Prevalence of Unruptured Cerebral Aneurysms in Chinese Adults Aged 35 to 75 Years

A Cross-sectional Study

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Background: The reported prevalence of unruptured cerebral aneurysms (UCAs) varies widely.

Objective: To measure the prevalence of UCAs by using 3-dimensional time-of-flight magnetic resonance angiography in adults aged 35 to 75 years.

Design: Cross-sectional study done between June 2007 and June 2011.

Setting: Two communities chosen at random from 2 districts (1 urban and 1 suburban) in Shanghai, China.

Participants: 4813 adults aged 35 to 75 years.

Measurements: Three-dimensional time-of-flight magnetic resonance angiography, interpreted by 3 observers blinded to the participants' information, was used to identify the location and size of UCAs and to estimate the overall, age-specific, and sex-specific prevalence.

Results: 369 UCAs were found in 336 participants (130 men and 206 women); 4477 participants had no evidence of UCAs. The prevalence was 7.0% overall (95% CI, 6.3% to 7.7%), with 5.5% for men (CI, 4.6% to 6.4%) and 8.4% for women (CI, 7.3% to 9.5%). The overall prevalence of UCAs was higher in women than in men ($P < 0.001$) and peaked at ages 55 to 64 years in men and women. The UCAs were mostly located in the internal carotid artery (81%), and 90.2% had a maximum diameter less than 5 mm. Mean diameter was larger in women than in men (3.7 mm vs. 3.2 mm; $P < 0.009$).

Limitation: Participants were from 2 communities selected from 2 districts in Shanghai, and adults older than 75 years were not studied.

Conclusion: The overall prevalence of UCAs was 7.0% in Chinese adults aged 35 to 75 years, and most lesions had a diameter less than 5 mm.

Primary Funding Source: National Natural Science Foundation of China.

Ann Intern Med. 2013;159:514-521. www.annals.org
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Cerebral aneurysms are common lesions with a prevalence of 1% to 5% in adults and an annual rupture rate of 0% to 1% (1–4). Ruptured aneurysms, the most common cause of nontraumatic subarachnoid hemorrhage, can be catastrophic and have high mortality and morbidity rates (2, 3, 5, 6). Therefore, interest in detecting unruptured cerebral aneurysms (UCAs) and in exploring their natural history has been increasing in recent years. One of the largest recent studies in a Japanese cohort found that the natural course of UCAs varies according to their size, location, and shape (7). Other risk factors, such as aneurysm growth and a history of familial cerebral aneurysms and subarachnoid hemorrhage, have also been documented in previous studies (8–10).

To date, autopsy, digital subtraction angiography (DSA), computed tomographic angiography, and magnetic resonance angiography (MRA) have been validated for the detection of UCAs. It is likely that retrospective autopsy studies underestimate the prevalence of UCAs because the original material cannot be reviewed; in contrast, DSA studies probably overestimate prevalence due to the selection of a patient sample with suspected cerebral vascular diseases. Although computed tomographic angiography is the most frequently used diagnostic tool for detection of cerebral aneurysms (11–13), its use is often limited by an overprojecting bone at the base of the skull or by requiring iodine contrast media and radiation exposure (6, 13, 14). Being free of these limitations, MRA is ideal for the detection of UCAs in the general population (15–21). Our previous studies have shown that 3-dimensional time-of-flight MRA (3D-TOF MRA) offered high diagnostic accuracy and might replace DSA for the diagnosis and screening of UCAs (22, 23). The aim of this survey was to measure the prevalence of UCAs by using 3D-TOF MRA in Chinese adults aged 35 to 75 years in Shanghai, China.

See also:

Print
Summary for Patients I-30

Web-Only
Supplements

Methods

Study Design and Setting

This cross-sectional survey of UCAs in adults aged 35 to 75 years in Shanghai was done between June 2007 and June 2011. We selected 1 urban district (Changning) and 1 suburban district (Zhabei) from a total of 18 districts in Shanghai. These districts, whose age and sex ratios closely matched those in the 2007 Shanghai census (**Supplements 1** and **2**, available at www.annals.org), represent an economically well-developed area (Changning) and an economically developing area (Zhabei). One community was randomly selected from each of these 2 districts for subsequent enrollment (**Figure 1**). All eligible participants aged 35 to 75 years were invited to participate and were required to provide written informed consent before inclusion. The study was approved by the institutional review board of our hospital.

Study Sample and Recruitment

The eligible population was divided into 4 subgroups according to age (35 to 44, 45 to 54, 55 to 64, and 65 to 75 years). The MRA survey was done at our institution and adhered to protocols that had been previously established to define the clinical and MRA criteria for UCA screening. The a priori exclusion criteria included pacemaker implantation, metallic implants, nonadherence of participants, pregnancy (≤3 months), denture implants, false eye, bionic ear, or claustrophobia.

Procedures and Measurements

All participants were asked to complete a standard questionnaire to provide demographic characteristics, personal and family medical history, and lifestyle risk factors. Questions included smoking (defined as having smoked >100 cigarettes in a lifetime) (24), alcohol consumption (defined as consumption of >30 g of alcohol per week for 1 year or more) (24), hypertension, diabetes, hyperlipidemia, stroke, coronary heart disease, myocardial infarction, and arrhythmia. Participants had a physical examination that included measurement of height, weight, and blood pressure and calculation of body mass index.

All 3D-TOF MRA examinations were done on an Achieva 3.0T MRI system (Philips Healthcare, Amsterdam, The Netherlands). Image acquisition and the approaches used in image postprocessing have been described in detail (23). In brief, 3D-TOF MRA was done by using 3-dimensional T1-weighted fast-field sequences with the following settings for image acquisition: repetition time/echo time, 35/7; flip angle, 20 degrees; field of view, 250 × 190 × 108; 4 slabs (180 slices); slice thickness, 0.8 mm; matrix, 732 × 1024; and acquisition time, 8 minutes and 56 seconds. The acquired image data sets were then transferred to a workstation (IntelliVue Guardian Early Warning Score; Philips Healthcare), in which reconstruction with maximum intensity projection and volume rendering was done with a 3-dimensional specialized software package (Volume Inspection, Philips Medical Systems, Amsterdam, The Netherlands). Then, we used the single-artery highlighting approach to screen and detect UCAs. Any adverse events during the MRA examinations, including panic attack, claustrophobia, dizziness, or falling during the procedure, were queried and monitored by the investigators.

> ***Context***
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> The prevalence and typical characteristics of unruptured cerebral aneurysms are unclear.
>
> ***Contribution***
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> This cross-sectional study found a 7.0% prevalence of unruptured cerebral aneurysms in Chinese adults aged 35 to 75 years. Aneurysms were more common in women than men, and prevalence increased with age in both sexes. Only 8.7% of the aneurysms were deemed potentially risky for rupture based on size, shape, and location.
>
> ***Caution***
>
> There were no natural history data, and the study sample did not include people older than 75 years.
>
> ***Implication***
>
> Unruptured cerebral aneurysms may be common, but their clinical significance remains unclear.
>
> *—The Editors*

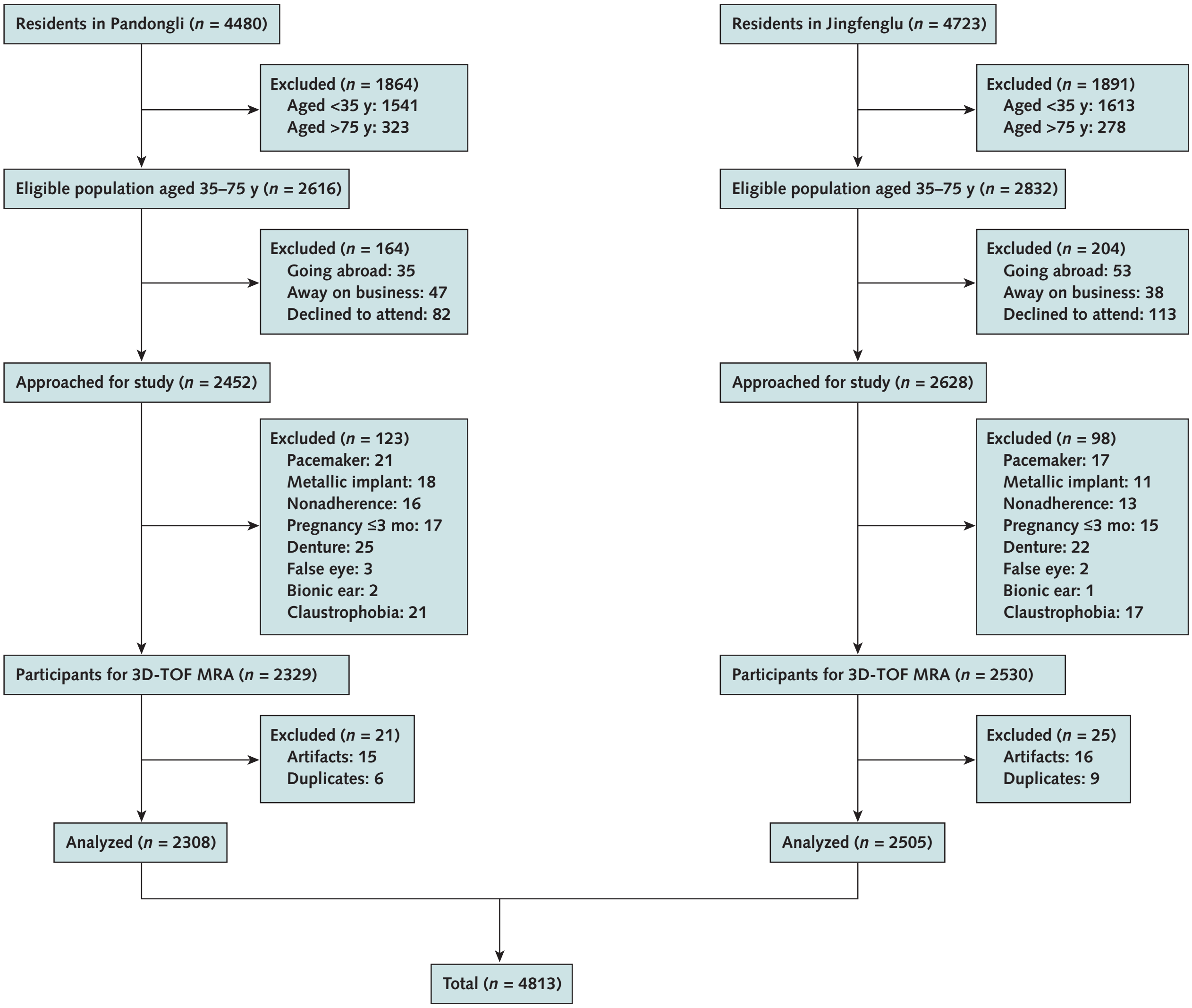
Image Review

The UCAs were defined as an abnormal focal dilatation of a cerebral artery with attenuation of the vessel wall (25) or an infundibulum with a maximum diameter greater than 3 mm. Only UCAs with a diameter 2 mm or more were included in this survey. "No cerebral aneurysm" was recorded if no aneurysm was identified on 3D-TOF MRA.

Three observers, blinded to the participants' information, independently analyzed all 3D-TOF MRAs with volume-rendering images on an offline workstation by using the single-artery highlighting approach (22, 23). The maximum intensity projection and the source images were presented onscreen and were regarded as supplements to the analysis. These images allowed the appropriate threshold for window width and level to be set for the differentiation of small aneurysms with infundibula. Interobserver discrepancies in the detection of cerebral aneurysms were resolved by consensus.

Confidence in the diagnosis of the aneurysms was ranked by using a previously described 5-point scale (18) that went from 5 (aneurysm definitely absent) to 1 (aneurysm definitely present). Examinations with 1 or more aneurysms ranked as "probably" or "definitely" present were considered positive; all others were negative. Aneurysm size was recorded as the maximum 2-dimensional angiographic dimension and categorized as less than 3 mm, 3 mm to less

Figure 1. **Study flow diagram.**



3D-TOF MRA = 3-dimensional time-of-flight magnetic resonance angiography.

than 5 mm, 5 mm to less than 10 mm, or 10 mm or more. The UCAs were morphologically classified as regular (saccular), irregular (lobular), and fusiform. Aneurysm sites were classified as internal carotid artery (including the posterior communicating artery), anterior cerebral artery (including the anterior communicating artery), middle cerebral artery (including the M1–2 bifurcation), and vertebrobasilar artery.

Statistical Analysis

Our study was designed to provide estimates representative of the prevalence of UCAs in the adult population of Shanghai. To calculate the appropriate sample size, a preliminary study ($n = 500$) was done that showed an initial prevalence of 8%. Accordingly, we calculated that a sample size of 4600 could produce a 2-sided 95% CI with a width equal to 1.6% for this prevalence survey.

Continuous variables are presented as means (SDs), and categorical variables are expressed as percentages. The Mann–Whitney U test was used to compare continuous variables. The chi-square and unpaired *t* tests were used to compare categorical variables if all expected frequencies were 5 or more; otherwise, the Fisher exact test was used. Interobserver agreement was expressed in terms of the Cohen κ value for categorical variables. All *P* values were 2-sided and were considered statistically significant if they were 0.05 or less. These analyses were done by using SPSS, version 20.0 (SPSS, Chicago, Illinois). In addition, the Cochran–Armitage trend test, conducted by using SAS, version 9.2 (SAS Institute, Cary, North Carolina), was adopted to examine whether a trend existed between age and the prevalence of UCAs. All data were analyzed at Fu Dan University's School of Public Health in Shanghai.

Table 1. **Sociodemographic and Clinical Characteristics**

Characteristic	Total (n = 4813)	No Aneurysm (n = 4477)	Aneurysm (n = 336)	P Value*
Mean age (SD), *y*	53.1 (10.1)	52.9 (10.1)	54.9 (10.0)	<0.001
Female/male, *n/n*	2445/2368	2239/2238	206/130	<0.001
Mean body mass index (SD), *kg/m²*	23.6 (3.0)	23.6 (3.0)	23.5 (3.0)	0.24
Smoking, *n (%)*†	1056 (21.9)	984 (22.0)	72 (21.4)	0.81
Alcohol use, *n (%)*‡	614 (12.8)	568 (12.7)	46 (13.7)	0.60
Hypertension, *n (%)*	1205 (25)	1109 (24.7)	96 (28.6)	0.121
Diabetes, *n (%)*	346 (7.2)	317 (7.1)	29 (8.6)	0.29
Hyperlipidemia, *n (%)*	378 (7.9)	341 (7.6)	37 (11.0)	0.027
Stroke, *n (%)*	141 (2.9)	128 (2.9)	12 (3.6)	0.47
Coronary heart disease, *n (%)*	103 (2.1)	93 (2.1)	10 (3.0)	0.28
Myocardial infarction, *n (%)*	17 (0.4)	14 (0.3)	3 (0.9)	0.099
Arrhythmia, *n (%)*	90 (1.9)	85 (1.9)	5 (1.5)	0.59

* For comparisons between no aneurysms and aneurysms.
† Smoked >100 cigarettes in a lifetime.
‡ Consumption of >30 g of alcohol per week for 1 y or more.

Role of the Funding Source

The National Natural Science Foundation of China and the Twelfth Five-Year National Science and Technology Support Program of China provided funding for the study. The funding source had no role in the design or conduct of the study, analysis or interpretation of the data, preparation of the manuscript, or decision to submit the manuscript for publication.

RESULTS

A flow chart of participant enrollment, which includes a summary of the UCA detection criteria, is shown in **Figure 1**. Of 5080 eligible participants aged 35 to 75 years, 221 were excluded because of pacemaker implantation, metallic implants, nonadherence, pregnancy, denture implants, false eye, bionic ear, or claustrophobia. Therefore, 4859 participants had 3D-TOF MRA. Of these, 17 experienced dizziness during the procedure but all of them completed the examination. Forty-six participants were excluded because of uninterpretable image quality with motion artifacts or duplicated registration and image acquisition. Therefore, 4813 participants (2368 men and 2445 women; median age, 53.0 years) were finally included in the study. The sociodemographic and clinical characteristics of the study participants are shown in **Table 1**. A DSA was done in 51 participants, and a follow-up 3D-TOF MRA was done in 78 participants; all of these examinations confirmed the existence of aneurysms. Follow-up 3D-TOF MRA and secondary prevention will be done for participants with aneurysms.

Prevalence of UCAs

Of the 4813 study participants, 130 men and 206 women were found to have UCAs on 3D-TOF MRA and 4477 participants had no UCAs. The interobserver agreement was excellent, with a κ statistic of 0.98 to 0.99 per aneurysm on 3D-TOF MRA. The prevalence of UCAs in adults was 7.0% (95% CI, 6.3% to 7.7%), with 5.5% for men (CI, 4.6% to 6.4%) and 8.6% for women (CI, 7.4% to 9.7%). The prevalence of UCAs was higher in women than in men ($P < 0.001$).

The age- and sex-specific prevalence of UCAs is shown in **Table 2**. The age-specific prevalence of UCAs increased significantly with increasing age (trend test, women $P =$

Table 2. **Age- and Sex-Specific Prevalence of Unruptured Cerebral Aneurysms**

Age	Men			Women			Total		
	Investigated, *n*	Aneurysms		Investigated, *n*	Aneurysms		Investigated, *n*	Aneurysms	
		Participants, *n*	Proportion (95% CI)		Participants, *n*	Proportion (95% CI)		Participants, *n*	Proportion (95% CI)
Total	2368	130	5.5 (4.6–6.4)	2445	206	8.6 (7.4–9.7)	4813	336	7.0 (6.3–7.7)
35–44 y	610	21	3.4 (2.0–4.9)	604	34	5.6 (3.8–7.5)	1214	55	4.5 (3.4–5.7)
45–54 y	893	48	5.4 (3.9–6.9)	904	73	8.1 (6.3–9.9)	1797	121	6.7 (5.6–7.9)
55–64 y	501	35	7.0 (4.7–9.2)	565	62	11.0 (8.4–13.6)	1066	97	9.1 (7.4–10.8)
65–75 y	364	26	7.1 (4.5–9.8)	372	37	9.9 (6.9–13.0)	736	63	8.6 (6.5–10.6)
P value of trend*	–	–	0.004	–	–	0.002	–	–	<0.001

* Calculated using the Cochran–Armitage trend test.

Table 3. **Location and Size of Unruptured Cerebral Aneurysms***

Variable	Men	Women	Total
Total, *n*	140	229	369
Arterial location of aneurysm, *n (%)*			
Internal carotid	108 (77.1)	191 (83.4)	299 (81)
Anterior cerebral	23 (16.4)	23 (10)	46 (12.5)
Middle cerebral	5 (3.6)	10 (4.4)	15 (4.1)
Vertebrobasilar	4 (2.9)	5 (2.2)	9 (2.4)
Size, *n (%)*			
<3 mm	68 (48.6)	82 (35.8)	150 (40.7)
3 to <5 mm	61 (43.6)	122 (53.3)	183 (49.6)
5 to <10 mm	11 (7.9)	23 (10)	34 (9.2)
≥10 mm	0 (0.0)	2 (0.9)	2 (0.5)
Mean aneurysm size (SD), *mm*	3.2 (1.2)	3.7 (1.9)	3.5 (1.7)

* Observed in 336 persons.

0.002; men, $P = 0.004$), peaking at 55 to 64 years in men and women.

Characteristics of UCAs

The location and size of UCAs in the 4 subgroups are shown in **Table 3** (for more details, see **Supplement 3**, available at www.annals.org). A total of 369 aneurysms were detected in 336 participants. Four of these participants were from 2 families (2 mother–daughter pairs). The remaining 332 participants were unrelated. Twenty-seven participants (8.0%) had several UCAs: One participant had 5 (0.3%), 3 participants had 3 each (0.9%), 23 participants had 2 each (6.8%), and 309 participants had 1 each.

In all, 299 aneurysms (81%) were located in the internal carotid artery, including 199 (53.9%) in the C5–6 segments of the Bouthillier classification (26) and 31 (8.4%) in the posterior communicating artery (**Figure 2**). Forty-six aneurysms (12.5%) were located in the anterior cerebral artery, including 40 (10.8%) in the anterior communicating artery (**Figure 3**). Fifteen aneurysms (4.1%) were located in the middle cerebral artery, including 11 (3%) in the M1–2 bifurcation and 9 (2.4%) in the vertebrobasilar artery. Of the 369 aneurysms, 333 (90.2%) were smaller than 5 mm. The mean maximum diameter of the aneurysm sac was 3.5 mm (SD, 1.7; range, 2.0 to 21.2 mm). The mean diameter was larger in women than in men (3.7 mm vs. 3.2 mm; $P = 0.009$) (**Table 3**). In all, 336 aneurysms (91.1%) were regular (saccular), whereas 32 aneurysms (8.7%) were irregular (lobular) or had a maximum diameter 7 mm or more. One aneurysm (0.2%) was fusiform.

DISCUSSION

Widely varying prevalence rates of cerebral aneurysms have been reported (27–31) because of differences in the age and sex distributions of the study populations, study methods, and sampling designs. A systematic review (4), which included 68 studies, estimated the overall prevalence

Figure 2. **Aneurysm of the right posterior communicating artery of an internal carotid artery in a woman aged 47 years.**

Top. A 3-dimensional time-of-flight magnetic resonance angiography image reveals a small aneurysm (*arrow*) of the right posterior communicating artery. **Bottom.** Image at 19-month follow-up. Note the increase in size of the aneurysm (*arrow*).

of UCAs to be 3.2% in a population without comorbid conditions (mean age, 50 years; 50% men). The reported prevalence of UCAs was 3.5-fold higher in imaging studies than in autopsy studies. In our study, we found a 7.0% prevalence of UCAs in a population aged 35 to 75 years, which exceeds the percentages reported in previous studies (4, 27–30). However, our results are in accordance with the findings of Kojima and colleagues (31), who reported a similar prevalence of UCAs in normal participants investigated with MRA.

The high prevalence of UCAs in this study is mainly attributable to the use of high-quality MRA at 3.0 T, which has been shown to have high accuracy and sensitivity for detection of cerebral aneurysms (23). Very small aneurysms overlapping with the internal carotid artery or those missed on 2-dimensional images were clearly detected by using MRA with volume-rendering images (23). Therefore, our study obtained a higher rate of small aneurysms than the previous studies (4, 27–30). The selected age range is another potentially important factor accounting for the high prevalence of UCAs. In this study, we included only adults aged 35 to 75 years, which is the age group prone to cerebral aneurysms. Therefore, the prevalence of UCAs in persons of this age in our study is expected to be higher than that reported in other studies that sampled a wider age group.

A systematic review (4) found an age-dependent prevalence of UCAs in women because it identified a higher prevalence in women than in men among adults older than 50 years. We did not see an age-dependent prevalence of UCAs in women in our survey. The peak prevalence was recorded at ages 55 to 64 years, potentially due to the balanced sex and age distributions in our study. We noted that the prevalence of UCAs was higher in women than in men, and the mean maximum aneurysm diameter was also larger in women. Therefore, our finding is in line with the hypothesis that decreases in estrogen concentration and estrogen-receptor density may contribute to an increased risk for cerebral aneurysms in women (32, 33).

The most frequent location of aneurysms was in the internal carotid artery, and most of these aneurysms were located in the C5–6 segments. The most probable explanation for this distribution feature is that we excluded ruptured aneurysms, which are most frequently located in the anterior or posterior communicating arteries. In addition, high-quality MRA enabled us to visualize more UCAs in the siphon segment of the internal carotid artery. Large cerebral aneurysms in the anterior or middle cerebral arteries are less likely to be encountered in the clinical setting because they tend to rupture at a small diameter. In contrast, aneurysms in the internal carotid artery often grow big before they rupture. Thus, it is conceivable that we detected many more UCAs in the internal carotid artery than previously reported (1–4).

Previous studies found that female sex, age, hypertension, and smoking or drinking were major risk factors for UCAs (4, 34, 35). Nieuwkamp and colleagues (36) found that smoking and hypertension were major risk factors for subarachnoid hemorrhage and that patients who survived a subarachnoid hemorrhage were at increased risk for cardiovascular disease. Our survey found associations only between female sex and age with the prevalence of UCAs. Although a large proportion of the participants in our study population had hypertension and cardiovascular disease, the associations between these risk factors and the prevalence of aneurysms were not statistically significant. Because this cross-sectional study mainly focused on the prevalence of UCAs, the association between the aforementioned risk factors and development of UCAs in Chinese adults needs exploration in additional, longitudinal studies.

Although small UCAs in the general population may never rupture, it is generally accepted that large, lobulated (with a daughter sac) aneurysms and those showing growth

Figure 3. **Aneurysm of the anterior communicating artery in a man aged 64 years.**

Top. A 3-dimensional time-of-flight magnetic resonance angiography image reveals a small aneurysm (*arrow*) of the anterior communicating artery. **Bottom.** Image at 20-month follow-up. Note that the aneurysm is the same size and has the same morphologic characteristics (*arrow*) as before.

during follow-up, especially if located in the anterior or posterior communicating arteries, M1–2 bifurcation, or posterior circulation, are prone to rupture and have a worse prognosis (1–4, 6, 27, 34, 35). Our study showed that 8.7% of the detected lesions were such potentially risky aneurysms. Prophylactic therapy and regular imaging surveillance, if adequately administered, may help prevent rupture.

Our study has limitations. Because the survey was conducted in 2 communities from 2 districts in Shanghai and adults older than 75 years were not studied, the findings may not be applicable to the general population. Despite the high diagnostic accuracy of 3D-TOF MRA, further validation using DSA was not done in all patients for confirmation. The study was cross-sectional and did not provide information on natural history and outcomes. The MRA examination was not completed in 221 participants because of pacemaker implantation, metallic implants, nonadherence, pregnancy, denture implants, a false eye, a bionic ear, or claustrophobia; 15 participants were excluded because of duplicated registration and image acquisition.

In summary, the overall prevalence of UCAs in Chinese adults aged 35 to 75 years is 7.0% and increases with age in both sexes. The most frequent location of UCAs is the C5–6 segment of the internal carotid artery, and most UCAs have a diameter less than 5 mm.

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Acknowledgment: The authors thank Drs. Gen-Ming Zhao and Guo-You Qin (School of Public Health, Shanghai Fu Dan University, Shanghai, China) for their assistance with the statistical analysis of the data during the preparation of this manuscript and Dr. C.S. Zee (Department of Neuroradiology, Keck Hospital of University of Southern California, Los Angeles, California) for editorial assistance.

Grant Support: By National Natural Science Foundation of China (grants 81171440 and 30970793), Twelfth Five-Year National Science and Technology Support Program of China (grants 2011BAI08B14 and 2011BAI08B06), Shanghai Important Subject Fund of Medicine (grants 05III023 and 074119505), and Program for Shanghai Outstanding Medical Academic Leader (grant LJ 06016).

Potential Conflicts of Interest: None disclosed. Forms can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M13-0927.

Reproducible Research Statement: *Study protocol*: The protocol is fully described in the manuscript. *Statistical code*: Available on request. *Data set*: Medicare data sets are available to qualified researchers but cannot be released by the investigators.

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References

1. **Wiebers DO, Whisnant JP, Huston J 3rd, Meissner I, Brown RD Jr, Piepgras DG, et al; International Study of Unruptured Intracranial Aneurysms Investigators.** Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment. Lancet. 2003;362:103-10. [PMID: 12867109]

2. **Brisman JL, Song JK, Newell DW.** Cerebral aneurysms. N Engl J Med. 2006;355:928-39. [PMID: 16943405]

3. **van Gijn J, Kerr RS, Rinkel GJ.** Subarachnoid haemorrhage. Lancet. 2007;369:306-18. [PMID: 17258671]

4. **Vlak MH, Algra A, Brandenburg R, Rinkel GJ.** Prevalence of unruptured intracranial aneurysms, with emphasis on sex, age, comorbidity, country, and time period: a systematic review and meta-analysis. Lancet Neurol. 2011;10:626-36. [PMID: 21641282]

5. **Bederson JB, Connolly ES Jr, Batjer HH, Dacey RG, Dion JE, Diringer MN, et al; American Heart Association.** Guidelines for the management of aneurysmal subarachnoid hemorrhage: a statement for healthcare professionals from a special writing group of the Stroke Council, American Heart Association. Stroke. 2009;40:994-1025. [PMID: 19164800]

6. **Wardlaw JM, White PM.** The detection and management of unruptured intracranial aneurysms. Brain. 2000;123 (Pt 2):205-21. [PMID: 10648430]

7. **Morita A, Kirino T, Hashi K, Aoki N, Fukuhara S, Hashimoto N, et al; UCAS Japan Investigators.** The natural course of unruptured cerebral aneurysms in a Japanese cohort. N Engl J Med. 2012;366:2474-82. [PMID: 22738097]

8. **Broderick JP, Brown RD Jr, Sauerbeck L, Hornung R, Huston J 3rd, Woo D, et al; FIA Study Investigators.** Greater rupture risk for familial as compared to sporadic unruptured intracranial aneurysms. Stroke. 2009;40:1952-7. [PMID: 19228834]

9. **Morita A, Kimura T, Shojima M, Sameshima T, Nishihara T.** Unruptured intracranial aneurysms: current perspectives on the origin and natural course, and quest for standards in the management strategy. Neurol Med Chir (Tokyo). 2010;50:777-87. [PMID: 20885112]

10. **Ishibashi T, Murayama Y, Urashima M, Saguchi T, Ebara M, Arakawa H, et al.** Unruptured intracranial aneurysms: incidence of rupture and risk factors [Letter]. Stroke. 2009;40:313-6. [PMID: 18845802]

11. **McKinney AM, Palmer CS, Truwit CL, Karagulle A, Teksam M.** Detection of aneurysms by 64-section multidetector CT angiography in patients acutely suspected of having an intracranial aneurysm and comparison with digital subtraction and 3D rotational angiography. AJNR Am J Neuroradiol. 2008;29:594-602. [PMID: 18065510]

12. **Li Q, Lv F, Li Y, Luo T, Li K, Xie P.** Evaluation of 64-section CT angiography for detection and treatment planning of intracranial aneurysms by using DSA and surgical findings. Radiology. 2009;252:808-15. [PMID: 19508992]

13. **Jayaraman MV, Mayo-Smith WW, Tung GA, Haas RA, Rogg JM, Mehta NR, et al.** Detection of intracranial aneurysms: multi-detector row CT angiography compared with DSA. Radiology. 2004;230:510-8. [PMID: 14699177]

14. **Romijn M, Gratama van Andel HA, van Walderveen MA, Sprengers ME, van Rijn JC, van Rooij WJ, et al.** Diagnostic accuracy of CT angiography with matched mask bone elimination for detection of intracranial aneurysms: comparison with digital subtraction angiography and 3D rotational angiography. AJNR Am J Neuroradiol. 2008;29:134-9. [PMID: 17928381]

15. **Atlas SW, Sheppard L, Goldberg HI, Hurst RW, Listerud J, Flamm E.** Intracranial aneurysms: detection and characterization with MR angiography with use of an advanced postprocessing technique in a blinded-reader study. Radiology. 1997;203:807-14. [PMID: 9169709]

16. **Schwab KE, Gailloud P, Wyse G, Tamargo RJ.** Limitations of magnetic resonance imaging and magnetic resonance angiography in the diagnosis of intracranial aneurysms. Neurosurgery. 2008;63:29-34; discussion 34-5. [PMID: 18728566]

17. **Bowen BC.** MR angiography versus CT angiography in the evaluation of neurovascular disease. Radiology. 2007;245:357-60. [PMID: 17940298]

18. **Okahara M, Kiyosue H, Yamashita M, Nagatomi H, Hata H, Saginoya T, et al.** Diagnostic accuracy of magnetic resonance angiography for cerebral aneurysms in correlation with 3D-digital subtraction angiographic images: a study of 133 aneurysms. Stroke. 2002;33:1803-8. [PMID: 12105357]

19. **Metens T, Rio F, Balériaux D, Roger T, David P, Rodesch G.** Intracranial aneurysms: detection with gadolinium-enhanced dynamic three-dimensional MR angiography-initial results. Radiology. 2000;216:39-46. [PMID: 10887226]
20. **Korogi Y, Takahashi M, Mabuchi N, Nakagawa T, Fujiwara S, Horikawa Y, et al.** Intracranial aneurysms: diagnostic accuracy of MR angiography with evaluation of maximum intensity projection and source images. Radiology. 1996; 199:199-207. [PMID: 8633146]
21. **White PM, Teasdale EM, Wardlaw JM, Easton V.** Intracranial aneurysms: CT angiography and MR angiography for detection prospective blinded comparison in a large patient cohort. Radiology. 2001;219:739-49. [PMID: 11376263]
22. **Li MH, Cheng YS, Li YD, Fang C, Chen SW, Wang W, et al.** Large-cohort comparison between three-dimensional time-of-flight magnetic resonance and rotational digital subtraction angiographies in intracranial aneurysm detection [Letter]. Stroke. 2009;40:3127-9. [PMID: 19556531]
23. **Li MH, Li YD, Tan HQ, Gu BX, Chen YC, Wang W, et al.** Contrast-free MRA at 3.0 T for the detection of intracranial aneurysms. Neurology. 2011;77: 667-76. [PMID: 21775735]
24. **Yang W, Lu J, Weng J, Jia W, Ji L, Xiao J, et al; China National Diabetes and Metabolic Disorders Study Group.** Prevalence of diabetes among men and women in China. N Engl J Med. 2010;362:1090-101. [PMID: 20335585]
25. **Meyers PM, Schumacher HC, Higashida RT, Derdeyn CP, Nesbit GM, Sacks D, et al.** Reporting standards for endovascular repair of saccular intracranial cerebral aneurysms. Stroke. 2009;40:e366-79. [PMID: 19246711]
26. **Bouthillier A, van Loveren HR, Keller JT.** Segments of the internal carotid artery: a new classification. Neurosurgery. 1996;38:425-32. [PMID: 8837792]
27. **Rinkel GJ, Djibuti M, Algra A, van Gijn J.** Prevalence and risk of rupture of intracranial aneurysms: a systematic review. Stroke. 1998;29:251-6. [PMID: 9445359]
28. **Iwamoto H, Kiyohara Y, Fujishima M, Kato I, Nakayama K, Sueishi K, et al.** Prevalence of intracranial saccular aneurysms in a Japanese community based on a consecutive autopsy series during a 30-year observation period. The Hisayama study. Stroke. 1999;30:1390-5. [PMID: 10390312]
29. **Horikoshi T, Akiyama I, Yamagata Z, Nukui H.** Retrospective analysis of the prevalence of asymptomatic cerebral aneurysm in 4518 patients undergoing magnetic resonance angiography—when does cerebral aneurysm develop? Neurol Med Chir (Tokyo). 2002;42:105-12. [PMID: 11936051]
30. **Winn HR, Jane JA Sr, Taylor J, Kaiser D, Britz GW.** Prevalence of asymptomatic incidental aneurysms: review of 4568 arteriograms. J Neurosurg. 2002; 96:43-9. [PMID: 11794602]
31. **Kojima M, Nagasawa S, Lee YE, Takeichi Y, Tsuda E, Mabuchi N.** Asymptomatic familial cerebral aneurysms. Neurosurgery. 1998;43:776-81. [PMID: 9766303]
32. **Harrod CG, Batjer HH, Bendok BR.** Deficiencies in estrogen-mediated regulation of cerebrovascular homeostasis may contribute to an increased risk of cerebral aneurysm pathogenesis and rupture in menopausal and postmenopausal women. Med Hypotheses. 2006;66:736-56. [PMID: 16356655]
33. **Mhurchu CN, Anderson C, Jamrozik K, Hankey G, Dunbabin D; Australasian Cooperative Research on Subarachnoid Hemorrhage Study (ACROSS) Group.** Hormonal factors and risk of aneurysmal subarachnoid hemorrhage: an international population-based, case-control study. Stroke. 2001;32: 606-12. [PMID: 11239175]
34. **de Rooij NK, Linn FH, van der Plas JA, Algra A, Rinkel GJ.** Incidence of subarachnoid haemorrhage: a systematic review with emphasis on region, age, gender and time trends. J Neurol Neurosurg Psychiatry. 2007;78:1365-72. [PMID: 17470467]
35. **Feigin VL, Rinkel GJ, Lawes CM, Algra A, Bennett DA, van Gijn J, et al.** Risk factors for subarachnoid hemorrhage: an updated systematic review of epidemiologic studies. Stroke. 2005;36:2773-80. [PMID: 16282541]
36. **Nieuwkamp DJ, Algra A, Blomqvist P, Adami J, Buskens E, Koffijberg H, et al.** Excess mortality and cardiovascular events in patients surviving subarachnoid hemorrhage: a nationwide study in Sweden. Stroke. 2011;42:902-7. [PMID: 21330628]

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