Treatment Risk for Elderly Patients with Unruptured Cerebral Aneurysm from a Nationwide Database in Japan

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■ BACKGROUND: This study aimed to clarify the risk factors of treatment for unruptured cerebral aneurysms (UCAs) in elderly patients by comparing the morbidity at discharge between surgical clipping and endovascular coiling in nonelderly (<65 years) and elderly (≥65 years) patients based on a national database in Japan.

■ METHODS: A total of 36,017, including 15,671 patients with UCA after exclusion of unknown location, were registered in the Diagnosis Procedure Combination, the nationwide database, from 2010 to 2015 in Japan. Outcome of Barthel Index at discharge was investigated and multivariate logistic regression analysis identified risk factors for morbidity of Barthel Index <90 at discharge in nonelderly and elderly patient groups.

■ RESULTS: Risk factors for morbidity at discharge were basilar artery aneurysm compared with internal carotid artery (ICA), diabetes mellitus (odds ratio [OR], 2.0–2.5; 95% confidence interval [CI], 1.6–3.7), antiplatelet drug, and anticoagulation drug; however, highest hospital volume compared with lowest was an inverse risk factor in both age groups. Endovascular coiling (OR, 0.4; 95% CI, 0.3–0.5) was a significantly inverse risk in the elderly group. Anterior communicating artery aneurysm compared with ICA was a significant risk (OR, 1.6; 95% CI, 1.0–2.6) in the nonelderly group; on the other hand, anterior communicating artery aneurysm (OR, 0.7; 95% CI, 0.5–0.95) and middle cerebral artery aneurysm (OR, 0.6; 95% CI, 0.5–0.8) compared with ICA were significantly inverse risks in the elderly group.

■ CONCLUSIONS: Endovascular coiling after control of diabetes mellitus was recommended for the treatment of UCA in elderly patients. The ICA location of aneurysm in the elderly should be paid attention as the treatment risk.

INTRODUCTION

Asymptomatic unruptured cerebral aneurysms (UCAs) are frequently discovered incidentally through screening. The American Heart Association and the American Stroke Association updated guidelines for managing patients with UCAs in 2015,[1] indicating that the treatment risk of patients with UCAs is related to advancing age and medical comorbidities; therefore, observation is a reasonable alternative in older patients (>65 years of age) (class IIa; level of evidence B). The treatment indications for UCA in the elderly remain unclear; however, some elderly patients should undergo interventional treatment based on the individual rupture risk, because the population is aging worldwide. Both surgical clipping and endovascular coiling were performed for UCA in increasing numbers of

elderly patients per 100,000 Medicare beneficiaries from 2000 to 2010.[2]

Asymptomatic UCAs are frequently discovered at brain checkup examinations in Japan. UCAs in Japanese patients are 2.8 times more likely to rupture than in Westerners,[3] and simultaneously higher age is a significant risk factor for UCA rupture in elderly patients.[4] The Japanese population includes a high proportion of elderly individuals and Japan has the highest total life expectancy at birth worldwide, according to health data from the Organization for Economic Co-operation and Development.[5] Therefore, many elderly patients older than 65 years receive treatment for UCAs in Japan. Consequently, we investigated the outcome and risk factors for morbidity in elderly patients with UCAs.

This study aimed to clarify the risk factors for morbidity at discharge after treatment for UCAs in nonelderly (<65 years) and elderly (≥65 years) patients, based on the Diagnosis Procedure Combination database, the national database of in-hospital patients in Japan.

METHODS

Ethical Statement

This study was approved by the institutional review board of Hiroshima University (number E-629) and Tokyo University (number 3501-[1]). Because of the anonymous nature of the data, the requirement for informed consent was waived.

Data Source

The Japanese Diagnosis Procedure Combination database is a national database of in-hospital patients in Japan, as described elsewhere.[6,7] The database contains administrative claims and abstract discharge data including the following: unique hospital identifiers; 7-digit postal codes of the patients' residential area; patients' age and sex; diagnoses and comorbidities on admission coded according to the *International Classification of Diseases, Tenth Revision* (ICD-10); medical history; treatment methods; complications after procedure; and Barthel Index (BI) at admission and discharge. The database in 2013 included data on approximately 7 million inpatients from >1000 hospitals, representing approximately 50% of all acute-care inpatient hospitalizations in Japan. All academic hospitals are obliged to participate in the database, but participation by nonacademic community hospitals is voluntary.

Patient and Aneurysm Selection and Data

This study included patients from 12 to 93 years of age who were admitted to hospital with a primary diagnosis of UCA from July 2010 to March 2015. Diagnoses of UCA were identified as code I671 of the ICD-10. A total of 36,017 patients with UCA were identified. This study included only patients at initial admission, only treatment with surgical clipping and/or endovascular coiling, and only single treatment of UCA, and excluded cases with unknown location of UCA, multiple aneurysms, and no BI assessment and other than 100 score at admission. Consequently, this study included 15,671 patients with UCAs (**Figure 1**).

Patient-level data included age, sex, medical history, internal oral medication on admission, treatment methods, aneurysm
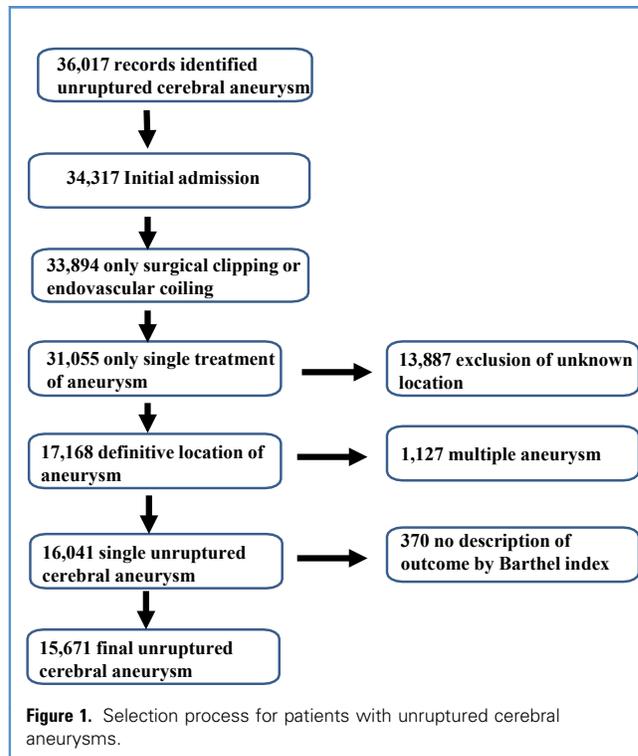

Figure 1. Selection process for patients with unruptured cerebral aneurysms.

location, complications after procedure, and BI score at discharge. Diabetes mellitus (ICD-10 code E14), hypertension (I10), cerebral infarction (I639), angina pectoris (I209), myocardial infarction (I219), and chronic heart disease (I509) were evaluated as medical history. Antiplatelet drug (aspirin, ticlopidine hydrochloride, cilostazol, clopidogrel sulfate, clopidogrel sulfate aspirin, and prasugrel hydrochloride), anticoagulation agents (warfarin potassium, dabigatran etexilate, edoxaban tosilate hydrate, rivaroxaban, and apixaban), and statins (atorvastatin calcium hydrate, rosuvastatin calcium, and pitavastatin calcium hydrate) were checked as internal oral medications on admission. Intracerebral hemorrhage (ICD-10 code I619), cerebral infarction (I639), subarachnoid hemorrhage (I609), congestive heart failure (I509), and pneumonia (J189) were evaluated as complications.

The hospital-level data included volume and type (academic or nonacademic). Hospital volume was defined as the number of patients with UCA treated at an individual facility during the study period and was categorized into 3 groups according to the tertiles of the volume so that the number of patients in each group was almost equal. Locations of the UCA were categorized as follows: internal carotid artery (ICA), anterior communicating artery (ACoA), middle cerebral artery (MCA), anterior cerebral artery, basilar artery (BA), vertebral artery, and others. Outcomes by treatment method were compared in the nonelderly (<65 years) or elderly (≥65 years) age groups. This division reflects the classification of the World Health Organization, which defines "aged people" as older than 65 years. The risk factors were identified by multivariate logistic regression analysis for the morbidity using BI <90 at discharge in each group.

Table 1. Baseline Characteristics and Outcome of Unruptured Cerebral Aneurysm in Nonelderly (<65 Years) Group

	Surgical Clipping (n = 4996)	Endovascular Coiling (n = 3023)	P Value
Age (years), median (interquartile range)	57.0 (50.0–62.0)	55.0 (47.0–60.0)	<0.001*
Sex (male)	1808 (36.2)	989 (32.7)	0.002*
Location of aneurysms			<0.001*
Internal carotid artery	1410 (28.2)	1839 (60.8)	
Anterior communicating artery	903 (18.1)	344 (11.4)	
Middle cerebral artery	2268 (45.4)	146 (4.8)	
Anterior cerebral artery	265 (5.3)	80 (2.6)	
Basilar artery	82 (1.6)	319 (10.6)	
Vertebral artery	63 (1.3)	261 (8.6)	
Other	5 (0.1)	34 (1.1)	
Hospital volume			<0.001*
1	1584 (31.7)	927 (30.7)	
2	1485 (29.7)	1173 (38.8)	
3	1927 (38.6)	923 (30.5)	
Academic	1131 (22.6)	937 (31.0)	<0.001*
Medical history			
Diabetes mellitus	364 (7.3)	180 (6.0)	0.022*
Hypertension	1991 (39.9)	893 (29.5)	<0.001*
Cerebral infarction	157 (3.1)	677 (22.4)	<0.001*
Angina pectoris	101 (2.0)	95 (3.1)	0.002*
Myocardial infarction	2 (0.04)	3 (0.1)	0.30
Chronic heart disease	41 (0.8)	18 (0.6)	0.25
Complication			
Intracerebral hemorrhage	16 (0.3)	6 (0.2)	0.31
Cerebral infarction	180 (3.6)	285 (9.4)	<0.001*
Subarachnoid hemorrhage	0 (0.0)	0 (0.0)	
Congestive heart failure	25 (0.5)	8 (0.3)	0.11
Pneumonia	89 (1.8)	44 (1.5)	0.27
Internal medicine on admission			
Antiplatelet	298 (6.0)	2649 (87.6)	<0.001*
Anticoagulation	46 (0.9)	39 (1.3)	0.12
Statin	386 (7.7)	234 (7.7)	0.98
Death (in-hospital mortality)	6 (0.1)	8 (0.3)	0.17
			Continues

Table 1. Continued

	Surgical Clipping (n = 4996)	Endovascular Coiling (n = 3023)	P Value
Barthel Index at discharge			0.68
Death	6 (0.1)	8 (0.3)	0.88
0	12 (0.2)	7 (0.2)	
5–30	10 (0.2)	5 (0.2)	
35–60	30 (0.6)	17 (0.6)	
65–85	56 (1.1)	31 (1.0)	
90	29 (0.6)	15 (0.5)	
95	52 (1.0)	22 (0.7)	
100	4801 (96.1)	2918 (96.5)	0.33

Values are number (%) except where indicated otherwise.
*$P < 0.05$.

Statistical Analysis

Categorical variables were compared using the χ^2 test or Fisher exact test. Continuous variables were compared using the t test or Mann-Whitney U test, as appropriate. Multivariate logistic regression analyses for morbidity using BI <90 at discharge were conducted in the nonelderly and elderly groups. The odds ratio (OR) and 95% confidence interval (CI) were calculated in each analysis. All statistical analyses were performed with Stata version 15 software (StataCorp LLC, College Station, Texas, USA).

Role of the Funding Source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

RESULTS

During the study period, 15,671 eligible patients were treated at 777 hospitals. The mean and median ages were 62.8 (standard deviation, 14.2) and 64 years, respectively. Surgical clipping was performed in 9922 patients and endovascular coiling in 5749 patients. **Tables 1** and **2** show the baseline characteristics and outcome in nonelderly (<65 years) and elderly (≥65 years) patients with UCA. Age, sex, location of aneurysms, hospital volume, academic hospital, and history of hypertension and cerebral infarction were all significantly different between the 2 groups. The rate of postprocedural cerebral infarction was significantly higher after endovascular coiling than surgical clipping in both nonelderly (P < 0.001, **Table 1**) and elderly (P < 0.001, **Table 2**) groups. The rate of morbidity of BI <90 at discharge showed no significant difference between surgical clipping and endovascular coiling in both nonelderly (P = 0.88, **Table 1**) and elderly (P = 0.65, **Table 2**) groups. In-hospital

Table 2. Baseline Characteristics and Outcome of Unruptured Cerebral Aneurysm in the Elderly (≥65 Years) Group

	Surgical Clipping (n = 4926)	Endovascular Coiling (n = 2726)	P Value
Age (years), median (interquartile range)	70.0 (68.0—74.0)	71.0 (68.0—76.0)	<0.001*
Sex (male %)	1299 (26.4)	660 (24.2)	0.038*
Location of aneurysms			<0.001*
Internal carotid artery	1204 (24.4)	1547 (56.7)	
Anterior communicating artery	866 (17.6)	390 (14.3)	
Middle cerebral artery	2392 (48.6)	161 (5.9)	
Anterior cerebral artery	322 (6.5)	102 (3.7)	
Basilar artery	74 (1.5)	390 (14.3)	
Vertebral artery	63 (1.3)	120 (4.4)	
Other	5 (0.1)	16 (0.6)	
Hospital volume			<0.001*
1	1681 (34.1)	930 (34.1)	
2	1472 (29.9)	1044 (38.3)	
3	1773 (36.0)	752 (27.6)	
Academic	989 (20.1)	806 (29.6)	<0.001*
Medical history			
Diabetes mellitus	576 (11.7)	270 (9.9)	0.017*
Hypertension	2426 (49.2)	1122 (41.2)	<0.001*
Cerebral infarction	219 (4.4)	557 (20.4)	<0.001*
Angina pectoris	240 (4.9)	144 (5.3)	0.43
Myocardial infarction	3 (0.1)	4 (0.1)	0.23
Chronic heart disease	75 (1.5)	51 (1.9)	0.25
Complication			
Intracerebral hemorrhage	11 (0.2)	9 (0.3)	0.38
Cerebral infarction	238 (4.8)	242 (8.9)	<0.001*
Subarachnoid hemorrhage	0 (0.0)	0 (0.0)	
Congestive heart failure	22 (0.4)	16 (0.6)	0.40
Pneumonia	83 (1.7)	60 (2.2)	0.11
Internal medicine on admission			
Antiplatelet	517 (10.5)	2253 (82.6)	<0.001*
Anticoagulation	132 (2.7)	78 (2.9)	0.64
Statin	537 (10.9)	327 (12.0)	0.15
Death (in-hospital mortality)	11 (0.2)	18 (0.7)	0.005*
			Continues

Table 2. Continued

	Surgical Clipping (n = 4926)	Endovascular Coiling (n = 2726)	P Value
Barthel Index at discharge			0.049*
Death	11 (0.2)	18 (0.7)	0.65
0	30 (0.6)	18 (0.7)	
5—30	29 (0.6)	18 (0.7)	
35—60	80 (1.6)	44 (1.6)	
65—85	131 (2.7)	65 (2.4)	
90	72 (1.5)	30 (1.1)	
95	107 (2.2)	44 (1.6)	
100	4,466 (90.7)	2,489 (91.3)	0.35

Values are number (%) except where indicated otherwise.
*P < 0.05.

mortality was significantly higher after endovascular coiling than after surgical clipping in the elderly (P = 0.005, Table 2) group.

Table 3 shows the results of multivariate logistic regression analysis for the morbidity of BI <90 in the nonelderly and elderly group, respectively. In the nonelderly group, age (P = 0.09) and treatment method (P = 0.13) were not significant risk factors, whereas location of ACoA compared with ICA (OR, 1.64; 95% CI, 1.03—2.61) and BA compared with ICA (OR, 2.46; 95% CI, 1.38—4.38), academic hospital (OR, 1.47; 95% CI, 1.06—2.03), medical history of diabetes mellitus (OR, 1.88; 95% CI, 1.20—2.95), and internal oral medication of antiplatelet agent (OR, 1.78; 95% CI, 1.05—3.00), anticoagulation agent (OR, 3.40; 95% CI, 1.57—7.39), and statin (OR, 1.83; 95% CI, 1.09—3.08) were significant risk factors, and highest hospital volume (OR, 0.40; 95% CI, 0.27—0.60) was a significantly inverse risk factor. On the other hand, in the elderly group, age (OR, 1.12; 95% CI, 1.10—1.14), location of BA compared with ICA (OR, 1.57; 95% CI, 1.08—2.30), medical history of diabetes mellitus (OR, 1.62; 95% CI, 1.23—2.13), and internal oral medication of antiplatelet agent (OR, 2.10; 95% CI, 1.60—2.76) and anticoagulation agent (OR, 2.01; 95% CI, 1.29—3.14) were significant risk factors, and endovascular coiling (0.37; 95% CI, 0.27—0.50), location of ACoA compared with ICA (OR, 0.69; 95% CI, 0.50—0.95) and MCA compared with ICA (OR, 0.64; 0.49—0.83), higher (OR, 0.72; 0.58—0.91) and highest hospital volumes (OR, 0.50; 95% CI, 0.39—0.65) were significantly inverse risk factors. Figure 2 a forest plot of the main results of multivariate logistic regression analysis for morbidity of BI <90 in nonelderly and elderly groups. In addition, we analyzed the absolute risk number for morbidity of BI <90 and ≥90 in the nonelderly group (Supplementary Table 1) and in elderly group (Supplementary Table 2).

DISCUSSION

Many comparisons of surgical clipping and endovascular coiling for UCA treatment have been reported.[8-13] Some studies have

Table 3. Odds Ratios and 95% Confidence Intervals of Multivariate Logistic Regression Analysis for the Morbidity of Barthel Index <90 at Discharge in Nonelderly and Elderly Groups
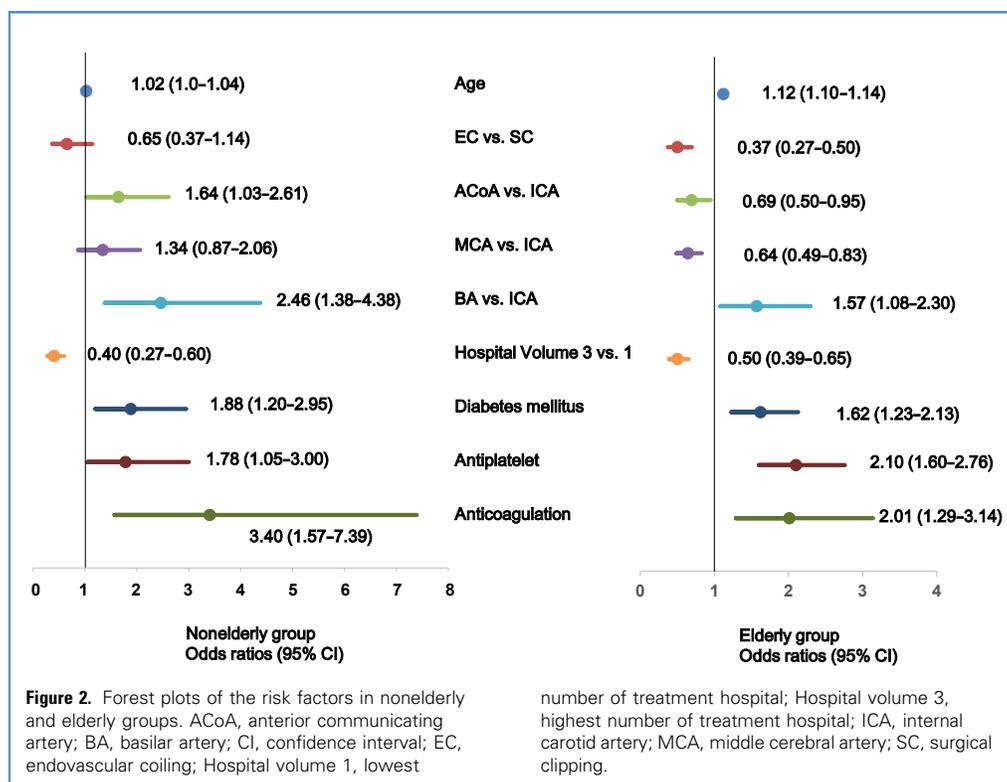
Variables	Nonelderly		Elderly	
	OR (95% CI)	P Value	OR (95% CI)	P Value
Age	1.02 (1—1.04)	0.09	1.12 (1.1—1.14)	<0.001*
Sex (male)	1.13 (0.83—1.56)	0.44	1.12 (0.89—1.41)	0.189
Endovascular coiling vs. surgical clipping	0.65 (0.37—1.14)	0.13	0.37 (0.27—0.50)	<0.001*
Location of aneurysms				
Internal carotid artery	Reference		Reference	
Anterior communicating artery	1.64 (1.03—2.61)	0.04*	0.69 (0.50—0.95)	0.023*
Middle cerebral artery	1.34 (0.87—2.06)	0.19	0.64 (0.49—0.83)	0.001*
Anterior cerebral artery	1.32 (0.61—2.85)	0.49	0.6 (0.37—0.99)	0.047*
Basilar artery	2.46 (1.38—4.38)	0.002*	1.57 (1.08—2.30)	0.019*
Vertebral artery	1.48 (0.7—3.12)	0.30	1.67 (0.98—2.86)	0.06
Others	4.44 (1.3—15.22)	0.018*	3.13 (1—9.79)	0.05*
Hospital volume				
1	Reference		Reference	
2	0.75 (0.53—1.04)	0.088	0.72 (0.58—0.91)	0.005*
3	0.40 (0.27—0.60)	<0.001*	0.50 (0.39—0.65)	<0.001*
Academic hospital	1.47 (1.06—2.03)	0.021*	1.16 (0.92—1.47)	0.20
Medical history				
Diabetes mellitus	1.88 (1.20—2.95)	0.006*	1.62 (1.23—2.13)	0.001*
Hypertension	1.19 (0.87—1.63)	0.27	0.91 (0.74—1.12)	0.36
Cerebral infarction	0.60 (0.33—1.09)	0.092	0.95 (0.69—1.33)	0.78
Angina pectoris	0.92 (0.37—2.29)	0.86	0.99 (0.66—1.50)	0.97
Chronic heart disease	2.33 (0.8—6.81)	0.12	1.10 (0.58—2.10)	0.77
Internal medication on admission				
Antiplatelet	1.78 (1.05—3.00)	0.031*	2.10 (1.60—2.76)	<0.001*
Anticoagulation	3.40 (1.57—7.39)	0.002*	2.01 (1.29—3.14)	0.002*
Statin	1.83 (1.09—3.08)	0.022*	1.26 (0.92—1.73)	0.15

OR, odds ratio; CI, confidence interval.
*$P < 0.05$.

described the functional outcome after treatment of UCA.[14-16] However, no nationwide database of treatment for UCA has included data about functional outcome and location of the UCA.[9,10,12,17-22] This study included the functional outcome using BI at discharge and information about the location of UCA, and multivariate logistic regression analysis was conducted for poor functional outcome at discharge. In addition, about half of the patients were elderly, with the oldest cohort for a nationwide study of UCA, because Japan has the highest aging population worldwide.[5]

Risk Factors for Morbidity

Age was significantly associated with an OR of 1.03 (95% CI, 1.0—1.1) for morbidity in a previous study,[23] and the OR was 1.02 (95% CI, 1.00—1.04) in the nonelderly and 1.12 (95% CI, 1.10—1.14) in the elderly in our study. Age has emerged as an important risk factor influencing outcomes after surgical clipping compared with endovascular coiling. However, specific criteria for age change according to the era and region, because the worldwide population is aging. Age 50 years was reported as the borderline for poor outcome during the previous era.[13,21,22]

Figure 2. Forest plots of the risk factors in nonelderly and elderly groups. ACoA, anterior communicating artery; BA, basilar artery; CI, confidence interval; EC, endovascular coiling; Hospital volume 1, lowest number of treatment hospital; Hospital volume 3, highest number of treatment hospital; ICA, internal carotid artery; MCA, middle cerebral artery; SC, surgical clipping.

Recently, age 65 years has been reported as the borderline for poor outcome.[12,18] The age threshold of in-hospital mortality for surgical clipping might be older than 65 years, because Japan has the fastest aging population in the world.

Posterior location was a significant predictor of poor outcome of UCA treatment in previous studies,[13] which is similar to our finding of a high OR for BA aneurysms compared with ICA aneurysms. However, the locational risk of anterior circulation UCA has not been reported. The location of ACoA aneurysm was a significant risk not only in surgical clipping[24] but also in endovascular coiling, especially in small aneurysms,[25] similar to the significant risk in the nonelderly. On the other hand, ACoA and MCA compared with ICA had a significantly inverse risk in the elderly, which suggests a significant risk of ICA aneurysm in the elderly, because the ICA was most likely to show atherosclerotic change in the elderly. ICA aneurysms were reported to be associated with perforator infarction after surgical clipping for UCA[26] and with complication of hemorrhage after endovascular coiling.[27]

A history of diabetes mellitus shows significant association with morbidity,[28] as found in our study in both the nonelderly and the elderly groups. Diabetes mellitus is highly correlated with atherosclerotic stabilized aneurysms in older patients[29] and was reported as a risk of microembolism after endovascular coiling of UCA.[30] Higher case volume is associated with reduced complications after surgical clipping of UCAs,[31] as confirmed in this study of the universal health system in Japan. Academic institute was a significant risk for morbidity in the nonelderly group in this study. This result may reflect the fact that more

difficult cases of UCA in the nonelderly are likely to be treated in an academic institute in Japan. Antiplatelet and anticoagulation drugs[28] are known as the risk of surgical clipping for the UCA and were confirmed as a risk for morbidity of UCA treatment in this study, because there were twice as many surgical clipping cases as endovascular cases.

Functional Outcome and In-Hospital Mortality
Morbidity and complications of treatment for UCA have been reported in 8.3%—14.8% of cases after surgical clipping and 3.7%—7.6% after endovascular coiling.[17,22,28] Our study found morbidity (BI <100) of 3.9% in nonelderly and 9.3% in elderly patients after surgical clipping and 3.5% in nonelderly and 8.7% in elderly patients after endovascular coiling. The most common complication was cerebral infarction after surgical clipping (3.6% in the nonelderly and 4.8% in the elderly) and after endovascular coiling (9.4% in the nonelderly and 8.9% in the elderly). This complication was significantly higher in endovascular coiling than in surgical clipping; however, almost all cases of cerebral infarctions might have been minor or asymptomatic because there was no difference in outcome. Other complications occurred in 0%—1.8% of cases, with no significant difference between treatments (Table 1). The proportion of complications and in-hospital mortality after surgical clipping was lower in our data than in previous reports[10,12]; however, these results were compatible with a recent meta-analysis.[28]

Surgical clipping was associated with lower in-hospital mortality than was endovascular coiling in both the nonelderly and the

elderly groups in our study; this finding was also confirmed in a recent meta-analysis.[28] In Japan, the proportion of surgical clipping seemed higher than in other countries. There are many possible reasons for this phenomenon: lack of endovascular doctors; historical treatment method of surgical clipping; less poor outcome of surgical clipping, as found in this study; >9500 available neurosurgeons and >7500 board-certified neurosurgeons in 2017; both treatments conducted by neurosurgeons, under the universal health care system.

Optimum Management for Elderly Patients with UCA

Conflicting opinions have been expressed on the appropriateness of interventional treatment rather than observationally conservative management.[8,13,32,33] Patients with UCA or small UCA without risk factors should receive conservative observation,[34,35] especially the elderly with a limited life expectancy. On the other hand, if elderly patients with UCA have some risk factors, several scoring studies may support the decision making for the treatment of elderly UCA.[3,36,37] If interventional treatment is selected, endovascular coiling should be performed in high-volume hospitals after control of diabetes mellitus, and UCA located in the ICA in the elderly should be paid attention during treatment.

Limitations

There are several limitations to this study, which uses an administrative database.[38,39] First, aneurysm size, morphology, history of subarachnoid hemorrhage, and family history of subarachnoid hemorrhage are essential clinical factors for decision making. However, these factors were not recorded and were potentially unmeasured confounders in this database, the same as other nationwide databases. Second, this study did not use planned prospective cohorts or registries. Therefore, diagnoses are less well validated, and data are less detailed in secondary databases. Third, this database was only in-hospital, so we could not assess morbidity and mortality after discharge, Fourth, the present results might not be generalizable to other countries with different conditions, and the results of this study must be interpreted with caution in each region.

CONCLUSIONS

Endovascular coiling after control of diabetes mellitus is recommended for the treatment of UCA in elderly patients. The ICA location of aneurysm in the elderly should be paid attention as a treatment risk.

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Supplementary Table 1. The Absolute Risk Number for Morbidity of Barthel Index <90 and ≥90 of Unruptured Cerebral Aneurysm in the Nonelderly (<65 Years) Group

	BI at Discharge				
	Surgical Clipping (%) (n = 4996)		Endovascular Coiling (%) (n = 3023)		
	Death to <90 (N = 114)	90–100 (N = 4882)	Death to <90 (N = 68)	90–100 (N = 2955)	P Value
Age (years), median (interquartile range)	59.0 (52.0–62.0)	57.0 (50.0–61.0)	57.0 (48.0–61.0)	55.0 (47.0–60.0)	<0.001*
Sex (male)	51 (44.7)	1757 (36.0)	26 (38.2)	963 (32.6)	0.002*
Location of aneurysms					<0.001*
Internal carotid artery	24 (21.1)	1386 (28.4)	27 (39.7)	1812 (61.3)	
Anterior communicating artery	25 (21.9)	878 (18.0)	11 (16.2)	333 (11.3)	
Middle cerebral artery	50 (43.9)	2218 (45.4)	8 (11.8)	138 (4.7)	
Anterior cerebral artery	6 (5.3)	259 (5.3)	2 (2.9)	78 (2.6)	
Basilar artery	4 (3.5)	78 (1.6)	13 (19.1)	306 (10.4)	
Vertebral artery	4 (3.5)	59 (1.2)	5 (7.4)	256 (8.7)	
Other	1 (0.9)	4 (0.1)	2 (2.9)	32 (1.1)	
Hospital volume					<0.001*
1	55 (48.2)	1529 (31.3)	27 (39.7)	900 (30.5)	
2	36 (31.6)	1449 (29.7)	27 (39.7)	1146 (38.8)	
3	23 (202)	1904 (39.0)	14 (20.6)	909 (30.8)	
Academic	24 (21.1)	1107 (22.7)	33 (48.5)	904 (30.6)	<0.001*
Medal history					
Diabetes mellitus	20 (17.5)	344 (7.0)	5 (7.4)	175 (5.9)	<0.001*
Hypertension	56 (49.1)	1935 (39.6)	20 (29.4)	873 (29.5)	<0.001*
Cerebral infarction	4 (3.5)	153 (3.1)	9 (13.2)	668 (22.6)	<0.001*
Angina pectoris	5 (4.4)	96 (2.0)	0 (0.0)	95 (3.2)	0.001*
Myocardial infarction	0 (0.0)	2 (<1)	0 (0.0)	3 (0.1)	0.75
Chronic heart disease	2 (1.8)	39 (0.8)	2 (2.9)	16 (0.5)	0.047*

Values are number (%) except where indicated otherwise.
BI, Barthel Index.
*P < 0.05.

Supplementary Table 2. The Absolute Risk Number for Morbidity of Barthel Index <90 and ≥90 of Unruptured Cerebral Aneurysm in the Elderly (≥65 Years) Group

	BI at Discharge				
	Surgical Clipping (n = 4926)		Endovascular Coiling (n = 2726)		
	Death to <90 (N = 281)	90—100 (N = 4645)	Death to <90 (N = 163)	90—100 (N = 2563)	P Value
Age (years), median (interquartile range)	73.0 (69.0—77.0)	70.0 (67.0—74.0)	75.0 (69.0—81.0)	71.0 (68.0—75.0)	<0.001*
Sex (male)	78 (27.8)	1221 (26.3)	40 (24.5)	620 (24.2)	0.2
Location of aneurysms					<0.001*
Internal carotid artery	99 (35.2)	1105 (23.8)	85 (52.1)	1462 (57.0)	
Anterior communicating artery	40 (14.2)	826 (17.8)	19 (11.7)	371 (14.5)	
Middle cerebral artery	112 (39.9)	2280 (49.1)	10 (6.1)	151 (5.9)	
Anterior cerebral artery	17 (6.0)	305 (6.6)	2 (1.2)	100 (3.9)	
Basilar artery	6 (2.1)	68 (1.5)	33 (20.2)	357 (13.9)	
Vertebral artery	5 (1.8)	58 (1.2)	12 (7.4)	108 (4.2)	
Other	2 (0.7)	3 (0.1)	2 (1.2)	14 (0.5)	
Hospital volume					<0.001*
1	128 (45.6)	1553 (33.4)	71 (43.6)	859 (33.5)	
2	93 (33.1)	1379 (29.7)	53 (32.5)	991 (38.7)	
3	60 (21.4)	1713 (36.9)	39 (23.9)	713 (27.8)	
Academic	61 (21.7)	928 (20.0)	49 (30.1)	757 (29.5)	<0.001*
Medical history					
Diabetes mellitus	54 (19.2)	522 (11.2)	17 (10.4)	253 (9.9)	<0.001*
Hypertension	136 (48.4)	2290 (49.3)	67 (41.1)	1055 (41.2)	<0.001*
Cerebral infarction	21 (7.5)	198 (4.3)	27 (16.6)	530 (20.7)	<0.001*
Angina pectoris	21 (7.5)	219 (4.7)	7 (4.3)	137 (5.3)	0.16
Myocardial infarction	0 (0.0)	3 (0.1)	0 (0.0)	4 (0.2)	0.58
Chronic heart disease	7 (2.5)	6S (1.5)	5 (3.1)	46 (1.8)	021

BI, Barthel Index.
*P < 0.05.