CT-guided stereotactic fibrinolysis of spontaneous and hypertensive cerebellar hemorrhage: long-term results

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The surgical indication for spontaneous cerebellar hemorrhage is not as controversial as the operative management of intracranial hemorrhage. Timing of the operation is crucial: intervening too early can produce an additional strain on the patient and an increased risk, while waiting too long to evacuate the hematoma can be fatal. This dilemma may be a factor in the relatively high mortality and morbidity rates following both operative and conservative treatment that have been reported in the literature (42.5% and 30%, respectively).

In long-term studies on 14 patients, the authors have shown that stereotactic puncture and fibrinolysis for cerebellar hemorrhage is a valuable alternative to treatments used currently. The method consists of computerized tomography (CT)-guided stereotactic puncture and partial evacuation of the hematoma. After fibrinolysis with urokinase, the residual hematoma can be completely evacuated via a catheter introduced into the cavity of the hematoma. Only one of the 14 patients died in the direct postoperative phase; the remaining patients were enjoying a good to very good quality of life 6 months after the acute event. Two patients subsequently died as a result of pneumonia and cerebral infarction, respectively; both conditions were unrelated to the hemorrhage. The authors conclude that the CT-guided stereotactic method is simple, effective, and safe, and can be applied to patients of any age.

KEY WORDS • cerebellar hemorrhage • fibrinolysis • urokinase • stereotaxis • timing of surgery

The incidence of cerebellar hemorrhage varies considerably in the literature; a range of between 0.3% and 0.7% among individuals coming to autopsy has been reported in several large series. Bleeding in the cerebellum accounts for 10% of all intracranial hemorrhages. In 60% to 80% of cases the hemorrhages are caused by hypertension, the remaining 20% to 40% are the result of various diseases including vascular deformities, tumors, trauma, and (in many cases) anticoagulation therapy. The hemorrhages usually occur unilaterally and only rarely extend to the contralateral side. The source of bleeding is often assumed to be in the nucleus dentatus cerebelli. Invasion of the ventricular system is observed in 70% to 80% of cases. Tamponade of the fourth ventricle interferes with normal circulation, absorption, and drainage of cerebrospinal fluid (CSF) resulting in hydrocephalus, which can worsen the prognosis.

Unlike intracerebral hemorrhage, there is little controversy over the surgical indication for cerebellar hemorrhage, even though the mortality and morbidity rates reported in the computerized tomography (CT) era are relatively high (Table 1). Since 1985, stereotactic puncture with fibrinolysis of hematomas has been performed at our institution. Initially applied to intracerebral hem-

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Operative Therapy</th>
<th>Conservative Therapy</th>
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<tbody>
<tr>
<td></td>
<td>No. of Cases</td>
<td>No. of Deaths</td>
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<tr>
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<td>Taneda, et al., 1987</td>
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<td>Gerritsen van der Hoop, et al., 1988</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>totals</td>
<td>94</td>
<td>40 (42.5%)</td>
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*All six series report cases treated since computerized tomography became available.
FIG. 1. Case 4. Computerized tomography scans revealing recent hemorrhage in the right cerebellar hemisphere, displacement of the fourth ventricle and aqueduct, and compression of basal cisterns, particularly the ambient cistern.

**TABLE 2**

Summary of data for 14 patients with cerebellar hemorrhage*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Preop</th>
<th>Postop</th>
<th>Karnofsky Scale (0 to 100)</th>
<th>Volume Removed (ml)</th>
<th>Time to Op† (hrs)</th>
<th>Follow-Up Period (mos)</th>
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<td>5</td>
<td>58, F</td>
<td>8</td>
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<td>6</td>
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mean values 60.9 ± 14.4 9.3 ± 1.3 13.6 ± 1.0 87.7 ± 11.6 31.3 ± 9.0 44.7 ± 30 19.2 ± 11.5

* One patient (Case 1) died 17 months later of apoplectic infarction, a second (Case 5) died of pulmonary embolism one month after hemorrhage, and a third (Case 6) died of bronchitis and pneumonia 6 months after the acute event. GCS = Glasgow Coma Scale score either before or 48 hours after surgery. — = data not available. Means are expressed ± standard deviation.
† Time lapsed between acute event and surgery.
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Fig. 2. Case 4. Computerized tomography scans taken 4 days after stereotactic evacuation and fibrinolysis in the same patient as described in Fig. 1.

orrhages, the method has proved highly suitable for evacuating cerebellar hematomas, as the results of the following studies demonstrate.

Clinical Material and Methods

Patient Population

From 1985 to 1989, a total of 14 patients suffering from cerebellar hemorrhage were treated by stereotactic puncture and fibrinolysis at our institution (Table 2). There were nine women and five men, with a mean age of 60.9 years. In all cases, patient history revealed long-term hypertension.

Surgical Technique

The procedure consisted of stereotactic puncture as described by Mundinger and coworkers, and partial evacuation of the hematoma. After fibrinolysis with urokinase had been performed, the residual hematoma was completely evacuated through a silicone catheter introduced into the cavity of the hemorrhage. Because surgery required the patients to be placed in a prone position, which interferes with breathing, general anesthesia was usually induced. Special hematoma evacuators were not used in order to protect the healthy cerebellar tissue. After partial evacuation of the liquid part of the hemorrhage, which constituted less than 25% to 30% of the lesion volume, a silicone catheter with a 2-mm outer diameter was inserted through the incision into the hematoma cavity. Complications such as the clot breaking into the fourth ventricle and the presence of a so-called "ventricular tamponade" disturb the CSF circulation and result in occlusive hydrocephalus. To avoid these complications, the catheter tip should lie in the fourth ventricle as confirmed by CT scan. The residual blood was then dissolved with two or three applications of 5000 U of urokinase in 5 ml of saline solution and fibrinolysed at 6- to 8-hour intervals. Ten to 30 ml of additional blood with traces of CSF could be evacuated. At the end of the procedure, the hematoma was almost completely evacuated (Figs. 1 and 2). The catheter was then removed. During the 2 days of fibrinolysis treatment, a broad spectrum of antibiotics was administered to prevent infection. On the 2nd day after surgery, the patients were fully alert and could be mobilized.

Results

Neurological Condition

The average level of consciousness as judged by the Glasgow Coma Scale (GCS) immediately before the
operation was a score of 9.3 ± 1.3 (mean ± standard deviation). This indicated that the patients were in a deep sleep, that they reacted to painful stimuli, but that they were not alert nor were they able to give coherent answers to questions. Forty-eight hours postoperatively, the patients' level of consciousness had improved by two to three GCS points and continued to improve until scores of 12 to 15 had been reached (Table 2). Eight of the 14 patients were completely alert at that time, four patients were slightly drowsy, and two were very drowsy. The patients were only slightly disoriented and could be awakened by noise at any time. They were able to locate stimuli and gave coherent answers upon direct questioning (Fig. 3).

Operative Findings

In 11 of the 14 patients, the hemorrhage had invaded the ventricular system. These patients had an incomplete tamponade of the fourth ventricle and secondary supratentorial hydrocephalus. Surgery was performed from 10 to 96 hours after the acute event (average 44.7 ± 30 hours) (Table 2). The hemorrhage was located in the left hemisphere in five of these patients, and in the right hemisphere in six.

In all patients, substantial defects were observed as a result of bleeding in the cerebellum or in the vicinity of the nucleus dentatus cerebelli. No patient with hydrocephalus required a shunt procedure. In the 11 patients with invasion of the ventricular system, the ventricular hematomas were evacuated at regular intervals.

Postoperative Course

The follow-up period in 13 of the 14 patients averaged 19.2 ± 11.5 months (range 6 to 38 months). One patient (Case 5, Table 2) died 4 weeks after the hemorrhage due to an acute pulmonary embolism. Another patient (Case 6) died 6 months after cerebellar bleeding as a result of bronchitis and secondary pneumonia which were unrelated to the hemorrhage. This patient had been recovering satisfactorily and the primary symptoms had rapidly regressed. A third patient (Case 1) died of an ischemic infarction 17 months after the operation. Alterations of the cerebral vessels as a result of long-term hypertonia had been observed in this patient.

All surviving patients remain in good to very good condition, scoring an average of 86 ± 10.4 on the Karnofsky scale. They are self-sufficient and fully integrated in their familial environment; those who have not retired due to age have returned to work and resumed normal activities. Residual symptoms could be detected in only one patient (Case 9), who suffered temporary dizziness and ataxic gait disturbances.

Discussion

Indications for Surgical Treatment

The course and prognosis of intracerebellar hemorrhage, regardless of treatment, is poor. In the pre-CT era, the average rate of mortality was 60% to 80%,6,7,11,14 which is the same as for intracranial hemorrhage. If disturbances of consciousness and clinical signs of brain-stem compression occur, a mortality rate of 100% can be expected unless surgical evacuation is instituted.4 The indications for evacuation of these hematomas are less controversial and include the development of clinical symptoms, the CT findings, and other evidence of the spread of bleeding.2-4,7,23

The mortality rate of patients in preoperative coma is as high as 70% to 75%, even when surgical evacuation is performed. By contrast, in patients who are conscious preoperatively the mortality rate is only 17% to 25%. Thus, the timing of surgery for evacuation of the hematoma is absolutely crucial.11,20 The growth of the lesion in the posterior fossa blocks the flow of CSF, thereby causing hydrocephalus, which in turn worsens the prognosis. The greatest danger exists, however, when an increase of direct pressure in the posterior cranial fossa leads to compression of the brain stem and midbrain. When increasing disturbances of consciousness and eye motility, double vision, and pyramidal signs occur, the outcome is usually very poor, if not fatal. The patient eventually becomes comatose and shows signs of respiratory depression and early stages of herniation and compression.

Ott, et al.,24 observed that approximately 50% of their primarily conscious patients showed rapid clinical deterioration 2 days after and 25% of patients 7 days after the appearance of symptoms. Therefore, efforts should be made to relieve the compression as soon as possible. Failure to operate immediately after signs of cerebral compression and disturbed consciousness appear may further increase the relatively high rate of mortality and morbidity. On the other hand, surgery undertaken too early poses a high risk which can complicate the favorable course of a cerebellar hemorrhage.
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In a study of 75 patients with cerebellar hemorrhage, Taneda, et al., were able to establish a direct relationship between the prognosis and course of the disease and the changes in the basal cisterns, particularly the quadrigeminal cistern. No patient with a compressed and displaced quadrigeminal cistern or a compressed superior vermiform cistern survived. In their relatively large series, deaths were reported in eight (22.2%) of the 36 surgically treated patients and 10 (25.6%) of the 39 conservatively treated patients. These results are consistent with our findings. Alterations of the basal cisterns (particularly the ambient and superior vermiform cisterns), in conjunction with the corresponding clinical symptoms, therefore constitute an indication for surgical evacuation. The CT-guided stereotactic method of treating cerebellar hemorrhage (described above) and subsequent fibrinolysis of the residual hematoma have produced promising results, as shown by this long-term study.

Fibrinolysis in a Rat Model

A neurotoxic effect of urokinase was ruled out in animal experiments. Eighty-four Wistar rats (each weighing between 200 and 300 gm) were injected with 250 U urokinase into the striatum, thalamus, or fourth ventricle. A control group was administered an equal amount of physiological saline. The animals were sacrificed and histological examination was performed at 15 minutes, 30 minutes, 60 minutes, 24 hours, or 7 days after injection.

Light microscopy revealed evidence of tissue lesions in the puncture track. In the rats sacrificed within 1 day after injection of urokinase, perifocal edema, isolated hemorrhaging, and ganglial cell destruction were observed (Fig. 4 left). Such alterations were considerably reduced in the rats sacrificed after 7 days, at which time signs of resorption with monocytes, adipoid cells, and reactive proliferation of vessels and astroglia were found (Fig. 4 right). Cell lesions or destruction of the tissue of the brain parenchyma, ventricular ependyma, or subarachnoid space caused by a toxic effect of urokinase could not be proved. Nor was there any evidence of the fibrinolytic agent causing increased bleeding or additional permeability disturbances. These findings are consistent with those obtained by Julow, who found no neurotoxic effect of urokinase on the subarachnoid space.

Since patients regain full consciousness soon after the CT-guided stereotactic procedure, the duration of intensive care treatment and hence the overall stay in the hospital can be shortened. Oral feeding and physical therapy can be initiated very soon after surgery.

There was only one death during the 4-week postoperative observation period, which was the result of a massive pulmonary embolism. Two patients died of causes not related to the hemorrhage 6 and 18 months after the acute event. The remaining 11 patients are in good general condition and are leading a normal life.

The short operating time, the relatively low risk involved, and the lack of danger to healthy brain support the use of CT-guided fibrinolysis for treatment of cerebellar hemorrhage. In our opinion, this method is an effective alternative to the therapies used to date.

References


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