Follow-up Study of Intracranial Aneurysms with Special Reference to Long-term Social Rehabilitation

Hiroshi ISE, Akira YAMAURA, Katumi ISOBÉ, Nobuo OKA and Hiroyasu MAKINO

Department of Neurological Surgery, Chiba University
School of Medicine, Chiba

Abstract

192 patients with aneurysms of anterior circulation were evaluated with respect to social rehabilitation. All underwent definitive surgery and were followed for more than 6 months. 168 patients (87.5%) returned to full or partial employment. Factors such as age, preoperative level of consciousness, preoperative Hunt and Hess' grading, requirement of shunts, the presence or absence of an intraventricular hematoma, and evidence of ventricular dilatation on computerized tomograms were the most important in predicting social recovery. The prophylaxis and treatment of epilepsy following subarachnoid hemorrhage are also discussed.

Key words: cerebral aneurysm, postoperative epilepsy, computerized tomography, electroencephalography, psychometry, anticonvulsant therapy

Introduction

Many factors are relevant to the outcome of both surgery and conservative therapy of aneurysms. In the surgical management of aneurysms, such complications as preoperative rupture, cerebral vasospasm, normal pressure hydrocephalus, and psychological disturbances, remain problematic. Long-term follow-up studies are required to evaluate the results of various surgical procedures and to select the best treatment. In this study, we focused our attention on the patient's clinical condition, the computerized tomographic (CT) scan, electroencephalogram (EEG), and psychometric data in relation to social rehabilitation.

Materials and Methods

457 patients with cerebral aneurysms were treated in the Departments of Neurological Surgery of Chiba University and of two affiliated hospitals from June, 1968 through May, 1981. 366 patients (80.1%) underwent direct intracranial surgery; the remaining 91 patients were treated conservatively, either because of their poor neurological status or because they died before surgery could be performed.

We evaluated 192 patients (244 aneurysms) who underwent direct operation and survived for more than 6 months. They include 82 males and 110 females. Their ages ranged from 12 to 74 years (51.1 ± 12.0 years). Of the 192 patients, 150 had single aneurysm and the other 42 had multiple aneurysms. Figure 1 shows the locations of the aneurysms. Single aneurysms in the posterior circulation were excluded from our analysis. The follow-up period ranged from 6 to 160 months with the mean of 32.9 months. All the patients underwent direct operation for aneurysms of the internal carotid artery system.

The patients were divided into five groups according to Hunt and Hess.11) Grade 5 patients did not undergo surgery. The Glasgow Coma Scale (GCS) was also applied to evaluate the level of consciousness, and the total scores were used in the analysis. CT scans and EEGs were obtained at regular intervals. In analyzing the CT scans, we paid particular attention to evidence of subarachnoid hemorrhage, intraventricular hematoma, intracerebral hematoma, low-density areas, and ventricular dilatation. In assessing the EEGs, we especially looked for diffuse

Received September 13, 1984; Accepted April 5, 1985
and focal slow waves and paroxysmal discharges — particularly spikes, sharp waves, and high-voltage slow bursts. The intelligence quotient (IQ) of the Wechsler Adult Intelligence Scale (WAIS), as well as the subtest scores, were used to evaluate mental function in a small number of cases. Follow-up data were gathered from outpatient charts. The degree of recovery was designated as follows: good recovery (GR): no deficit, or minimal deficits that did not hinder the patient’s return to premorbid employment; moderately disabled (MD): mild deficits, able to care for self, partially able to work; severely disabled (SD): nursing care required; vegetative state (V): unable to move or communicate; and dead (D). Clinical factors and neurophysiological and neuroradiological findings were also studied in relation to social recovery.

Results

I. Degree of recovery (Table 1)

145 patients (75.5%) were judged to have made a good recovery. Twenty-three patients (12.0%) were moderately disabled, five because of systemic (extracranial) complications. Twelve patients (6.3%) were severely disabled, two because of systemic (extracranial) diseases. Three patients (1.6%) were in a vegetative state resulting from pre- or intraoperative rupture of the aneurysm. Nine patients (4.7%) died during the follow-up period (more than 6 months after surgery). Four of these deaths were attributed to malignant neoplasms.

II. Surgical treatment and outcome

201 aneurysms (82.4%) were clipped. Coating with a piece of muscle or with biobond was added to clipping with 21 aneurysms (8.6%). Coating alone was applied to 10 aneurysms (4.1%). The other two aneurysms were treated by trapping or proximal arterial ligation plus coating. Ten aneurysms were not managed surgically, either because of their location or size or because of the poor neurological status of the patient.

Only 14 patients underwent direct operation within 48 hours of the last hemorrhage. 158 patients underwent surgery more than 1 week after the last hemorrhage (Table 2A). There was no correlation between timing of the operation and outcome. Nine patients required ventricular drainage prior to surgery, and 33 (17.2%) required shunt procedures after direct operation. Of the 157 non-shunted patients, 143 (91.1%) achieved full or partial social recovery. Similar recovery was attained by 23 (69.7%) of the 33 shunted patients. The difference in degree of recovery between shunted and non-shunted patients was statistically significant ($\chi^2 = 11.3006, p < 0.005$). The time intervals from direct operation to shunt procedure are shown in Table 2B. Thirty-three patients underwent shunt operations within 1 year following

<table>
<thead>
<tr>
<th>Grade</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GR</td>
</tr>
<tr>
<td>1</td>
<td>52</td>
</tr>
<tr>
<td>2</td>
<td>49</td>
</tr>
<tr>
<td>3</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>145</td>
</tr>
</tbody>
</table>

GR: good recovery, MD: moderately disabled, SD: severely disabled, V: vegetative state, D: dead.

*Two cases are excluded because of insufficient data.
direct surgery (81.8% within 2 months).

III. Age and sex and outcome

The five outcome categories are depicted according to age decade in Fig. 2. Serious neurological deficits were not seen in younger patients. The prognosis is significantly better for patients less than 40 years old than for those more than 41 years old ($\chi^2=5.8590$, $p<0.025$).

There was no significant correlation between sex and outcome.

IV. Location and number of aneurysms and outcome

Table 3 shows the location of the operated aneurysms in relation to recovery. There was no significant correlation, but patients with aneurysms on the middle cerebral artery tended to recover poorly. Of the 150 patients with a single aneurysm, 118 (78.7%) achieved a good recovery. Twenty-seven (64.3%) of the 42 patients with multiple aneurysms recovered satisfactorily. The difference was not significant.

V. Preoperative clinical condition and outcome

Table 1 shows the relationship between preoperative grading and outcome. Over 81% of the patients (101 of 124) preoperatively classified as grade 1 or 2 (neither disturbance of consciousness nor major neurological deficits) were able to return to their pre-illness activities. Only 17 of the grade 1 and 2 patients (13.7%) were moderately or severely disabled. The remaining six patients died —four of cancer, one of a hypertensive intracerebral hemorrhage, and one of hemorrhage from a thalamic arteriovenous malformation. In contrast, 24 of the 68 patients (35.3%) with preoperative disturbance of consciousness or neurological deficits (grades 3 and 4) were handicapped or died postoperatively. Thus, grade 1 and 2 patients had significantly better recovery than grade 3 and 4 patients ($\chi^2=6.6615$, $p<0.01$).

Table 3 Location of the treated aneurysm and outcome

<table>
<thead>
<tr>
<th>Location</th>
<th>Outcome</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GR</td>
<td>MD</td>
</tr>
<tr>
<td>ICA</td>
<td>54</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>62(89%)</td>
<td></td>
</tr>
<tr>
<td>ACA</td>
<td>62</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>72(90%)</td>
<td></td>
</tr>
<tr>
<td>MCA</td>
<td>54</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>64(81%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>170</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>198(86%)</td>
<td></td>
</tr>
</tbody>
</table>

More precise data concerning preoperative consciousness were obtained through analysis of the GCS scores obtained immediately prior to surgery (Table 4). According to GCS scores, 121 patients were alert (15 point), 81.8% of whom had a good recovery. GCS ratings were distributed from 5 to 14 points in 68 patients, 43 (63.2%) of whom had a good recovery. The difference was statistically significant ($X^2=8.0463$, $p<0.005$). Of patients with high GCS scores (14 or 15), nine died. Six of these patients were grade 1 or 2 on the preoperative clinical rating. The other three died of diabetic dehydration, general deterioration following an epileptic seizure, and an accident.

Preoperative motor weakness was noted in 54 patients, 29 of whom fully recovered. Twenty-four of these 29 patients (82.8%) improved within 6 months of direct surgery. Among the remaining 25 patients who suffered motor weakness in the preoperative period, 14 underwent CT scanning, and intracerebral hematoma was demonstrated in five. Three of the 29 patients who recovered from preoperative motor weakness had intracerebral hematomas. Of 12 patients with preoperative aphasia, five recovered during the postoperative period. Two of these patients had intracerebral hematomas.

### VI. Seizures

Thirteen patients (6.8%) had seizures preoperatively. Postoperative prophylactic anticonvulsants were given to them (phenobarbital 100 mg/day, diphenylhydantoin sodium 300 mg/day, or sodium valproate 600-1,200 mg/day, or a combination), and only two had postoperative seizures. Including these two, a total of 18 patients (9.4%) had postoperative seizures. The time interval from operation to occurrence of seizures was analyzed. Sixteen patients (88.9%) had an initial seizure within 1 year, and all 18 patients within 2 years, and all but one were successfully controlled with anticonvulsant therapy. One patient had an initial seizure 3 months after a decompressive craniectomy for marked brain swelling, and intractable epilepsy continued for 4 years. However, after cranioplasty to correct a depressed skin flap, the seizures stopped. Preoperative CT scans showed intracerebral hematomas in 12 patients, but none of them had preoperative seizures. Three of these 12 patients, however, had seizures during the postoperative period. On the other hand, CT scans were obtained in 13 of the 18 patients with postoperative seizures, and 12 showed an intracerebral area of low density. Among 77 patients whose postoperative CT scans showed areas of low density, 12 had seizures. There was only one epileptic patient among the 68 patients who did not have a low-density area ($X^2=8.8133$, $p<0.005$).

Sixty-eight patients (35.4%) discontinued their prophylactic anticonvulsants during the postoperative period because of normalization of their EEG patterns (66 patients), liver dysfunction, or side effects, such as cutaneous eruptions (2 patients). The time intervals between operation and withdrawal of medication are shown in Table 5. The mean interval was 25.8 months (0-90 months). These patients were followed for an average of 10.8 months (maximum, 108 months) after withdrawal, and during this period seizures recurred in only two patients. One had taken anticonvulsants irregularly and the other had discontinued because of liver dysfunction. Seizures were again controlled when the medications were taken regularly. In contrast, 16 of the 18 patients with postoperative epilepsy had taken the medications as prescribed.

### Table 4

<table>
<thead>
<tr>
<th>GCS score</th>
<th>Outcome</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GR</td>
<td>MD</td>
</tr>
<tr>
<td>15</td>
<td>99</td>
<td>9</td>
</tr>
<tr>
<td>14</td>
<td>29</td>
<td>5</td>
</tr>
<tr>
<td>13</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
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</tr>
<tr>
<td>8</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>142</td>
<td>23</td>
</tr>
</tbody>
</table>

GCS: Glasgow Coma Scale. *Three cases are excluded because of insufficient data.

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**Table 5**

<table>
<thead>
<tr>
<th>After operation</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediately</td>
<td>2</td>
</tr>
<tr>
<td>Within 1 year</td>
<td>24</td>
</tr>
<tr>
<td>Within 2 years</td>
<td>12</td>
</tr>
<tr>
<td>Within 3 years</td>
<td>13</td>
</tr>
<tr>
<td>Within 4 years</td>
<td>3</td>
</tr>
<tr>
<td>Within 5 years</td>
<td>7</td>
</tr>
<tr>
<td>Within 6 years</td>
<td>6</td>
</tr>
<tr>
<td>Within 8 years</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
</tr>
</tbody>
</table>
VII. Other factors and outcome

Eighty-four CT scans were taken preoperatively, and 59 scans, all taken within 1 week from the last subarachnoid hemorrhage, were analyzed in this study. Five factors were evaluated. The correlation between each factor and the postoperative outcome is shown in Fig. 3. The patients who had an intraventricular hematoma and ventricular dilatation had a poor outcome. EEGs were obtained preoperatively on 15 patients. Six patients' EEGs were normal. Paroxysmal discharges were seen in two patients and slow waves in seven patients. The correlation between epileptic seizures and paroxysmal discharges or focal slow waves in the postoperative EEGs is shown in Table 6. Focal slow waves were significantly related to epilepsy ($\chi^2 = 4.4946$, $p < 0.05$).

The WAIS was applied postoperatively on a total of 53 occasions to 42 patients. There was no difference between verbal and performance IQs. There was no difference in IQ between patients with right side and left side craniotomies (Fig. 4). Patients with right craniotomy had slightly higher scores on the comprehension and similarities subtests, whereas those with left craniotomy did better in the digit span and object assembly subtests. However, no significant differences were found. Figure 5 shows the relationship between the WAIS scores and location of the aneurysm. The IQs did not differ between patients with anterior communicating artery aneurysms and patients with other aneurysms. However, patients with anterior communicating artery aneurysms scored significantly lower in the similarities ($t = 2.0795$, $p < 0.05$) and picture arrangement ($t = 2.0330$, $p < 0.05$) subtests. Eight patients were examined repeatedly (two to four times). Improvements of IQ continued for 2 years after operation (Fig. 6).

Discussion

Many reports have been published about the various problems resulting from surgical treatment of aneurysms. The timing of and indications for surgical treatment are still controversial, and they are important issues to resolve, especially in cases where cerebral vasospasms occur. We followed 192 patients who underwent direct intracranial operation for cerebral aneurysms. Of these, 145 returned to their previous jobs, and 23 to less strenuous employment. Thus, 87.5% of the patients achieved an acceptable recovery. The literature reports a 60-90% recovery rate. According to the literature, shunt procedures were performed in 1.4-21.2% of aneurysm patients after radical surgery. Sakamoto et al. reported a social recovery rate of only 55.8% for shunted patients. In our study, 33 patients (17.2%) required a shunt procedure, and 69.7% returned to their jobs. However, the social recovery rate was poor in the shunted group. All of these shunts were performed within 1 year of the direct operation for cerebral aneurysm. We believe that we must watch for hydrocephalus in aneurysm patients for at least 1 year after surgery.

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Many reports state that the preoperative neurological status influenced the outcome. Kobayashi et al. found, in 278 patients, a significant correlation between Hunt and Hess' grading and residual symptoms beyond 6 months after opera-
The percentage of social recovery was 87.1% for grade 1 and 2 patients, 62.3% for grade 3 patients, and only 27.7% for grade 4 patients. Hori et al. reported on 346 cases of anterior communicating artery aneurysms. According to them, 82.9% of 245 patients with Hunt's grade 0 to 2 returned to their jobs, whereas 52.5% of 101 patients with grade 3 or 4 returned to their jobs. In our experience, there was a significant difference between grade 1 and 2, collectively, and grade 3 or higher. Our findings suggest that patients with no neurological deficit and no disturbance of consciousness before surgery have a high expectation of returning to work postoperatively.

The GCS has rarely been applied to evaluate the preoperative level of consciousness in aneurysm patients. In terms of recovery, we noticed a significant difference between preoperative GCS scores of 15 and scores of less than 15.

Motor weakness and aphasia were important factors in predicting social recovery, and we followed the course of preoperative paresis and aphasia. Postoperatively, motor weakness and aphasia subsided, respectively, in 53.7% and 41.7% of patients. Neither symptom had any obvious correlation with the presence of intracerebral hematoma detected by CT scan. Improvement can be expected for one year postoperatively; only a few patients continue to improve beyond that point.

Another important problem is the prophylaxis and treatment of epilepsy. According to the literature, the incidence of epilepsy was nearly 10% (4.5-22%) following subarachnoid hemorrhage treated by surgery or conservative therapy. Richardson et al. reported an epilepsy rate of 10.5% in patients who survived for more than 1 year. In their series, the initial seizure occurred within 6 months in 18 patients, within 12 months in 20 patients, and within 18 months in 10 patients. The initial seizure occurred within 18 months in 90.6% of patients who developed epilepsy. In our series, 29 patients (15.1%) developed epilepsy pre- or postoperatively. Of the 18 patients who had seizures postoperatively, 16 had the first seizure within 1 year of surgery and the other two within 2 years. The difference in time of onset was possibly due to a

Fig. 4 Side of craniotomy and Wechsler Adult Intelligence Scale (WAIS). Patients with right side craniotomy (circle; 23 patients) had slightly higher scores on comprehension and similarities, and patients with left side craniotomy (triangle; 23 patients) scored higher on digit span and object assembly. No significant differences were found. F-IQ: full-scale intelligence quotient, V-IQ: verbal IQ, P-IQ: performance IQ.
difference in the length of the follow-up period or in the method of using anticonvulsants.

High risk factors for epilepsy have been reported and include such conditions as middle cerebral artery aneurysm, intracerebral hematoma, relatively young age, cortical damage during surgery, and postoperative residual brain damage. On the contrary, Cabral et al. reported that vasospasm, unconsciousness during hemorrhage, and presence of hematoma are not correlated with the development of epilepsy. In our patients, a low-density lesion seen on the postoperative CT scan, probably due to vasospasm or inappropriate surgery, was highly correlated with seizure activity. We observed a rare case of intracranial seizures lasting for 4 years following decompressive craniectomy, and the cause seemed to be an unfavorable effect on the cortex created by the atmospheric pressure.

It is controversial whether or not prophylactic anticonvulsant therapy is necessary after surgery for aneurysm, and when the anticonvulsant therapy should be discontinued. North et al., in a double-blind study, examined the effects of phenytoin in 203 cases of intracranial surgery. They concluded that

Fig. 5 Location of aneurysm and WAIS. Anterior communicating artery aneurysms (circle; 28 patients) were associated with significantly lower scores on the similarities and picture arrangement subtests. triangle: other aneurysms (22 patients).

Fig. 6 Repeat WAIS examination. Improvement in IQ was noted for 2 years after direct operation. circle: performance IQ, triangle: verbal IQ.
phenytoin reduced the incidence of postoperative epilepsy when a therapeutic level of the drug was maintained. Richardson et al.\textsuperscript{28} recommended 6 to 12 months of drug prophylaxis for patients with internal carotid artery and anterior cerebral artery aneurysms, and 2 to 3 years for patients with middle cerebral artery aneurysm and intracerebral hematoma. Fabinyi et al.\textsuperscript{8} asserted that there seems to be little justification in preventing a patient from driving for a year after aneurysm surgery if his course has been free of complications and the anticonvulsant cover is adequate. Asato et al.\textsuperscript{3} stated that not all patients should be given anticonvulsants after craniotomy and that the indication should be considered individually for each patient. Our policy concerning anticonvulsant therapy after subarachnoid hemorrhage is as follows: (1) Patients with preoperative or postoperative seizures should take anticonvulsants for at least 2 years after their last seizure. (2) All patients should take anticonvulsants following direct surgery, as long as side effects or liver dysfunction do not appear. (3) The timing of withdrawal of anticonvulsants is determined by the disappearance of paroxysmal discharges on the EEG. Seizures did not recur in patients in whom anticonvulsant therapy was discontinued according to the above criteria. However, final conclusions can be drawn only after longer follow-up has been accomplished.

Yamada\textsuperscript{36} stated that improvement of epilepsy parallels, to some extent, normalization of the EEG. But he added that EEG findings alone are not adequate for deciding when to discontinue anticonvulsant therapy. Normalization of the EEG preceded or coincided with improvement in seizure activity in 34\% of his patients, and in 66\% the EEG normalized after the seizures decreased. Spikes or sharp waves were not predictive of epilepsy, according to Cabral and Scott.\textsuperscript{3} Spikes and focal fast waves were infrequent in postoperative epilepsy in the experience of Asato et al.\textsuperscript{3} and therefore patients should be closely observed even after the EEG has normalized. Juul-Jensen\textsuperscript{12} reported that slow wave foci and bilateral paroxysms were strongly associated with the recurrence of epilepsy. In our patients there was no correlation between paroxysmal discharges and epilepsy; however, focal slow waves were associated with epilepsy, as was reported by Juul-Jensen.\textsuperscript{11}

Studies concerning the correlation between the preoperative CT findings and the outcome are rather few. Kobayashi et al.\textsuperscript{14} studied 85 CT scans and found that in patients classified as grade 3 and 4 (Hunt and Hess), intracerebral hematoma, low-density areas, and ventricular dilatation were common; the symptoms caused by these lesions persisted for a long time postoperatively. Our patients whose CT scans showed intraventricular hematoma and ventricular dilatation also had a poor recovery rate.

It is well known that certain psychological disorders often appear after operation for aneurysm. The commonest symptoms include disorientation, memory disturbance, and Korsakoff's syndrome. Saito et al.\textsuperscript{29} reported several symptoms that disrupt patients' daily functioning after surgery for anterior communicating artery aneurysm. The patients themselves complained of memory deficit (35\%), disturbance in thinking (21\%), disorientation (7\%), and motor weakness (8\%). Their families complained of emotional changes, such as irritability (26\%) and euphoric state (10\%). Saito et al.\textsuperscript{29} found Korsakoff's syndrome in only 6 to 10\% of the patients. Other investigators\textsuperscript{18,19,23} have found the incidence of psychological disorders in aneurysm patients to be 47 to 60\% preoperatively and 53 to 67\% postoperatively. According to Matsukado et al.,\textsuperscript{20} psychological problems are common in patients with anterior communicating artery aneurysms. Maeda et al.\textsuperscript{19} found that the likelihood of psychological disturbance was significantly affected by the number of ruptures (single or double), whether the patient was conscious or unconscious during the rupture, and whether or not the interval of unconsciousness exceeded 24 hours.

In most cases, Korsakoff's syndrome and disorientation disappear within 6 months. However, memory disturbances and personality changes tend to persist for more than a year and may prevent patients from returning to their jobs.\textsuperscript{18-20} Ropper et al.\textsuperscript{27} reported a 31\% mortality rate and morbidity in good-risk patients. They stated that in the majority of patients, impaired capacity for work was not caused by physical deficits, but rather by psychological or emotional disturbances.

Logue et al.\textsuperscript{17} administered the WAIS to 65 patients with anterior cerebral aneurysms. There was no significant correlation between the IQ and subtest scores and the side on which the aneurysm occurred, but as a group these patients scored lower in object assembly, similarities, and picture arrangement. Kodama et al.\textsuperscript{16} stated that the performance IQ improved later than the verbal IQ. In verbal IQ, information recovered early, and comprehension, numerical reasoning capacity, and logical thinking capacity improved later. They emphasized the necessity for follow-up of more than 2 years postoperatively in order to predict the extent of social recovery using IQ. In our patients, IQs continued to improve for 2 years after operation.
References


Address reprint requests to: H. Ise, M.D., Department of Neurological Surgery, Chiba University School of Medicine, 1-8-1 Inohana, Chiba 280, Japan.