Treatment and prognosis of elderly patients with unruptured cerebral aneurysms

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Objective: In recent years, the number of cases of unruptured intracranial aneurysms in older patients has been increasing, but the best treatment remains a matter of debate. This study aimed to compare the treatment methods for unruptured intracranial aneurysms in patients aged 65 years and older.

Methods: A retrospective review was conducted of data from unruptured intracranial aneurysms treated with surgical clipping or endovascular coiling between 2004 and 2019. Clinical and imaging information was collected. The treatment methods, procedure-related complications, and imaging and clinical results were analyzed. Data were assessed through a comparative analysis of underlying diseases (diabetes mellitus, hypertension, and hypercholesterolemia), smoking and alcohol use history, the location and size of the aneurysms for patients who received each treatment, and complications that occurred after each treatment.

Results: Of 211 patients over the age of 65, 71 were treated with clipping and 140 with coiling. The complications that occurred immediately after treatment included postoperative hemorrhage (subarachnoid hemorrhage, intracerebral hemorrhage, intraventricular hemorrhage), chronic subdural hemorrhage, infection, and puncture site infection. Postoperative computed tomography images of the clipping sites had four times more opacity than those of coil embolization, but the outcomes (Glasgow outcome scores) showed no significant differences between clipping and coil embolization.

Conclusion: Coil embolization and clipping are safe and effective treatment methods for unruptured intracranial aneurysms in elderly patients. Thus, the active treatment of unruptured intracranial aneurysms, which are likely to be which are at risk for rupture, should be considered.

Keywords: Intracranial aneurysm; Aged; Clip, surgical; Coil embolization

Introduction

The elderly population is increasing exponentially every year and many populations experience life expectancies over 80 years. In most developed countries, more than 75% of the population die after the age of 75 [1]. With the development of non-invasive imaging examination methods, the diagnosis rate of unruptured cere-

bral aneurysms in the elderly is increasing [2]. Over the past few decades, the development of microsurgical and intravascular surgical treatment techniques has greatly improved, leading to better outcomes in patients with unruptured cerebral aneurysms [3,4]. In addition, the development of neurocritical care and patient monitoring has played an important role in enhancing the safety associated with aggressive treatments [5,6]. Although studies of treatment methods have reported that intravascular coil embolization has significantly lower overall and short-term mortality than direct neck clipping [1], the recurrence rate of cerebral aneurysms is significantly higher [7]. Although intravascular coil embolization is commonly performed in the elderly [2], it is difficult to execute due to the physiological complications, such as vacuum tortuosity and atherosclerosis, which accompany aging. Therefore, the elder-
ly often choose only conservative therapy without invasive treatment [8]. The aging process changes the patient’s physiological condition, resulting in a reduced life expectancy, increased comorbidities, an increased surgical risk due to the invasiveness and extended operating hours, and an increased risk of intravascular coil embolization due to vascular tortuosity and arteriosclerosis [9]. In such situations, neurosurgeons experience conflicts over the choice of the treatment method for unruptured cerebral aneurysms in the elderly. In this study, we aimed to perform a retrospective analysis of clinical and imaging data from elderly patients with unruptured cerebral aneurysms, including the treatment methods.

Material and Method

Patients

Data were collected from patients with cerebral aneurysms from 1997 to 2017 at Gyeongsang National University Hospital. A total of 2,850 patients treated for unruptured cerebral aneurysms were enrolled. Patients were included if they were aged 65 years or older, regardless of sex, and had a cerebral aneurysm detected by angiography. The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board Gyeongsang National University Hospital (protocol code: GNUH 2022-02-014 and March 15, 2022).

Method

Of the total 2,850 patients, 211 elderly patients aged 65 years or older were diagnosed with cerebral aneurysm and subjected to coil embolization or clipping. All 211 patients had a follow-up period of less than 6 months. Of these, 3 overlapping patients were excluded from the study, and a total of 208 patients were analyzed. Patients who underwent cerebral direct neck clipping and coil embolism were classified according to the location of the cerebral aneurysm. The treatment strategies were determined through discussions with a neurosurgery specialist and a neurosurgeon who could perform neurological intervention procedures. Patient records were analyzed to assess the results obtained using the 2 different treatment methods.

Clinical outcomes

We used the Glasgow outcome score (GOS) to quantify the clinical results of patients at the time of discharge after clipping or coil embolization. GOS scores of 1 to 3 points suggest a poor prognosis, and GOS scores of 4 to 5 points suggest a good prognosis. Post-surgical complications, including cerebral hemorrhage (intracerebral hemorrhage, subarachnoid hemorrhage, and intraventricular hemorrhage), chronic subarachnoid hemorrhage, cerebral infarction, and puncture site infection, were analyzed. Patients who were followed up after surgery were subjected to angiographic computed tomography after 3 months and magnetic resonance imaging after 6 months, after which outpatient revisits were performed on a yearly basis to clarify the postoperative change or to find out aneurysm recurrence.

Results

After excluding cases of overlapping procedures and insufficient data, a total of 208 patients were analyzed. Of those patients, 69 underwent clipping surgery (47 females, 22 males), about twice the case, and 139 underwent coil embolization (99 females, 40 males). The average age of patients undergoing clipping and coil embolization was 68.29 and 71.46 years, respectively (Table 1). The average size of the cerebral aneurysm subjected to clipping and coil embolization was 7.4 mm and 7.09 mm, respectively (Table 1). There were 15 patients with complications after clipping, of which 7 (9.9%), 2 (2.8%), and 6 (8.5%) developed post-surgical hemorrhage, chronic subdural hematoma, and cerebral infarction, respectively. Three of the 6 patients who developed cerebral infarction after clipping were discharged from the hospital.

Table 1. Basic information of patients with unruptured intracranial aneurysms

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Clip</th>
<th>Coil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65–69</td>
<td>39</td>
<td>55</td>
</tr>
<tr>
<td>70–74</td>
<td>24</td>
<td>50</td>
</tr>
<tr>
<td>75–79</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>≥ 80</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>47</td>
<td>99</td>
</tr>
<tr>
<td>Male</td>
<td>22</td>
<td>40</td>
</tr>
<tr>
<td>Underlying diseases or health behaviors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>47</td>
<td>97</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Alcohol use</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Smoking</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Aneurysm location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior circulation</td>
<td>58</td>
<td>88</td>
</tr>
<tr>
<td>Posterior circulation</td>
<td>11</td>
<td>51</td>
</tr>
<tr>
<td>Aneurysm size (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3–9</td>
<td>55</td>
<td>116</td>
</tr>
<tr>
<td>Over 9</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>Total (n = 208)</td>
<td>69</td>
<td>139</td>
</tr>
</tbody>
</table>

Values are presented as number (%).
because of improved symptoms. Five patients developed complications after the coil embolization surgery. Among them, post-surgical brain hemorrhage occurred in 2 (1.4%) patients, and puncture site infection occurred in one (0.7%) patient. Of the 2 patients with cerebral infarction following embolization surgery, one improved and was discharged (Table 2).

Two cerebral infarctions occurred at the anterior communicating artery, 2 cases occurred at the middle cerebral artery (MCA) after clipping, and 2 cases occurred at the anterior cerebral artery 2/3 junction during coil embolization. The total number of complications was 3 times higher after clipping than after coil embolization, which was a significant result (Table 2). However, the difference between the GOS of the 2 treatment groups was not significant at the time of discharge. After clipping surgery, 53 patients were discharged with a GOS of 5 points; 8 patients were discharged with a GOS of ≤ 4 points, 2 of whom recovered to a GOS of 5 points. After coil embolization surgery, 131 of 140 patients were discharged with a GOS of 5 points and 8 with ≤ 4 GOS points, 2 of whom recovered to a GOS of 5 points (Table 2).

There were 3 recurrences at the unruptured cerebral aneurysm clipping and coil embolization sites: 2 cases after clipping and one after coil embolization. MCA clipping was performed in both recurrences after clipping; additional coiling was performed in the area where recurrence occurred after coil embolization. In coil embolization, recurrence occurred in the remaining neck area of the unruptured cerebral aneurysm in the basilar artery bifurcation; even in secondary embolization, not all saccular aneurysms were blocked, and outpatient progress was observed.

There were 5 cases in which clipping was performed on unruptured cerebral aneurysms that remained after the onset of subarachnoid hemorrhage. Of the 5 cases, 3 MCA, 1 anterior communicating artery (AcomA), and 1 anterior choroidal artery were treated. The 13 cases in which coil embolization was performed were more diversely located than those in clipping: 4 posterior communicating artery, 2 AcomA, 2 superior cerebellar artery, 1 MCA, 1 internal carotid artery, 1 posterior inferior cerebellar artery, 1 paracalinaid artery, and 1 distributed at the anterior cerebral artery 2/3 junction.

### Discussion

For the elderly, the treatment of unruptured cerebral aneurysms has been controversial. Many studies have been published regarding the management of unruptured cerebral aneurysms [3,10–12]. Neurosurgeons choose more active treatments if patients with ruptured aneurysms are in good condition [13]. Moreover, conservative treatment should be considered for elderly patients in poor condition [14,15], because the elderly, unlike young people, are more likely to develop poor health, malnutrition, and complications before and after surgery [16]. In the treatment of unruptured cerebral aneurysms, surgical treatment occurs less often because of poor prognosis [8], and coil embolization treatment is more widely used because of the rapid development of intravascular treatment technology (Fig. 1).

Intravascular treatment is preferred in elderly patients with weak immunity and physically poor conditions who are less able to withstand invasive and somewhat aggressive procedures [17]. According to a recent meta-analysis, intravascular treatment performed in elderly people, especially patients with subarachnoid hemorrhage, is effective but results in high mortality and sequelae [18]. However, some consider surgical treatment to be safer and more effective due to the recent development of intraoperative monitoring systems and postoperative intensive care [5,6]. In our study, although clipping resulted in 3 times more complications than coil embolization, there was no significant difference in the final GOS identified at the time of discharge after surgery. Therefore, both clipping and coil embolization are safe and effective treatments for unruptured cerebral aneurysms in patients aged 65 years or older, and positive results can be derived through clipping (Fig. 2, Table 2).

In addition, for both clipping and coil embolization procedures, cerebral aneurysms recurred in the same locations. Based on our data, the recurrence of cerebral aneurysms occurred more than 4 times more often with coil embolization than with clipping. Therefore, although coil embolization is considered relatively safe, clipping is more effective in terms of preventing recurrence.

Age plays an important role in patients with unruptured cerebral aneurysms [19]. In older patients, the risk of developing an aneurysm is high [20], and the probability of rupturing a cerebral aneurysm is also higher [3,4]. Neurosurgeons determine the treatment

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**Table 2. Complications after treatment with clipping and coil embolization**

<table>
<thead>
<tr>
<th>Complication</th>
<th>Clip</th>
<th>Coil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without complication</td>
<td>53</td>
<td>131</td>
</tr>
<tr>
<td>Complication</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Postoperative acute hemorrhage</td>
<td>7 (9.9)</td>
<td>2 (1.4)</td>
</tr>
<tr>
<td>ICH, SAH, IVH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic SDH</td>
<td>2 (2.8)</td>
<td></td>
</tr>
<tr>
<td>Infarction</td>
<td>6 (8.5)</td>
<td>2 (1.4)</td>
</tr>
<tr>
<td>Puncture site infection</td>
<td>1 (0.7)</td>
<td></td>
</tr>
</tbody>
</table>

Values are presented as number (%). ICH, intracerebral hemorrhage; SAH, subarachnoid hemorrhage; IVH, intraventricular hemorrhage; SDH, subdural hemorrhage. 3 recovered, 1 recovered.
of unruptured cerebral aneurysms according to the patient’s age. For example, patients aged < 50 years are less likely to develop post-surgical complications, such as cerebral hemorrhage \cite{21,22}. On the other hand, surgical clipping has a high mortality rate and poor prognosis in patients aged 65 years or older \cite{16}. However, according to our results, this does not apply to all elderly patients, who can have a good prognosis after a craniotomy, reducing the perception that surgical treatment should be excluded because of an advanced age.

This study had several limitations. Data were collected retro-

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Fig. 1. Changes in the use of clip and coil embolization treatment for cases of unruptured cerebral aneurysm.

Fig. 2. A multiple-comparison graph showing patients treated by coil embolization. Those with pre-operative Glasgow outcome scores (GOS) of 4 or 5 showed no change in postoperative GOS (estimated marginal mean [emmean], 4.6), but some patients treated by coil embolization with a pre-operative GOS lower than 4 still had a low postoperative GOS (emmean, 3.7). However, patients treated by clipping with a pre-operative GOS of 4 or 5 had no change in the GOS (emmean, 4.6), and those with a pre-operative GOS lower than 4 had increases in their postoperative GOS (emmean, 4.7).

TRT: preOP.GOS, treatment: preoperation GOS.
Elderly patients with cerebral aneurysms

respectively, and patients were not treated in a randomized manner. Therefore, a potential selection bias may have affected the outcome of patients treated with the 2 different treatments. In addition, the size of the cohorts, especially of patients treated with surgical clipping, was small. Therefore, a large, prospective randomized study should be conducted to offer a more acute perspective on the surgical decisions for older patients with cerebral aneurysms.

**Conclusion**

This study provides evidence of a more stable and effective treatment for elderly patients with unruptured cerebral aneurysms. Based on our study, coil embolization and clipping were both safe and effective for elderly patients with cerebral aneurysms, and treatment should be carefully determined for patients with unruptured cerebral aneurysms. Aggressive clipping treatment for unruptured cerebral aneurysms should be considered, with a good prognosis.

**Conflicts of interest**

No potential conflict of interest relevant to this article was reported.

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