INTRODUCTION

The increase in the number of Korea’s elderly is growing faster than the elderly population of any other OECD nations. In 1960, the number of Korean citizens aged 65 and older was 726,000, or 2.9% of the whole Korean population. Korea’s elderly population increased to 3.37 million, or 7.1% of the total, in the year 2000. Moreover, Korea’s elderly citizens are expected to reach the number of 10.1 million, or 19.3% of the total population, by 2030. The life expectancy of Koreans in 1960 was 52.4 years. In 2000, it reached 75 years, and it will likely reach 79 years by the year 2030. Recently, the incidence of unruptured intracranial aneurysms (UIAs) has shown a steady increase owing to advances in neuroimaging modalities, such as computed tomography (CT) angiography and magnetic resonance (MR) angiography, with sensitivities of 76% to 98% and specificities of 85% to 100%. Physicians are performing those tests more frequently during patients’ general health check-ups and to evaluate minor symptoms. However, the established guidelines do not exist yet for ideal management of unruptured intracranial aneurysms in elderly patients. Approximately 2% of adults have unruptured aneurysms, and these aneurysms’ annual risk of rupture is approximately 0.7%, according to an epidemiologic study by Rinkel, et al. The number of subarachnoid hemorrhages (SAHs) in the general population is relatively low (6 to 9 cases per 100,000 person-years) in U.S. The International Study on Unruptured Intracranial Aneurysms (ISUIA) indicated that the natural progression of unruptured aneurysms might be more benign than physicians previously thought. Considerable discussion among researchers has focused on the natural history of asymptomatic unruptured aneurysms. After the ISUIA reported its results, many institutions felt obliged to manage patients with UIAs in a more conservative fashion. Endovascular morbidity and mortality seem to be less dependent on a patient’s age, suggesting that this approach offers ad-
vantages for older patients. Deciding on the optimal treatment strategy for elderly patients with unruptured intracranial aneurysms requires careful assessment of each individual's treatment-related morbidity and life expectancy and an accurate knowledge of the natural history of this disease process. Unfortunately, physicians have had only limited data regarding elderly patients with unruptured aneurysms. In this single unit series, we report our experience with managing unruptured intracranial aneurysms in elderly patients.

**MATERIALS AND METHODS**

**Patient characteristics**

We retrospectively analyzed all patients, aged 65 years and older, diagnosed with unruptured intracranial aneurysms (UIAs) at the Cerebrovascular Center from 1997 to 2009. We reviewed 109 patients harboring 136 unruptured aneurysms. All data was in the form of registered data, which provided specifics on the following variables: age, sex, treatment modality, location and size of aneurysm(s), symptoms, 1-year outcome, and risk factors, such as cardiovascular disease, hypercholesterolemia, smoking, and family history of stroke. Cardiovascular diseases included angina, atherosclerosis, stroke, congestive heart failure, coronary artery disease, myocardial infarction, and peripheral vascular disease. We categorized the numerically -continuous variables, such as age and aneurysm size, into three categories, for statistical analyses. Also, we classified the one-year clinical outcomes into four categories: full recovery without deficits, transient disability, permanent disability, and death. We classified treatments into three groups: surgical clipping group (Group A), coil embolization group (Group B), and untreated group (Group C). Of the 109 patients, 56 patients underwent surgical clipping and 25 patients were treated by coil embolization. The remaining 28 patients were untreated but observed. The follow-up period in the outpatient department is 1 to 10 years until loss to follow up. Long-term follow-up methods included charts and telephone calls. We classified the aneurysms' locations as follows: 1) internal carotid artery, 2) anterior cerebral artery, 3) middle cerebral artery, 4) vertebral artery-basilar artery, and 5) multiple lesions in Fig. 1. The use of digital subtraction angiography made accurate estimation of aneurysmal sizes possible. For the size of an aneurysm, we measured the necks and heights of the aneurysms on the vertebral artery-basilar artery by coil clipping and aneurysms on the middle cerebral artery were more frequently treated by clipping and aneurysms on the vertebral artery-basilar artery by coil clipping. The observation group visited outpatient clinic annually to observe the change of shape of dome and size of aneurysms with computed tomography angiography until loss to follow up.

**Statistical analysis**

We analyzed the data using SPSS 15.0 for Windows. We present the outcome scores using mean values and 95% confidence intervals. To compare differences in means of continuous data, we used independent-samples t-tests. p-values less than 0.05 were considered statistically significant. We carried out univariate logistic regression analyses to identify predictors of morbidity and mortality.

**RESULTS**

**Patient characteristics**

The 109 patients with at least 1 year of follow-up had a total of 136 aneurysms: numbers of one aneurysm are in 88 patients, two aneurysms in 16 patients, had three aneurysms in four patients, and four aneurysms in one patient. Twenty-nine patients were male, and 80 were female. Their mean age was 72 years. These cases included a variety of UIA clinical manifestations: chronic non-specific headaches; dizziness, with or without nausea; cranial nerve palsy (ptosis, visual dimness, and diplopia); tingling sensations; and seizures.

Chronic headache was not only the most common presenting symptom but also the most frequent symptom accompanied by other neurologic deficits. We defined “chronic headache” using the International Headache Society (HIS) classification, requiring that the headache last for at least 3 months, have a fre-
frequency of more than 15 days per month, and have a non-cata
trophic, recurring character. The preoperative chronic headache
group that also received treatment numbered 22 patients. Using
Waters’s Headache Questionnaire, we found 11 patients pre-

tended with mild headache, 8 patients with moderate headache,
and 3 patients with severe headache. Treatment outcomes in-
cluded marked relief of headaches in majority of patients com-
plaining of chronic headaches before treatment. In addition,
they recovered from preoperative depression and anxiety. How-
ever, we didn’t find any reason why they recovered from head-
ache after treatment. This is not simply correlated with size ef-
ects of aneurysms.

The health check survey and/or routine neuroimaging evalua-
tions incidentally detected seventy-six patients (69.7%). Many
elderly patients had risk factors for stroke, as follows: 63 (57.8%)
had cardiovascular disease, 45 (41.3%) had diabetes mellitus, 29
(26.6%) smoked, 27 (24.8% ) had hypercholesterolemia, and 18
(16.5%) had a family history of stroke.

**Characteristics of the aneurysms and treatment modalities**

The aneurysms were located in the internal carotid artery (ICA)
in 49 instances (35.5%), in the middle cerebral artery (MCA) in
42 (30.5%), the anterior cerebral artery (ACA) in 28 (20.2%), and
the vertebro-basilar artery (VA-BA) in 19 (13.8%) (Fig. 2). The
mean size of the aneurysms was 7.19 mm. The size of aneurysms
were less than 4 mm in 25 patients, from 4 mm to 7 mm in 44
patients, and larger than 7 mm in 40 patients, mean size of 7.19
mm (Fig. 1). Fifty-six patients (55%) underwent clipping, 25
underwent coiling (22.9%), and 28 patients (25.7%) received no
treatment but, rather, close monitoring of their clinical condi-
tions, with neuroimaging follow-up periodically. The mean age
of patients receiving clipping was 70.6 years. The patients un-
dergoing coil embolization had a mean age of 71 years. The
mean age in the untreated group was 75.6 years (Fig. 3).

Patients with certain conditions showed poor clinical outcomes,
as compared with who did not have these factors, as follows: hy-
pertension (p=0.009), diabetes mellitus (p=0.000), hypercholes-
terolemia (p=0.000), smoking (p=0.000), a family history of stroke
(p=0.001), and cardiovascular risk factors (hypercholes-
terolemia, p=0.008; diabetes mellitus, p=0.008). Patients age 75 years
or older did not receive treatment but were observed.

**Postoperative 1-year outcome and prognostic factors**

The overall 1-year morbidity and mortality rates were 2.46% and
0%. The morbidity was 1.78% for clipping treatment and
4% for coiling treatment (Table 1). In univariate analysis, which
considered only the treatment groups, multiple aneurysms (p=
0.021), hypertension (p=0.012), diabetes mellitus (p=0.000), hy-
pertension (p=0.000), smoking (p=0.000), and a family history of stroke
(p=0.001) correlated significantly with poor recovery at 1-year post-operative. Observation group was not
evaluated because only one variable could be processed in uni-

**Fig. 2. Location of aneurysms according to treatment modality. Middle cere-
bral artery including the bifurcation is the most common site of aneurysm. Mul-
tiple aneurysms are 18.3%. ACA : anterior cerebral artery, ICA : internal carotid
artery, MCA : middle cerebral artery, VA-BA : vertebral artery-basilar artery. Group
A (surgical clipping), Group B (coil embolization) and Group C (observation)**

**Fig. 3. Age distribution of patients with unruptured intracranial aneurysm
according to treatment modality. Regardless of treatment modality, most pa-

tients are in their seventh decades of life. Group A (surgical clipping), Group
B (coil embolization) and Group C (observation).**
outcome, even though former studies noted that aneurysms <5 mm had a higher risk of rupture than did aneurysms of a larger size. Complications after the treatment procedures were perforator ischemia in the clipping group and thromboembolism in the coiling group. In the clipping group, four patients suffered from perforator ischemia, and three of them recovered fully. One patient suffered from postoperative infections. In the coiling group, three patients experienced thromboembolism, and one of them developed permanent disability but there was no recanalization. In the observation group, patients older than 75 years also suffered from terminal cancer, heart attack, and infectious respiratory disease but did not experience hemorrhage. Only two patients with symptomatic lesions, hypertension, and/or family history of stroke refused treatment against recommendation of treatment, despite repeated advice from the neurosurgeons because of irregular shape of domes, and died of ruptured subarachnoid hemorrhages within one year of diagnosis. One patient had irregular shape of multiple aneurysms with multi-lobulated domes.

The other patients showed growing size during one year. Also, 26 observed but untreated patients with few risk factors constantly worried that they carried a risk of rupture from unruptured intracranial aneurysms.

**DISCUSSION**

In younger patients, surgical treatment, as opposed to the natural progression of the disease, is more effective in terms of both prolonging lives and improving the quality of life. Surgical treatment is probably of less relevance to elderly persons because of low complications in the coiling group and thromboembolism in the clipping group. In the clipping group, four patients suffered from perforator ischemia, and three of them recovered fully. One patient suffered from postoperative infections. In the coiling group, three patients experienced thromboembolism, and one of them developed permanent disability but there was no recanalization. In the observation group, patients older than 75 years also suffered from terminal cancer, heart attack, and infectious respiratory disease but did not experience hemorrhage. Only two patients with symptomatic lesions, hypertension, and/or family history of stroke refused treatment against recommendation of treatment, despite repeated advice from the neurosurgeons because of irregular shape of domes, and died of ruptured subarachnoid hemorrhages within one year of diagnosis. One patient had irregular shape of multiple aneurysms with multi-lobulated domes.

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**Table 1. Clinical outcome according to the treatment modalities**

| Clinical outcome       | Number of patients (%) | Overall |
|------------------------|------------------------|---------|
|                        | Clipping | Coiling |       |
| Good recovery          | 51 (91)  | 22 (88) | 73 (90) |
| Transient disability   | 4 (7)     | 2 (8)   | 6 (7)   |
| Permanent disability   | 1 (2)     | 1 (4)   | 2 (3)   |
| Death                  | 0         | 0       | 0       |
| Total                  | 56        | 25      | 81      |

Good recovery: immediately after surgery; Transient disability: recovered within 1 month

**Table 2. Variables related to unfavorable clinical outcome (within 1 year)**

|                          | Univariate analysis | Multivariate analysis |
|--------------------------|---------------------|-----------------------|
|                          | Total   | Clipping | Coiling | Total   | Clipping | Coiling |
| Age (more than 70 years) | 0.942   | 0.519    | 0.118   | 0.909   | 0.598    | 0.383    |
| Presence of symptom      | 0.000*  | 0.002*   | 0.418   | 0.000*  | 0.023*   | 0.112    |
| Location of aneurysm     | 0.116   | 0.056    | 0.633   | 0.057   | 0.103    | 0.302    |
| Size of aneurysm         | 0.859   | 0.900    | 0.349   | 0.768   | 0.917    | 0.740    |
| Dome to neck ratio       | 0.961   | 0.186    | 0.127   | 0.279   | 0.192    | 0.460    |
| Multiplicity of aneurysm | 0.021*  | 0.013*   | 0.310   | 0.004*  | 0.036*   | 0.079    |
| Hypertension             | 0.012*  | 0.078    | 0.211   | 0.009*  | 0.059    | 0.166    |
| Diabetes mellitus        | 0.000*  | 0.027*   | 0.077   | 0.000*  | 0.019*   | 0.055    |
| Hypercholesterolemia     | 0.000*  | 0.000*   | 0.087   | 0.000*  | 0.000*   | 0.010*   |
| Smoking                  | 0.000*  | 0.021*   | 0.016*  | 0.000*  | 0.023*   | 0.031*   |
| Family history of stroke | 0.000*  | 0.455    | 0.004*  | 0.001*  | 0.230    | 0.011*   |
| Treatment modality       | 0.373   | -        | -       | 0.482   | -        | -        |

*statistically significant. Univariate analysis was considered only in the treatment group but multivariate analysis included the observation group

In this study, two patients aged 72 and 73 years old ignored symptoms and multiple risk factors such as cardiovascular diseases, high cholesterol levels, and symptomatic lesions. When asked on the phone with regards to their health, they were already died from rupture of aneurysms. The treatment modalities for UIAs in the elderly focus on low complications in the prophylaxis of ruptures. Therefore, physicians have a certain tendency to prefer coiling for older, asymptomatic aneurysms and aneurysms located on the internal carotid artery and verteobasilar artery. At this point it appears that the risks associated with surgical clipping and endovascular coiling, in terms of stroke or death from the procedure, are the same. A critical point in endovascular treatment is that the morphological result

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Good recovery: immediately after surgery; Transient disability: recovered within 1 month

Table 2. Variables related to unfavorable clinical outcome (within 1 year)
may be incomplete or may worsen after time. Given the poten-
tial life spans of elderly patients (man; 76 years old, woman; 82
years old by Statistics Korea), partial treatments (if they protect
against early rebleeding and recanalization), may be preferential
to the complete treatments appropriate for younger patients.
This study’s results suggest coil packing can be the better choice
for elderly patients who have short life expectancy.

However, we found different results in the long-term follow-
up that ranged from 1 to 10 years. During this time, some pa-
tients were offered the option of observations without endovas-
cular therapy or microsurgical clip ligation. As in another
survey, unruptured aneurysms found in the elderly were pre-
dominantly in females. Moreover, elderly females also showed a
higher frequency of multiple aneurysms and a lower frequency
of anterior communicating artery aneurysms when compared
to younger female patients. Nevertheless, the one year clinical
outcome did not correlate to treatment modality in either uni-
variate analysis $(p=0.373)$ or multivariate analysis $(p=0.482)$.
The recent review by the Korean Society of Cerebrovascular
Surgery (KSCVS) showed the same results in a retrospective
study of 1,696 cases enrolled over one year at 48 hospitals in
South Korea. Ogilvy et al. investigated the risk factors in 604
UIAs. The authors noticed age, aneurysm size, and location of
the posterior circulation was independently associated with
morbidity and with mortality. In our study, we could find six
strong risk factors: multiple aneurysms, hypertension, diabetes
mellitus, hypercholesterolemia, smoking, and family history of
stroke. Probably these risk factors might influence on the grow-
ing of aneurysms, perforator ischemia after clipping and throm-
bomobilism after coiling.

We propose that preoperative routine chemistry must include
monitoring patient cholesterol levels, which have frequently
been neglected. In addition, we found headache, the most com-
mon symptom, was treatable after management. Among the 22
patients who presented with preoperative, chronic headache,
only one complained of worsened headache after receiving sur-
gical clipping. Two patients stated that they experienced no
changes in their headaches. Twenty patients (90.9%) reported
their headaches improved. All of these patients reported their
headaches improved during the first week after treatment. This
is not simply correlated with size effects of aneurysms. Further
evaluation for this result should be analyzed.

The ISUIA study in 2003 assessed 1,591 patients during fol-
low-up and found 10.1% morbidity and 2.7% mortality rates.
In 2005, Moroi et al. reported 0.3% mortality and 2.2% morbidity
rates. Another study by Raaymakers, found 2.1% mortality and
10.9 % morbidity rates in a meta-analysis of 2,460 UIAs
treated by clipping and reported in 61 publications between Jan-
uary and June 1996. In our survey, the overall one morbidity
and mortality rates were 2.46% and 0%, respectively. The one
year morbidity rate was 1.78% for clipping and 4% for coiling
procedures. These figures are lower than the ones in the litera-
ture. Furthermore, we need to consider cost-effectiveness. Of

South Korea’s 49-million population, 7% is over age 65, and half
of South Korea’s elderly households live in a state of “relative
poverty,” having incomes below 50% of the nation’s average
household income. The major health-care problems of the Ko-
rean elderly are difficulties in paying for health care services and
in providing long-term care when they become frail. The treat-
ment costs for elderly patients with cerebral aneurysms increase
as the patients get older. For this reason, physicians should make
greater efforts, via a screening system, to treat unruptured cere-
bral aneurysms as early in each patient’s life as possible. Then,
physicians need to determine the approach that is most cost-ef-
fective for each patient.

This study has some limitations. This study does not address
the influence of endovascular therapy, which should feature
prominently in any decision-making process. Without ran-
domization, a management protocol where neurosurgeons and
interventional neuroradiologists decide, on a case-by-case basis,
about the preferred individual treatment causes selection bias.
For example, a primary physician with unjustifiable optimism
and unreasonable risk aversion might insist that unruptured an-
eurysms in old and sick patients with cerebrovascular diseases
should be left untreated. Endovascular repair of aneurysms can
be inferior in broad-based aneurysms, and surgery is superior
to endovascular treatment for MCA aneurysms with an unfa-
orable geometry, even if the patient has many risk factors for
general anesthesia. Finally, we derived the data from a single in-
stitute with a relatively low number of patients. We may have
methodologically overlooked some potential, confounding vari-
able of statistical significance.

CONCLUSION

We found patients with certain conditions showed poor clin-
ical outcomes as compared with those who did not have these
factors, which were as follows: hypertension, diabetes mellitus,
hypercholesterolemia, smoking, and a family history of stroke.
Treatment modality in these elderly patients did not correlate
with poor outcomes. Both clipping and coiling treatments had
favorable results in elderly patients. Surgical clipping did not
lead to inferior outcomes in our study, although coil emboliza-
tion is generally more popular for treating elderly patients. We
emphasize that there is no mortality case and rupture of aneu-
rysms in the treatment groups. In the treatment of patients more
than 65 years old, treatment of unruptured intracranial aneu-
rysms should be considered positively.

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