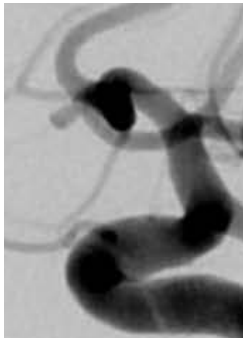



Figure 1: **Probability of subarachnoid haemorrhage over time for patients who did not have surgery**

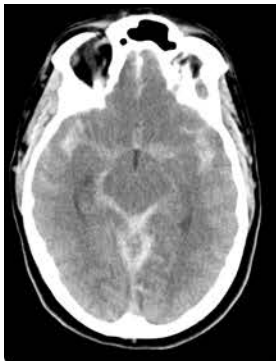
# We see small aneurysms rupture all the time

44F – 3mm basilar apex

60F – 2mm MCA bifurcation



39M – 4mm ACoA



38F – 3mm PCoA

# 25-year retrospective study of ruptured ANR at Johns Hopkins

RESEARCH—HUMAN—CLINICAL STUDIES

## Small Aneurysms Account for the Majority and Increasing Percentage of Aneurysmal Subarachnoid Hemorrhage: A 25-Year, Single Institution Study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The data herein were presented at the American Association of Neurological Surgeons meeting in Los Angeles from April 22-26, 2017.



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**BACKGROUND:** Prospective studies of unruptured aneurysms have shown very low rates of rupture for small aneurysms (<10 mm) and suggested that the risk of treatment outweighs benefit. However, common clinical practice shows that patients with aneurysmal subarachnoid hemorrhage (aSAH) frequently have small aneurysms.

**OBJECTIVE:** To investigate trends in size and location of ruptured aneurysms over a 25-yr period.

**METHODS:** A prospective, Institutional Review Board-approved database of all patients presenting to our institution with aSAH from 1991 to 2016 was analyzed. Cerebral angiography identified the source of hemorrhage. Patients with nonaneurysmal etiologies were excluded.

**RESULTS:** Complete data were available for 1306/1562 patients (84%) with aSAH from 1991 to 2016. The average age was 53 yr and 72% of patients were female. The average size of ruptured aneurysms over 25 yr was 8.0 mm. The average size of ruptured aneurysms decreased steadily with each 5-yr interval from 10.1 mm (1991-1996) to 6.6 mm (2012-2016; $P < .001$). Overall, very small aneurysms (<5 mm) were responsible for aSAH in 41% of patients. The percentage of very small ruptured aneurysms rose from 29% during the initial 5-yr period (1991-1996) to 50% in the most recent period. Likewise, the percentage of ruptured aneurysms that were 5 to 9 mm rose from 26% to 34% ($P < .001$). In the past 5 yr, aneurysms <10 mm accounted for 84% of aSAH. Vessel of origin ($P = .097$) and aneurysm location ($P = .322$) did not vary with time.

**CONCLUSION:** Ruptured small and very small aneurysms represent a majority and increasing share of aSAH. Identification and prophylactic treatment of these aneurysms remains an important clinical role for cerebrovascular neurosurgery.



**KEY WORDS:** Subarachnoid hemorrhage, Cerebral aneurysm

Neurosurgery 0:1–8, 2017 DOI: 10.1093/neuros/nyx464 www.neurosurgery-online.com


Aneurysmal subarachnoid hemorrhage (aSAH) is a devastating neurological condition, despite modern improvements in neurosurgery, neuroradiology, and neurocritical care. Outcomes following aSAH remain poor, with one-third mortality and only half of patients making a functional recovery.[1] Concurrently, unruptured intracranial aneurysms are being identified more frequently secondary to improved imaging technology and more frequent cranial imaging.[2-4] As such, prophylactic aneurysm treatments to prevent aSAH, particularly by endovascular means, have increased in recent years.[5-7] Certain prospective trials of unruptured intracranial aneurysms, most notably International Study of Unruptured Intracranial Aneurysms (ISUIA), suggest that the risk of small aneurysms (<10 mm in size) rupturing is low and that the morbidity of treatment is unjustified.[8,9] Although these studies have been widely criticized,[10] they have nonetheless impacted some practitioners'

**ABBREVIATIONS: ANOVA**, analysis of variance; **aSAH**, Aneurysmal subarachnoid hemorrhage; **CTA**, computed tomography angiography; **FDA**, Food and Drug Administration; **ISAT**, International Subarachnoid Aneurysm Trial; **ISUIA**, International Study of Unruptured Intracranial Aneurysms; **MCA**, middle cerebral artery SAH, subarachnoid hemorrhage; **MRA**, magnetic resonance angiography




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# >1300 SAH, vessel of origin unchanged over time

**TABLE 1. Demographics**

| | Number | Percent/standard deviation |
|---|---|---|
| Total patients | 1306 | |
| Age | 52.8 (0-94) | ±14.8 |
| Female sex | 936 | 72% |
| Race | | |
| White | 720 | 55% |
| Black | 519 | 40% |
| Other | 67 | 5% |
| Size | | |
| 0-5 | 539 | 41.3% |
| 5-9 | 410 | 31.4% |
| 9-14 | 198 | 15.2% |
| 14-25 | 123 | 9.4% |
| >25 | 35 | 2.7% |

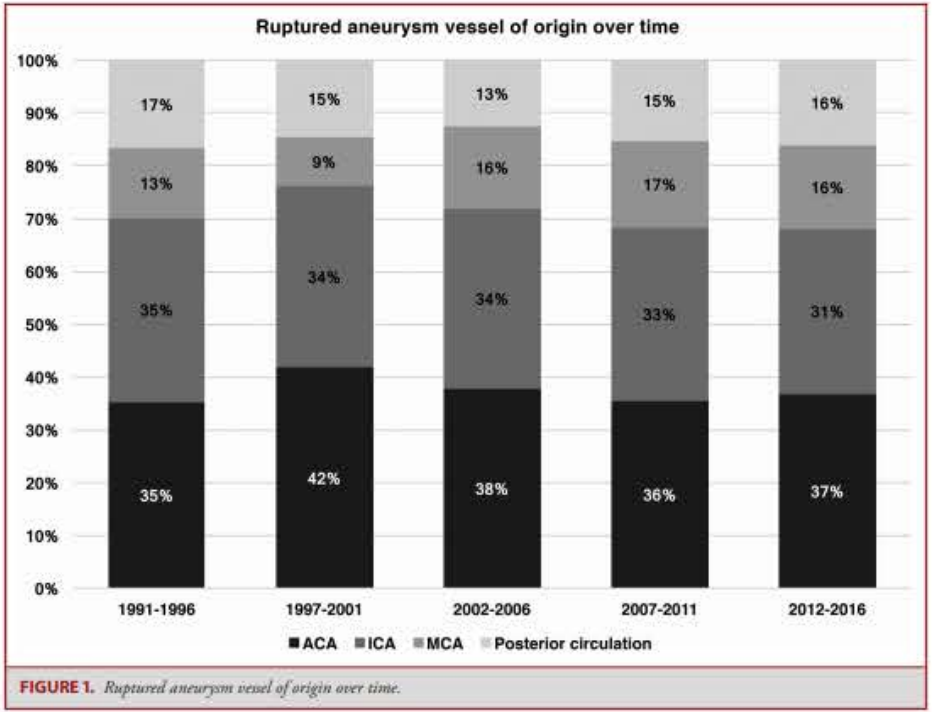


**FIGURE 1.** *Ruptured aneurysm vessel of origin over time.*

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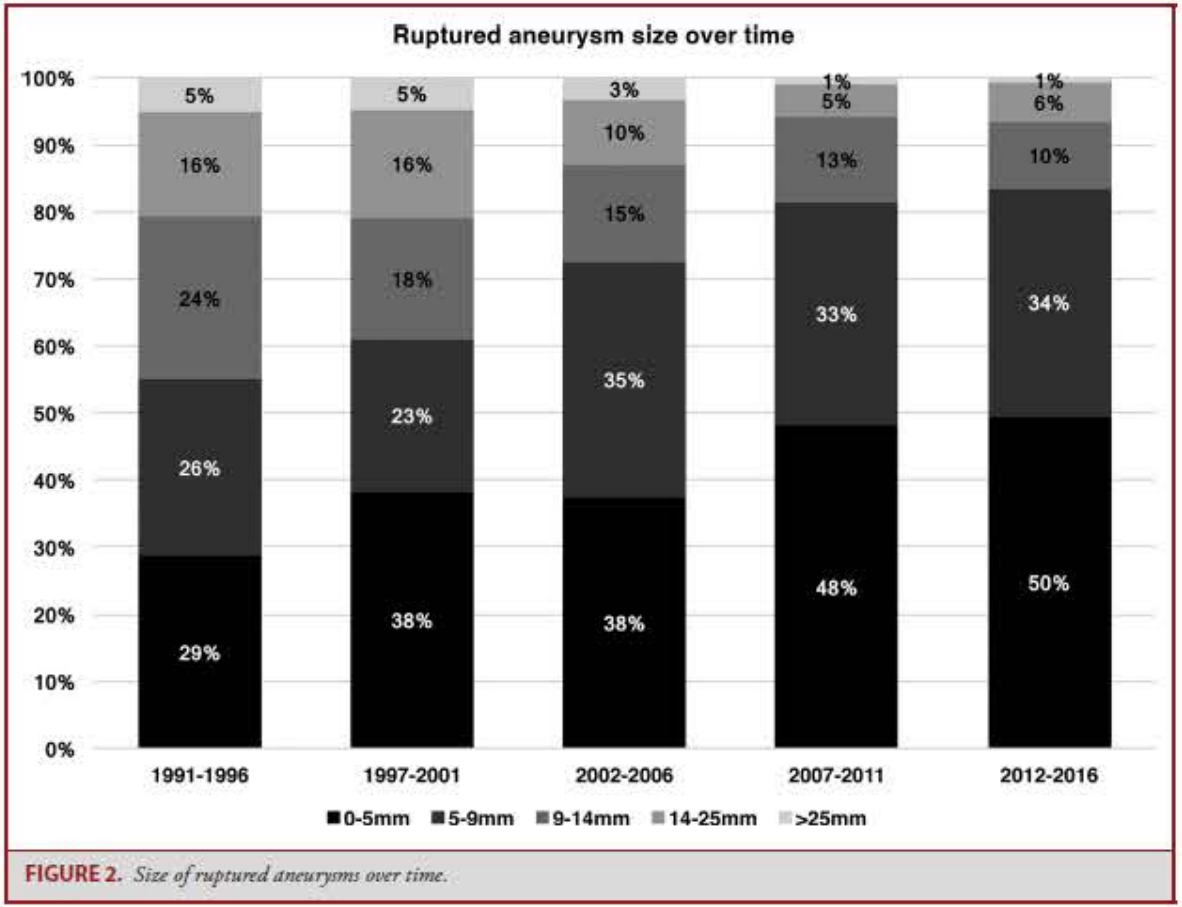



**FIGURE 2.** *Size of ruptured aneurysms over time.*

Most recent 5yr interval:

- 50% 5mm or less
- 84% <10mm

# Similar trend toward increasing proportion of very small aneurysms in the literature

| Author | Publication year | Location | Patients | Enrollment start | Enrollment finish | <5mm (%) |
|---|---|---|---|---|---|---|
| Lee et al. (40) | 2015 | Korea | 200 | 2012 | 2014 | 47 |
| Froelich(26) | 2016 | Australia | 131 | 2010 | 2015 | 49 |
| Dolati(27) | 2015 | Canada | 123 | 2008 | 2012 | 37 |
| Zhao(28) | 2014 | China | 766 | 2006 | 2013 | 51 |
| Kashiwazaki(16) | 2013 | Japan | 851 | 2003 | 2011 | 28 |
| Tahir(17) | 2009 | Pakistan | 55 | 2004 | 2007 | 24 |
| Nahed(18) | 2005 | USA | 152 | 2001 | 2004 | 33 |
| Taylor(19) | 2004 | USA | 127 | 1998 | 1999 | 33 |
| Forget(20) | 2001 | USA | 245 | 1996 | 2000 | 35 |
| Shiue(21) | 2011 | Australia | 432 | 1995 | 1998 | 22 |
| ISAT(24) | 2002 | Intl | 2143 | 1994 | 1997 | 52 |
| Horiuchi(22) | 2006 | Japan | 2577 | 1988 | 2002 | 39 |
| Osawa(23) | 2001 | Japan | 2055 | 1988 | 1998 | 38 |
| Ohashi(42) | 2004 | Japan | 280 | 1984 | 2001 | 26 |
| Inagawa(41) | 2010 | Japan | 285 | 1980 | 1998 | 24 |
| Kassell(12) | 1983 | Intl | 676 | 1980 | 1987 | 13 |
| Rosenorn(13) | 1993 | Denmark | 908 | 1978 | 1983 | 18 |
| Sundt(14) | 1982 | USA | 644 | 1969 | 1981 | 23 |
| Mccormick(15) | 1970 | USA | 54 | 1970 | 1970 | 4 |

# Increased use of noninvasive vascular imaging has identified more unruptured aneurysms

**Trends in the Utilization of CT Angiography and MR Angiography of the Head and Neck in the Medicare Population**

David P. Friedman, MD, David C. Levin, MD, Vijay M. Rao, MD

**Table 3.** Aggregate procedure volumes, 2002 vs 2007

| Study Type | Year 2002 | Year 2007 | % Change 2002-2007 |
|---|---|---|---|
| Head CTA | 8,987 | 83,297 | 827% |
| All head MRA | 272,387 | 377,820 | 39% |
| All head examinations | 281,374 | 461,117 | 64% |
| Neck CTA | 9,796 | 115,021 | 1,074% |
| All neck MRA | 192,653 | 253,170 | 31% |
| All neck examinations | 202,449 | 368,191 | 82% |
| All CTA | 18,783 | 198,318 | 956% |
| Duplex ultrasound | 2,533,820 | 3,038,905 | 20% |
| Catheter angiography | 234,160 | 159,006 | −32% |

# Small aneurysms missed on noninvasive imaging

## Accuracy of Computed Tomography Angiography in the Diagnosis of Intracranial Aneurysms

*Gustavo Pradilla[1], Robert T. Wicks[1], Uri Hadelsberg[3], Philippe Gailloud[1,2], Alexander L. Coon[1], Judy Huang[1], Rafael J. Tamargo[1]*

**Table 10.** Results Summary

| | |
|---|---|
| False CTA positives: Aneurysms found on CTA but ruled out by DSA | 27 cases of total 132 (20.5% of cases) |
| False CTA negatives: Aneurysms missed by CTA but confirmed by DSA | 29 cases of total 134 (21.6% of cases) |

CTA, computed tomography angiography; DSA, digital subtraction angiography.

**Table 7.** Size of Aneurysms Missed By Computed Tomography Angiography (CTA) but Found on Digital Subtraction Angiography (False CTA Negatives)

| Size | Total Aneurysms |
|---|---|
| Very small (0–5 mm) | 28 (96.6%) |
| Small (6–10 mm) | 1 (3.4%) |
| Medium (11–15 mm) | 0 |
| Large (16–24 mm) | 0 |

# Increased identification has led to increased interventions for unruptured aneurysms

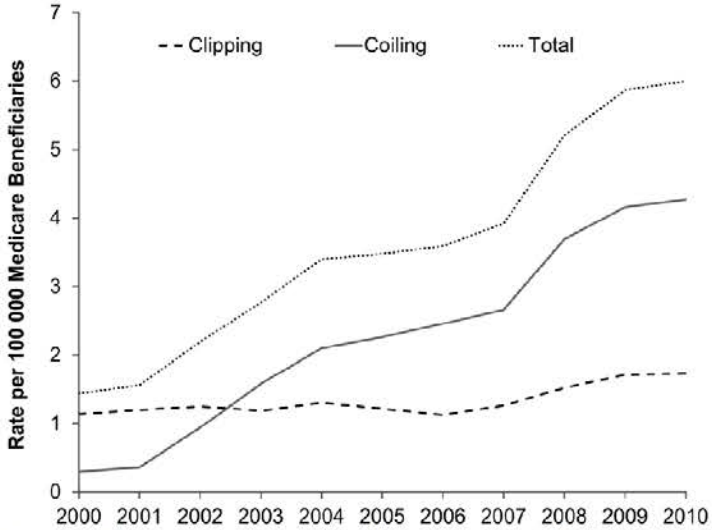



**Figure 1.** Rates of clipping and coiling of unruptured intracranial aneurysms per 100 000 Medicare beneficiaries, 2000 to 2010.

**Clipping and Coiling of Unruptured Intracranial Aneurysms Among Medicare Beneficiaries, 2000 to 2010**

Jessica J. Jalbert, Abby J. Isaacs, Hooman Kamel and Art Sedrakyan

*Stroke.* 2015;46:2452-2457; originally published online August 6, 2015;

Over 25 years, elective interventions for have increased from 33% to 80% of total aneurysm treatments at JHH

# SAH incidence has not changed despite increased elective treatments

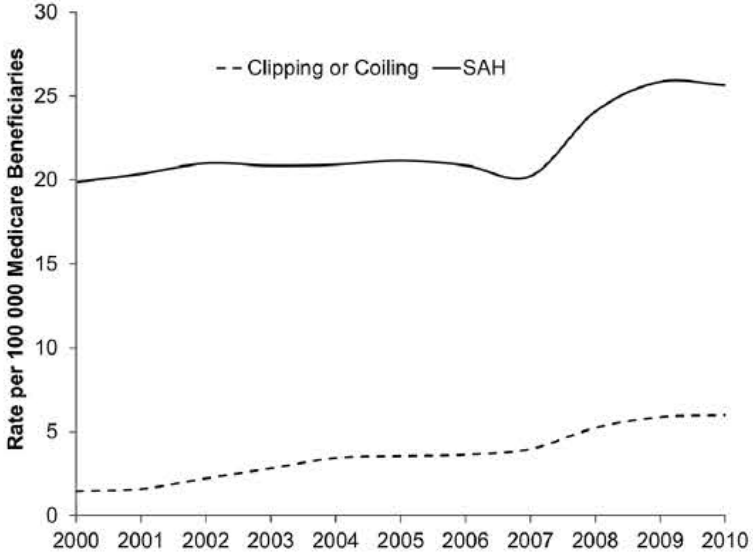


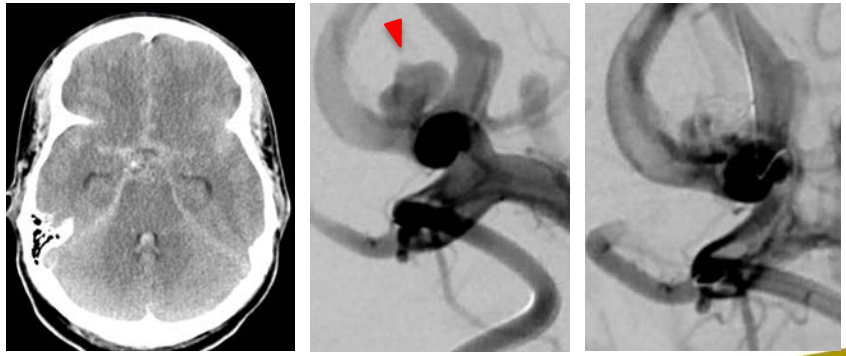

**Figure 3.** Age- and sex-standardized rates of clipping or coiling and of subarachnoid hemorrhage per 100 000 Medicare beneficiaries, 2000 to 2010.

**Clipping and Coiling of Unruptured Intracranial Aneurysms Among Medicare Beneficiaries, 2000 to 2010**

Jessica J. Jalbert, Abby J. Isaacs, Hooman Kamel and Art Sedrakyan

*Stroke.* 2015;46:2452-2457; originally published online August 6, 2015;

4mm ACoA



# Majority of patients in ISUIA selected out for elective intervention

**Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment**

*International Study of Unruptured Intracranial Aneurysms Investigators**

*Lancet* 2003; **362**: 103–10

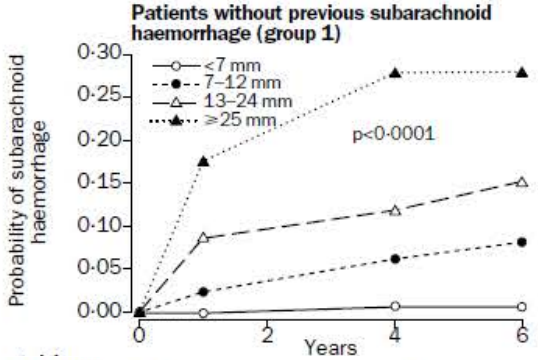



Figure 1: **Probability of subarachnoid haemorrhage over time for patients who did not have surgery**

**Procedures**
Patients were assigned to one of two cohorts—operated or unoperated—based on whether surgical or endovascular treatment of at least one unruptured intracranial aneurysm was planned on clinical grounds at the time the patient was first seen at the ISUIA centre. All patients

**Findings** 4060 patients were assessed—1692 did not have aneurysmal repair, 1917 had open surgery, and 451 had endovascular procedures. 5-year cumulative rupture rates for

Patients with aneurysms thought to be most vulnerable were certainly among the majority (58%) of ISUIA enrollees who were selected out for surgery

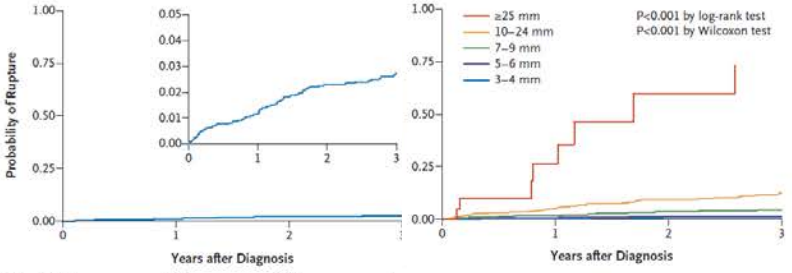
# Less selected prospective studies have shown annual rates of rupture approaching 1%

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

## The Natural Course of Unruptured Cerebral Aneurysms in a Japanese Cohort

The UCAS Japan Investigators*





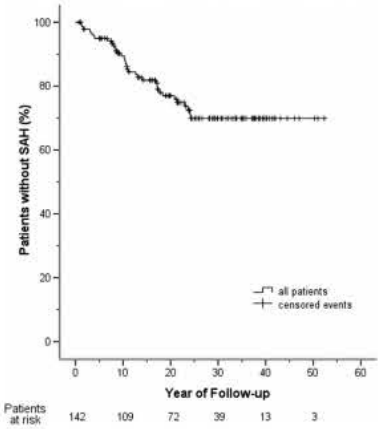




**Figure 1.** Kaplan–Meier curve showing cumulative rates of aneurysm rupture for all patients. The markers of the curves indicate censored events. SAH indicates subarachnoid hemorrhage.

## Natural History of Unruptured Intracranial Aneurysms
### A Long-term Follow-up Study

Seppo Juvela, MD, PhD; Kristiina Poussa, MD; Hanna Lehto, MD; Matti Porras, MD, PhD

# AHA has dropped language recommending conservative treatment of aneurysms <10mm

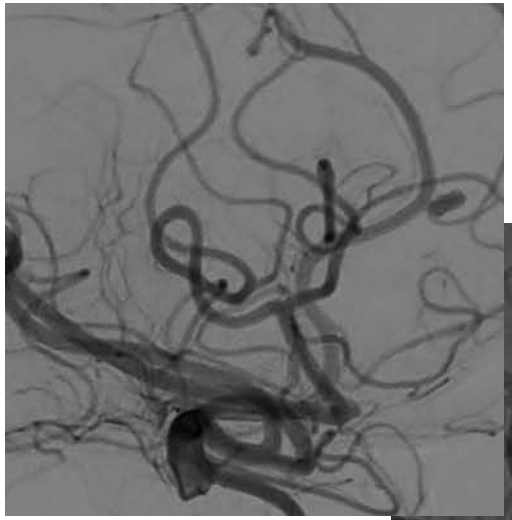
**AHA Scientific Statement**

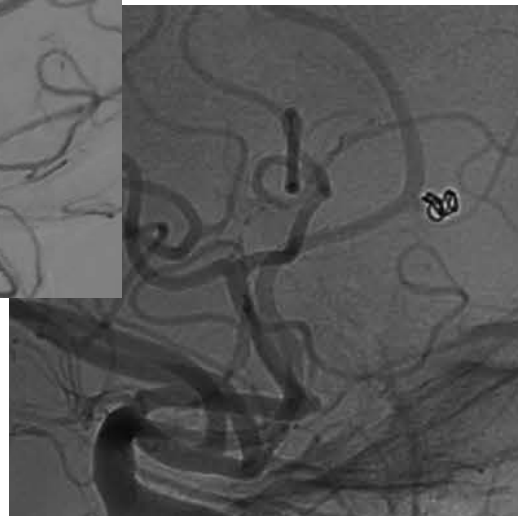
**AHA/ASA Guideline**

4. In consideration of the apparent low risk of hemorrhage from incidental small (<10 mm) aneurysms in patients without previous SAH, treatment rather than observation cannot be generally advocated. However, special

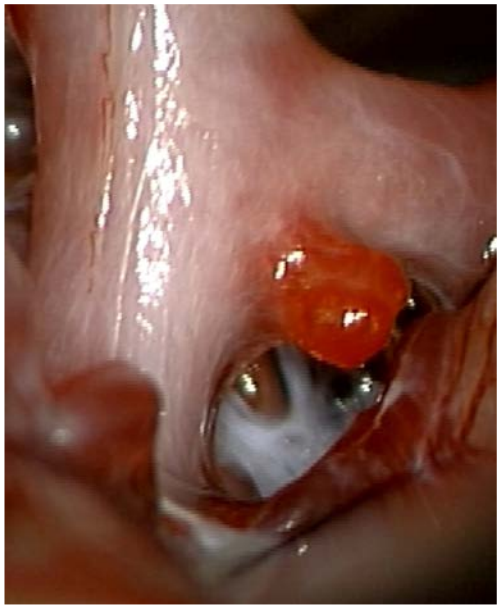
5. The treatment risk of patients with UIAs is related to advancing age, medical comorbidities, and aneurysm location and size, so in older patients (>65 years of age) and those with associated medical comorbidities with small asymptomatic UIAs and low hemorrhage risk by location, size, morphology, family history, and other relevant factors, observation is a reasonable alternative *(Class IIa; Level of Evidence B)*.

# Early case at Strong: 49F 3mm ruptured A2-3 aneurysm





# Implications for counseling patients with cerebral aneurysms

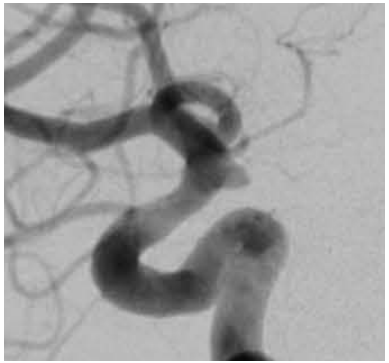


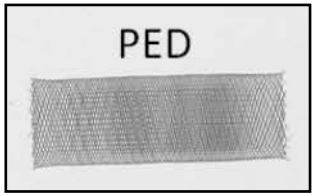
1mm ICA termination

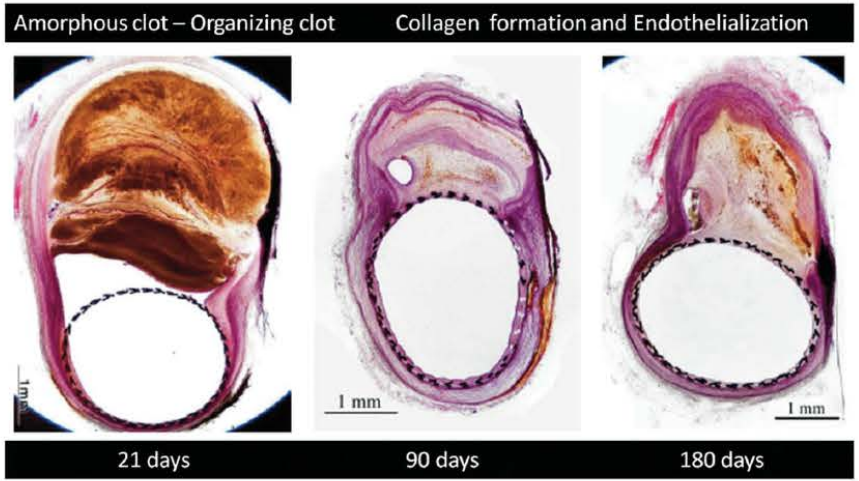
- Size threshold limits identification of dangerous ANR and ability to reduce SAH
- Patients with incidental aneurysms of all sizes should be evaluated for rupture risk

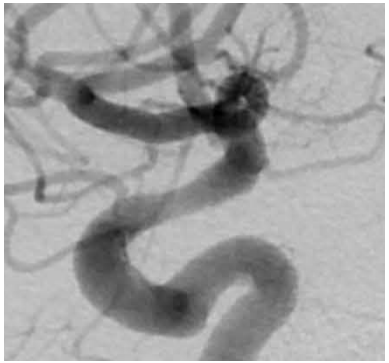
5mm MCA

# Small bilateral posterior communicating artery aneurysms obliterated with flow diversion





# Low complications in the largest single-institution experience with flow diversion

JNS CLINICAL ARTICLE

**Declining complication rates with flow diversion of anterior circulation aneurysms after introduction of the Pipeline Flex: analysis of a single-institution series of 568 cases**

*Geoffrey P. Colby, MD, PhD,[1] Matthew T. Bender, MD,[1] Li-Mei Lin, MD,[2] Narlin Beaty, MD,[1] Justin M. Caplan, MD,[1] Bowen Jiang, MD,[1] Erick M. Westbroek, MD,[1] Bijan Varjavand, MD,[1] Jessica K. Campos, MD,[1] Judy Huang, MD,[1] Rafael J. Tamargo, MD,[1] and Alexander L. Coon, MD[1]

[1]Department of Neurosurgery, Johns Hopkins Medicine, Baltimore, Maryland; and [2]Department of Neurosurgery, University of California Irvine, Orange, California

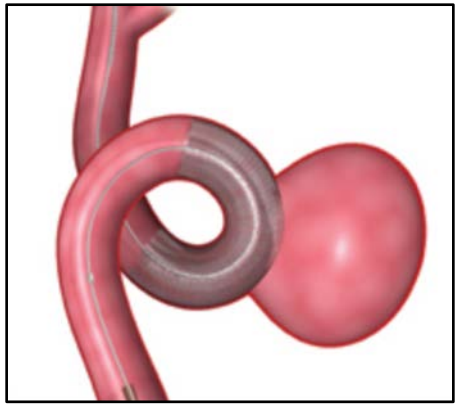
PED 10mm true ophthalmic

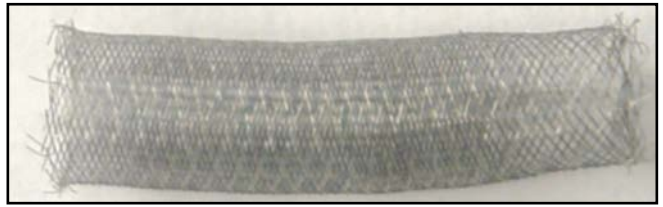
TABLE 4. Clinical outcomes

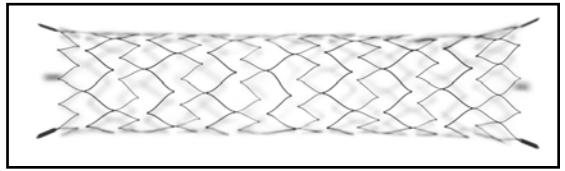
| Outcome | Value | | | p Value |
|---|---|---|---|---|
| | Classic | Flex | Total | |
| LOS in days | | | | 0.085 |
| Mean ± SD | 2.60 ± 4.8 | 2.01 ± 3.3 | 2.27 ± 4.1 | |
| Range | 1–48 | 1–30 | 1–48 | |
| Discharge POD 1 | 158 (62.7) | 235 (74.4) | 393 (69.2) | 0.003 |
| Discharge home/prior level of care | 236 (93.7) | 300 (94.9) | 536 (94.4) | 0.509 |
| Major complication | 14 (5.6) | 6 (1.9) | 20 (3.5) | 0.019 |
| Minor complication | 28 (11.1) | 22 (7.0) | 50 (8.8) | 0.083 |
| Mortality | 4 (1.6) | 2 (0.6) | 6 (1.1) | 0.270 |
| Minor stroke | 2 (0.8) | 3 (0.9) | 5 (0.9) | 0.820 |
| Major stroke | 5 (2.0) | 1 (0.3) | 6 (1.1) | 0.054 |
| ICH | 6 (2.4) | 4 (1.3) | 10 (1.8) | 0.316 |
| SAH | 3 (1.2) | 1 (0.3) | 4 (0.7) | 0.217 |
| Transient deficit | 3 (1.2) | 10 (3.2) | 13 (2.3) | 0.119 |
| CN palsy | 7 (2.8) | 1 (0.3) | 8 (1.4) | 0.013 |
| Iatrogenic dissection | 0 (0.0) | 3 (0.9) | 3 (0.5) | 0.121 |
| Groin hematoma | 13 (5.2) | 7 (2.2) | 20 (3.5) | 0.059 |
| Groin infection | 4 (1.6) | 0 (0.0) | 4 (0.7) | 0.025 |

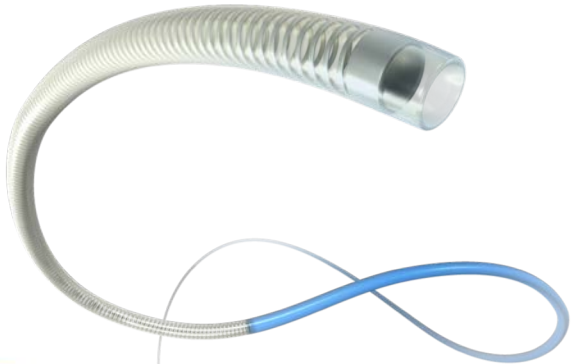
CN = cranial nerve; LOS = length of stay; POD = postoperative day.
Values are presented as the number of aneurysms (%) unless stated otherwise.

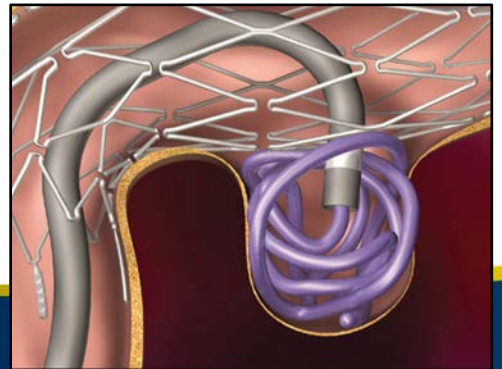
# Expanding endovascular toolbox

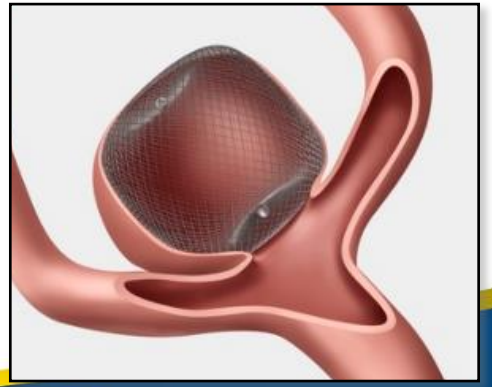












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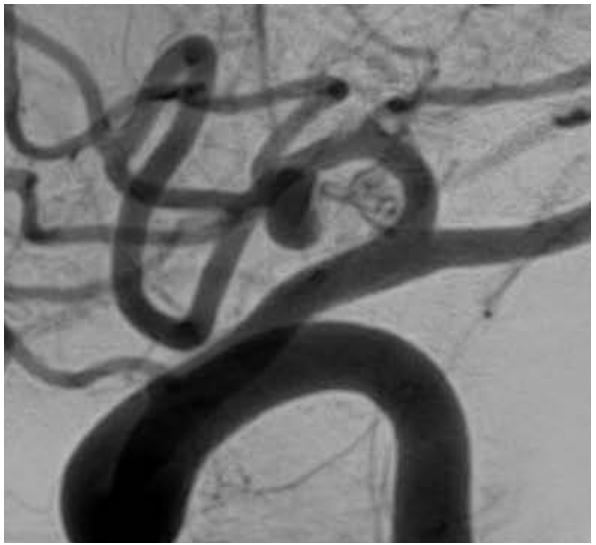
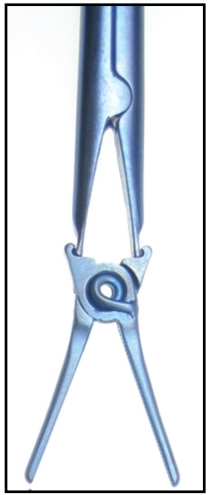
# Open surgery needed: Unruptured true PICA

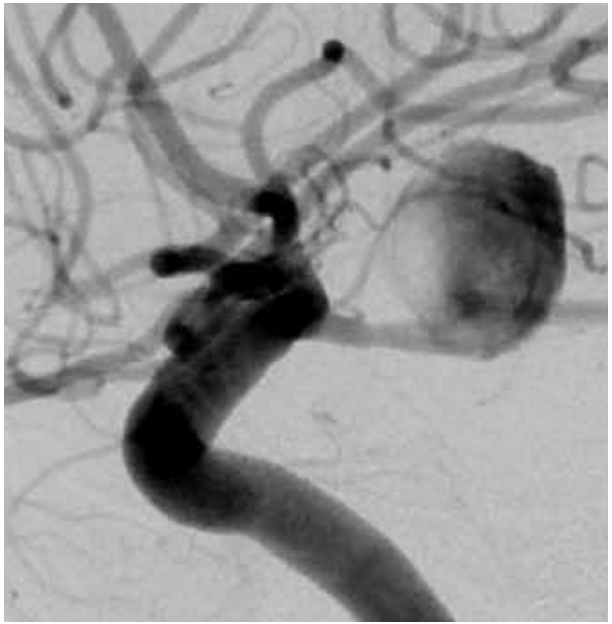
- 63F p/w vertigo and 4mm irregular aneurysm along lateral medullary segment of PICA treated w/ far lateral SOC for clipping

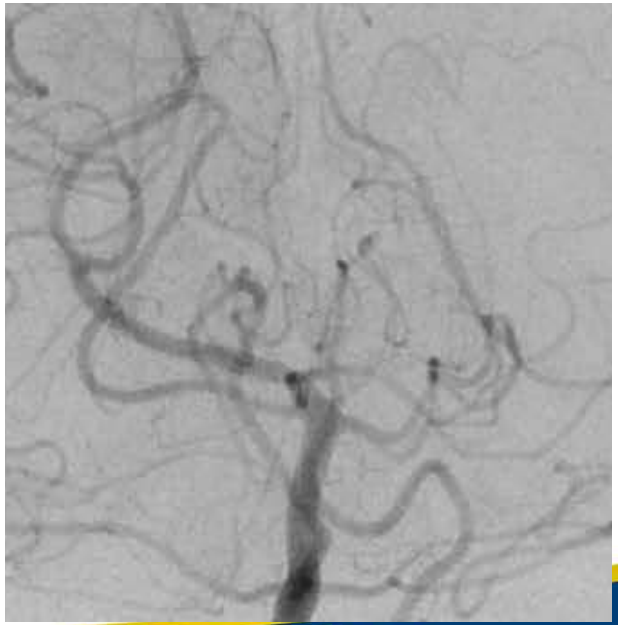




# Open surgery needed: True aneurysm of a fetal posterior communicating artery

- 40M p/w headaches and blurry vision





# ISUIA relies on inflated estimate of risks associated with treatment

**Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment**

*International Study of Unruptured Intracranial Aneurysms Investigators**

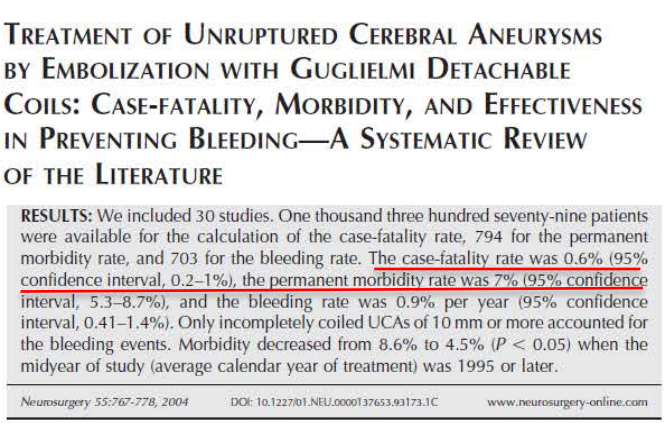
*Lancet* 2003; **362:** 103–10

| | Open surgical | Endovascular |
|---|---|---|
| | Group 1 (n=1591) | Group 1 (n=409) |
| **At 30 days** | | |
| Surgery-related death | 28 (1·8%) | 8 (2·0%) |
| Disability | | |
| Rankin score of 3–5 only | 48 (3·0%) | 9 (2·2%) |
| Impaired cognitive status only | 68 (4·3%) | 13 (3·2%) |
| Rankin score of 3–5 and impaired cognitive status | 74 (4·7%) | 8 (2·0%) |
| Overall morbidity and mortality for all patients | 218 (13·7%) | 38 (9·3%) |
| **At 1 year** | | |
| Surgery-related death | 43 (2·7%) | 14 (3·4%) |
| Disability | | |
| Rankin score of 3–5 only | 22 (1·4%) | 4 (1·0%) |
| Impaired cognitive status only | 87 (5·5%) | 13 (3·2%) |
| Both Rankin score of 3–5 and impaired cognitive status | 48 (3·0%) | 9 (2·2%) |
| Overall morbidity and mortality* for all patients | 200 (12·6%) | 40 9·8%) |

*Overall morbidity and mortality includes death, and one of both Rankin score 3–5 and impaired cc

Table 5: **Outcome 30 days and 1 year after surgery**

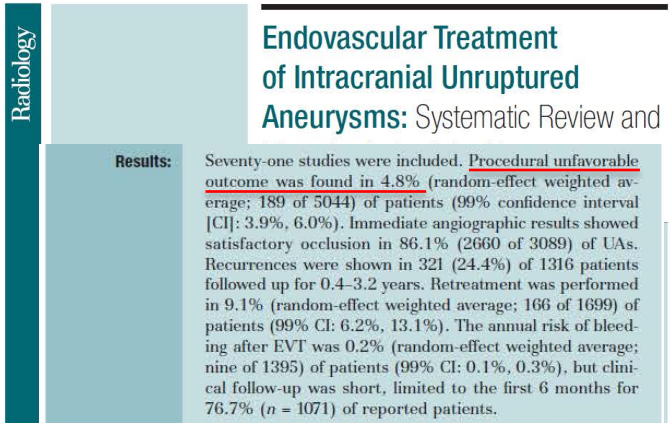
# Subsequent studies of elective coiling have shown lower risks



TREATMENT OF UNRUPTURED CEREBRAL ANEURYSMS BY EMBOLIZATION WITH GUGLIELMI DETACHABLE COILS: CASE-FATALITY, MORBIDITY, AND EFFECTIVENESS IN PREVENTING BLEEDING—A SYSTEMATIC REVIEW OF THE LITERATURE

**RESULTS:** We included 30 studies. One thousand three hundred seventy-nine patients were available for the calculation of the case-fatality rate, 794 for the permanent morbidity rate, and 703 for the bleeding rate. The case-fatality rate was 0.6% (95% confidence interval, 0.2–1%), the permanent morbidity rate was 7% (95% confidence interval, 5.3–8.7%), and the bleeding rate was 0.9% per year (95% confidence interval, 0.41–1.4%). Only incompletely coiled UCAs of 10 mm or more accounted for the bleeding events. Morbidity decreased from 8.6% to 4.5% ($P < 0.05$) when the midyear of study (average calendar year of treatment) was 1995 or later.

*Neurosurgery 55:767-778, 2004* DOI: 10.1227/01.NEU.0000137653.93173.1C www.neurosurgery-online.com



Radiology

Endovascular Treatment of Intracranial Unruptured Aneurysms: Systematic Review and

**Results:** Seventy-one studies were included. Procedural unfavorable outcome was found in 4.8% (random-effect weighted average; 189 of 5044) of patients (99% confidence interval [CI]: 3.9%, 6.0%). Immediate angiographic results showed satisfactory occlusion in 86.1% (2660 of 3089) of UAs. Recurrences were shown in 321 (24.4%) of 1316 patients followed up for 0.4–3.2 years. Retreatment was performed in 9.1% (random-effect weighted average; 166 of 1699) of patients (99% CI: 6.2%, 13.1%). The annual risk of bleeding after EVT was 0.2% (random-effect weighted average; nine of 1395) of patients (99% CI: 0.1%, 0.3%), but clinical follow-up was short, limited to the first 6 months for 76.7% ($n$ = 1071) of reported patients.