MATERIALS AND METHODS

We performed a retrospective review of elderly patients who underwent surgical clipping of UIAs between May 1999 and June 2010 in our institute. We exclude the aneurysm in the cavernous portion and the aneurysm was treated by endovascular coiling. We identified a total of 48 patients (54 aneurysms) aged 70 years or older (mean age, 72.11±1.96 years; range, 70-78 years). Forty-five patients were clinically followed-up in September 2010 by telephone interview or at visits to the outpatient department. Preoperative general inspection, such as cardio-pulmonary function test was fully evaluated. So, patients who have medical problems were excluded for the treatment. The neurologic state of the patients was assessed by neurologists and radiologic findings, including those of computed tomography (CT), transfemoral cerebral angiography (TFCA) and magnetic resonance image (MRI), were interpreted by neuroradiologists and a neurosurgeon. All patients underwent pre- and postoperative CT angiography. TFCA was performed preoperatively in 34 patients and postoperatively in 32. Surgical results were evaluated by...
neuroradiologists using postoperative three-dimensional angiography. Postoperative outcomes were evaluated using the modified Rankin scale (mRS) at 3 and 12 months after surgery\(^{(27)}\). Surgical morbidity was defined as newly developed neurological deficits lasting at least 7 days after surgery and correlated with MRI or CT findings. Perioperative risk factors for postoperative complications were analyzed. All statistical analyses were performed using the SPSS program (version 12.0; SPSS, Inc., Chicago, IL, USA). Categorical variables were compared using Pearson’s chi-square tests or Fisher exact tests, where appropriate. Continuous variables were reported as means±standard deviations and compared using independent Student t-tests or Mann-Whitney U-tests. A probability less than 0.05 was considered statistically significant. Postoperative stroke- or death-free survival time was assessed using the Kaplan-Meier method.

**RESULTS**

Of the 48 patients, 33 were women and 15 were men (Table 1). Preoperative maximum fundus diameter was 6.82±3.07 mm (range, 2.00 to 15.00 mm). Of the 54 aneurysms, none (0%) was a giant aneurysm (>25 mm in diameter), 12 (22.2%) were large, ranging from 10 to 24 mm in diameter, and 42 (77.8%) were small, less than 10 mm in diameter. Forty-two (87.5%) patients had single aneurysms and 6 (12.5%) had multiple aneurysms. Symptoms occurred in 42 (87.5%) patients and included headache, dizziness, transient ischemic attack, diplopia, memory disturbance and seizure; 6 (12.5%) patients were asymptomatic (Table 2). Of the 54 aneurysms, 22 (40.7%) were located in the internal carotid artery (ICA), 19 (35.2%) in the middle cerebral artery, 12 (22.2%) in the anterior cerebral artery, and 1 (1.9%) in the superior cerebellar artery (Table 3).

In 50 of the 54 aneurysms (92.6%) surgical clipping resulted in complete clipping, the remaining 4 (7.4%) were incompletely clipped (Table 4). Of these four, one M2 bifurcation aneurysm was treated by reconstruction of the base of the aneurysm due to a broad neck and severe atherosclerotic changes, thus avoiding parent vessel stenosis or occlusion. The other three aneurysms were large posterior communicating artery aneurysms with a fetal type posterior cerebral artery (PCA) and were treated by reconstruction with multiple clips to maintain patency of the PCA. Follow-up radiologic images taken more than 1 year after surgery showed no regrowth or change in morphology in aneurysms that underwent clip reconstruction. Of the 48 patients, 20 underwent follow-up radiologic imaging after 1 year to detect recurrences, but none showed recurrence of the aneurysms.

Except of one illustrated case described below, there were no medical related complications such as postoperative pneumonia or cardiac problem. Procedure-related complications occurred in seven (13.0%) aneurysms following surgery (Table 5);
these complications were not related to the size or location of the aneurysm. Complications included postoperative cerebral infarction in three aneurysms (5.6%), postoperative chronic subdural hematoma in two (3.7%), and ischemic intracranial hemorrhage and wound infection in 1 each (1.9%). Most common complication is postoperative cerebral infarction may be due to small vessel injury. It is similar as previous study. Fortunately, two cases of infarction were treated without sequelae but one case suffered from permanent neurologic sequelae. One patient died due to surgically related complications. Permanent neurological deficits occurred in two patients, one of whom died.

Post-treatment, 3-month outcomes were excellent (mRS 0-1) for 50 aneurysms (92.6%), good (mRS 2-3) for 2 (3.7%); and poor (mRS 4-5) for 1 (1.9%), with 1 death (mRS 6). One year after surgery clinical outcomes were excellent (mRS 0-1) in 93.2%, good (mRS 2-3) in 4.5%, poor (mRS 4-5) in 0%; and death (mRS 6) in 2.3%. At last follow-up, clinical outcomes were excellent (mRS 0-1) in 86.3%, good (mRS 2-3) in 5.9%, poor (mRS 4-5) in 4%, and death (mRS 6) in 3.9% (Table 6). Kaplan-Meier analysis showed that the cumulative rates of stroke- or death-free survival at 5 and 10 years were 100% and 77.8%, respectively. The mean event-free survival time in these 48 patients was 159.44 months (95% confidence interval, 128.11-190.78 months) (Fig. 1).

Case
A 72-year-old woman was admitted to our department due to suffering a headache and left ptosis for several days. Computed tomography (CT) showed calcification in both basal ganglia but no definite high density region in the basal or sylvian cistern (Fig. 2). TFCA showed a wide-necked large aneurysm on her left posterior communicating artery. After pterional craniotomy, the sac was isolated using two right-angled fenestrated clips. To decompress the oculomotor nerve, which was compressed by the aneurysm, we began to dissect the daughter sac adhering to the left oculomotor nerve. However, there was sudden blood flow from the dome of the aneurysm, leading to an unplanned neck dissection for proximal control. The neck portion was clipped temporarily, with multiple clips resulting in successful occlusion. Microvascular Doppler showed good blood flow of the posterior communicating artery and the distal ICA.

Table 5. Procedure-related complications and clinical outcomes after 3 months

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age/Sex</th>
<th>Location</th>
<th>Clinical Data</th>
<th>Size Cm</th>
<th>Complication/ Cause</th>
<th>mRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>72/F</td>
<td>ICA (P-comA)</td>
<td>Headache</td>
<td>9.00</td>
<td>ICH on Cerebellum, Infarction on left hemisphere d/t premature rupture, prolong proximal control Pneumonia</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>75/F</td>
<td>ACA (A23 junction)</td>
<td>Headache</td>
<td>7.20</td>
<td>Infarction &amp; hemorrhagic transformation d/t cortical vein injury</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>73/M</td>
<td>ACA (A23 junctions)</td>
<td>Headache</td>
<td>4.00</td>
<td>Chronic subdural hematoma</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>70/F</td>
<td>ICA (P-comA)</td>
<td>TIA</td>
<td>3.10</td>
<td>Wound infection</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>70/M</td>
<td>ACA (A-comA)</td>
<td>Hemiparesis</td>
<td>5.50</td>
<td>Chronic subdural hematoma</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>72/F</td>
<td>ICA (P-comA)</td>
<td>Headache</td>
<td>4.38</td>
<td>Subtle ischemic change</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>70/M</td>
<td>ICA (ICAb)</td>
<td>TIA</td>
<td>7.60</td>
<td>Subtle ischemic change</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 6. Clinical outcomes

<table>
<thead>
<tr>
<th></th>
<th>At admission</th>
<th>At discharge</th>
<th>At 3 months after surgery</th>
<th>At 12 months after surgery</th>
<th>At last follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>54</td>
<td>50</td>
<td>50</td>
<td>41</td>
<td>44</td>
</tr>
<tr>
<td>Good</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Poor</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Death</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

During the operation, the patient received six pints of packed red blood cells. Postoperative neurologic examination revealed right-sided hemiparesis (grade 2) and stupor mentality. A CT scan after surgery showed a low-density region around the operation site. The patient’s neurologic state did not recover and a CT scan 3 days after surgery revealed a high-density area on the left cerebellum and a low-density area on the left hemisphere. The patient died 21 days after surgery due to aggravated pneumonia and sepsis.

**DISCUSSION**

In South Korea, the average life expectancy of women is 83.3 years and that of men is 76.5 years. The development of new diagnostic technologies and the prolonged average life expectancy have led to increased detection of unruptured intracranial aneurysms in elderly patients. The prevalence of UIA in the general population is 4.2%\(^6\). Although a systematic review of UIA in international large-scale cohort studies showed that the annual risk of UIA rupture is very low\(^{13,18}\), patients with untreated UIA in Japan had a significantly higher risk of rupture\(^5\). Moreover, the risk of UIA rupture in Korean patients is similar to that in Japanese patients. Subarachnoid hemorrhage (SAH) from rupture of cerebral aneurysm is an important cause of stroke and the incidence of SAH increases with age\(^{13,18}\), from approximately 1.5 to 2.5 per 100,000 persons per year during the third decade of life to approximately 40 to 78 per 100,000 persons per year during the eighth decade\(^{16,19}\). The risk of rupture of UIA is about 3.05-5.7% per year in elderly patients, higher than in the general population\(^19\). In addition, the mortality rate after subarachnoid hemorrhage is high at about 32-67%, with about 30% of survivors having moderate to severe disability\(^3\). Among these patients, the rate of medical complications associated with poor outcomes was also high, including a death rate from medical complications of 23%\(^{16}\). Complications also increased with patient age, with outcomes being worse in elderly patients with than without complications. Moreover, UIA, and the knowledge that rupture could lead to death, can have a negative impact on quality of life.

UIA can be treated by placing a clip over the neck of the aneurysm, isolating it from the circulation, or endovascularly with detachable coils. Craniotomy to clip the UIA is regarded as more invasive and associated with greater risks for elderly patients because many are in poor general health, with conditions such as heart disease, renal disease, and/or cerebrovascular disease, all of which are poor prognostic factors for major surgery\(^{21}\). In contrast, endovascular treatment has low rates of procedural morbidity and mortality, particular advantages in patients with poor general health or multiple risk factors\(^5\). In UIA patients in general, endovascular treatment has been associated with lower rates of complications, mortality and morbidity rate than surgical clipping, with overall 30-day morbidity and mortality rates of 1.8% and 13.7%, respectively, in patients undergoing open surgery and 2.0% and 9.3%, respectively, in patients receiving endovascular treatment\(^{21}\). Another study found that the mortality rate was 0%, the morbidity rate was 8.3% and the embolization rate was 76% in patients with UIA\(^{16}\). Different findings have been observed in elderly patients, however, with endovascular treatment associated with higher rates of procedure-related morbidity and incomplete treatment. Patients’ vessels become more tortuous or kinked with age, and advanced atherosclerotic degeneration of the vessel may trigger ischemic complications of thromboembolic events during the endovascular procedure. A previous study (Table 7) found that, although there were no procedure-related deaths, complete embolization was accomplished in only 28% of elderly patients with UIAs, recanalization was common (24%), 14% required further embolization, and the rate of good outcomes (mRS, 0-2) was 91%\(^6\). Another study found that coiling resulted in excellent outcomes (mRS 0-1) in 83% of elderly patients, with a procedure-related morbidity rate of 9%, and death rate of 4.5%\(^6\).

Although the surgical risk of craniotomy for patients with UIA has been reported to be unrelated to patient age\(^8\), other studies have reported surgical morbidity rates of 6-16.7% and mortality rates of 0-5.2%\(^{9,21}\), higher than the rates of 2.2-15.3% and 0.3-2.3%, respectively, reported in all patients with UIA\(^2,10,11,14,21\). Moreover, the 1-year rate of poor outcomes in patients aged more than 70 years was 30%, higher than in other age groups.
In our series, the morbidity and mortality rates were 13.0% and 1.9%, respectively. The common complication was cerebral infarction due to small vessel injury during the operation. Moreover, 1-year outcomes were generally excellent, as was the event-free survival rate. Our findings are therefore better than those of previous studies of both surgical and endovascular treatment, with risks similar to those for middle-aged patients (Table 7). Compared with middle-aged patients, the elderly do not differ in the mechanism of the postoperative surgical complication. Avoiding damage to small vessels is most important during the surgery.

**CONCLUSION**

We found that surgical clipping was associated with favorable outcomes for elderly patients with UIAs. Our study design, however, was retrospective in nature, associated with inherent limitations and biases. Randomized prospective studies are required to show that surgical clipping of UIAs in this age group is safe and effective.

**References**