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Clinical outcome following surgical treatment for bilateral cerebellar infarction

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Objectives – To analyze the initial clinical and radiological findings, the surgical treatment, and the clinical outcome following surgical decompression in patients with space-occupying bilateral cerebellar infarction. *Materials and Methods* – Ten patients with expansive bilateral cerebellar infarction and decreased level of consciousness were operated with suboccipital craniectomy, removal of the infarcted tissue, and placement of external ventricular drainage. Long-term outcome was assessed using the modified Rankin scale (mRS). *Results* – Mean Glasgow coma scale (GCS) score before surgery was 8.9 ± 3.3 and improved to 12.6 ± 3.6 at discharge. At the long-term follow-up (median 57.6 months), six patients had a favorable outcome (mRS 1.3 ± 0.8). Four patients, all with an associated brain stem infarct, had a poor outcome. *Conclusions* – In the absence of brain stem infarcts, surgical treatment resulted in a favorable clinical outcome and should be considered a treatment option for patients with expansive bilateral cerebellar infarction.

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Introduction

Ischemic strokes in the posterior fossa are most commonly caused by atherosclerotic cerebrovascular disease or an embolic event. They usually present with non-specific symptoms such as dizziness, nausea, vomiting, and headache and are detected using modern neuroradiology (1–6). The optimal management of cerebellar stroke remains controversial. However, in patients with unilateral cerebellar infarcts, reduced level of consciousness and radiological evidence of tight posterior fossa, brain stem compression and/or development of hydrocephalus, urgent surgical decompression may be life saving (7–14).

Space-occupying bilateral cerebellar infarctions are relatively rare although they are caused by similar mechanisms (15–17). Predominately observational reports frequently describe conservatively managed cases or, with few exceptions, represent case reports or series without comparing the clinical and radiological characteristics with the effects of the applied treatment strategy (2, 4, 15, 17–21).

Because these lesions are infrequently encountered in most centers, it may be difficult to establish a standardized treatment regimen. However, it is desirable to obtain clinical outcome data to better define the role of surgical decompression and neurointensive care in the management of patients with expansive bilateral cerebellar infarction, altered level of consciousness and radiological evidence of posterior fossa compression.

In this study, the clinical and radiological characteristics as well as the short- and long-term outcomes of 10 patients with expansive bilateral cerebellar infarction treated with decompressive craniectomy and external ventricular drainage are presented and analyzed.

Patients and methods

Patients

From December 1999 to December 2007, we identified and included all patients with clinically significant bilateral cerebellar infarction who were

surgically managed in the Department of Neurosurgery, Uppsala University Hospital, Uppsala, Sweden. On admission, the patients' baseline characteristics including their past medical history were obtained, and a detailed clinical and neurological examination was performed. The neurological status of each patient was frequently assessed by applying the Glasgow coma scale (GCS) and the reaction level scale (RLS) scores (22, 23). All results were presented using either median or mean ± standard deviation.

Radiology

All patients underwent several brain computed tomography (CT) scans during their stay in our unit. The responsible vessel/s, the CT score (*vide infra*), other brain pathology, and the possible underlying cause of the infarction were also recorded. In six patients, magnetic resonance imaging (MRI), magnetic resonance angiography (MRA) and/or digital subtraction angiography (DSA) was also performed.

The vessel responsible for the infarction was identified according to the analysis by Tatu et al. (24). Based on the criteria proposed by Jauss et al. (9) where the compression of the 4th ventricle and the quadrigeminal cistern as well the dilatation of the inferior horn of the lateral ventricle was graded each from 0 to 3, a CT score of 0–9 was calculated. All CT scans were scored by an investigator (PT) who had no previous knowledge of the clinical status of each patient.

Clinical and surgical management

The patients were operated either in the acute phase (< 24 h) or later (> 24 h) in the course of the disease, depending on the progression and evolution of the clinical and radiological features. The indication to operate was primarily a depressed and/or deteriorating level of consciousness in combination with radiological criteria such as the degree of 4th ventricle compression and less the presence of hydrocephalus. In all patients, an external ventricular drainage (EVD) was placed in the right frontal horn. Immediately following the EVD insertion, all patients were operated in the prone position using a midline incision from just rostral to the external occipital protuberance down to approximately the spinous process of the C5 vertebra. Following release of the muscular attachments over the posterior fossa, a wide bilateral suboccipital craniectomy from just below the transverse sinus down to the foramen magnum was performed. A Y-shaped, wide opening of the dura followed. Next, removal of the clearly infarcted and necrotic tissue bilaterally was performed until the mass effect and swelling were sufficiently reduced. In selected patients, the arch of the C1 vertebra was also removed to allow additional decompression and dural opening. A duroplasty was performed and the wound was closed in several layers using interrupted sutures. In all patients, post-operative CT scans were performed (see Figs 1 and 2).

All patients who required mechanical ventilation post-operatively were treated in our Neurointensive Care Unit (NICU) using an intracranial pressure (ICP) – guided protocol. This strategy included normoventilation, head elevation (30°), and careful volume expansion to obtain normovolemia (25). A combination of intermittent intravenous (i.v.) morphine analgesia (1–3 mg Morfin Meda®; Meda, Sollentuna, Sweden) and continuous i.v. propofol infusion (1–4 mg/kg/h Propofol-®Lipuro; B.Braun Melsungen AG, Melsungen, Germany) was used for sedation. The treatment goals were to keep ICP at ≤20 mmHg and cerebral perfusion pressure at ≥60 mmHg. Cerebrospinal fluid (CSF) drainage, typically against a pressure of 20 mmHg, was cautiously applied when the radiological situation excluded a post-operative hematoma and indicated a low risk of upward cerebellar herniation.

Outcome

Outcome was assessed at discharge and in the long-term follow-up. The GCS and the RLS scores were used at discharge, whereas the modified Rankin scale (mRS) was used for the long-term outcome (26). A detailed and standardized questionnaire based on Wilson et al. (27) was sent to the patient's homes for estimating the outcome according to the mRS score. When there was no response to the questionnaire or when additional information was needed, the patients themselves or their relatives were contacted by phone. An mRS of ≥3 was evaluated as a poor outcome. Based on the questionnaire and the telephone interview, the outcome at 6 months post-surgery was also assessed. In all patients, the clinical condition did not change markedly from 6 months until the final follow-up, and outcome data was thus presented as the long-term mRS.

Results

Patients

The mean age of the 10 included patients (eight men, two women) was 54.9 ± 13 years. Headache, dizziness, and vertigo were among the predominant

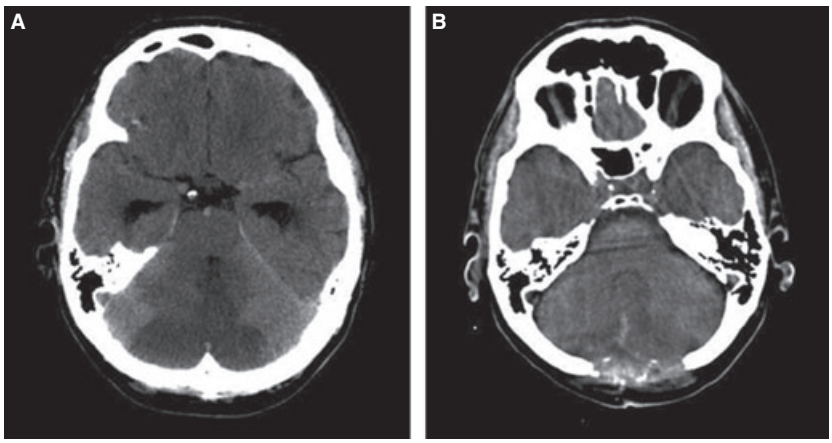

Figure 1. A–B: Patient 9. A 65-year-old man with a history of atrial fibrillation presented to the emergency room with dizziness and vertigo [Glasgow coma scale (GCS) 14]. Computed tomography (CT) scan showed bilateral cerebellar infarction without compression of the fourth ventricle or hydrocephalus. He deteriorated rapidly, became unconscious and was intubated (GCS and reaction level scale scores of 5). A repeat CT scan showed worsening of the expansive effects. A decompressive posterior fossa craniectomy with removal of the C1 arch, evacuation of the infarct, and insertion of an external ventricular drainage was performed. Following surgery and neurointensive care treatment, he improved remarkably, and at the final follow-up (44 months), his Rankin scale was 1. (A) Preoperative CT scan of the brain. Expansive bilateral infarction in the area of the middle branches of the posterior inferior cerebellar artery with presence of hydrocephalus and Grade II compression of the 4th ventricle. (B) Post-operative CT scan of the brain after decompressive craniectomy and removal of the infarcted tissue showing reduction of hydrocephalus and less posterior fossa compression.

initial symptoms, while dysarthria and limb paresis were present in three and two patients, respectively. Co-existing diseases and conditions such as arterial hypertension, atrial fibrillation, diabetes mellitus, myocarditis, and hypercholesterolemia were recognized as predisposing factors in six patients. The mean initial GCS score (at the first evaluation) was 12.3 ± 3.1, and the mean RLS score was 2.7 ± 1.6, respectively. The median time from ictus to clinical deterioration and surgery was 34 h (range 8–72 h). Five patients were operated within the first 24 h. At the time for surgery, the mean GCS score was 8.9 ± 3.3, and the mean RLS score was 3.9 ± 1.4, respectively. The median length of stay was 14 days (range 3–51 days; Table 1).

Radiology

A single posterior fossa artery was identified as the responsible vessel for the formation of the infarct in five patients [the posterior inferior cerebellar artery (PICA) in four patients and the superior cerebellar artery (SCA) in one patient; Figs 1 and 2]. In five patients, the infarction was attributed to the occlusion of two arteries (Table 1). The mean CT score prior to surgery was 5.2 ± 2.2, and preoperative hydrocephalus was evident in seven patients. Six patients underwent MRI, MRA, and DSA. In six cases, the cerebellar infarction was combined with other brain pathology with brain stem infarct being the most common (4/6). The etiology of the bilateral infarction was not determined in four patients. However, following DSA basilar artery stenosis ($n = 2$), vertebral artery dissection ($n = 2$) or arterial thrombosis ($n = 2$) were suggested as a cause for the infarction.

Clinical and surgical management

The EVD remained in place for 6.8 ± 4.3 days. In five patients, removal of CSF was needed for 2.4 ± 1.7 days because of persistent intracranial hypertension and/or persisting hydrocephalus. In one patient, a ventriculoperitoneal shunt was inserted 1 month following surgery. Clearly infarcted (necrotic) tissue was evacuated bilaterally in all patients. The arch of the first cervical vertebra (atlas) was removed in four patients. Seven patients required mechanical ventilation, while the median length of stay on mechanical ventilation was 6 days (range 1–13 days). All patients stayed in the neurointensive care unit until they were weaned from the ventilator and were in a stable medical condition (Table 2). No patient had a post-operative hematoma or CSF leak requiring re-operation.

Outcome

One patient died during his stay in our clinic. At discharge, one additional patient was in a deeply comatose state and died shortly after being released to another intensive care unit. The mean GCS and RLS scores for all patients at discharge

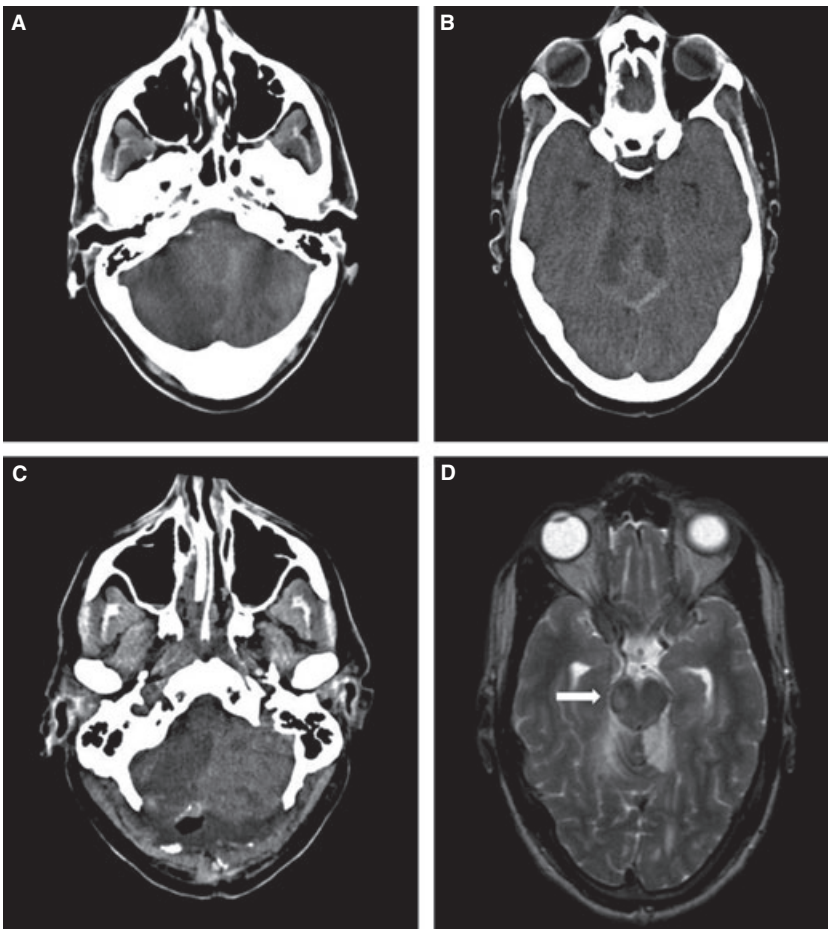

Figure 2. A–D: Patient 6. A previously healthy 36-year-old man suffered from sudden headache and vomiting. The morning thereafter he was found unconscious and upon arrival in the emergency room, he presented with a Glasgow coma scale score of 5. Brain CT scan showed a space-occupying bilateral cerebellar infarction with marked mass effect. The infarct was surgically decompressed immediately following the arrival in our unit. A post-operative magnetic resonance imaging (MRI) showed dissection of the right vertebral artery at the level of C1 and also a brain stem infarct. Following neurointensive care, the patient was extubated, and at discharge he was RLS:2, obeying verbal commands but was unable to speak. At the last long-term follow-up, the patient was mRS:4 with marked ataxia as the predominant problem. (A) Preoperative CT scan of the brain. Bilateral cerebellar infarction in the area of the middle and lateral branch of the posterior inferior cerebellar artery (PICA) on the right side and in the middle branch of PICA on the left side. Complete obliteration of the 4th ventricle with Grade III compression. (B) Preoperative brain CT scan on the same patient. Bilateral cerebellar infarction in the area of the middle branches of the superior cerebellar artery. (C) Post-operative brain CT scan showing decreased compression of the posterior fossa contents. (D) Post-operative T2-weighted brain MRI scan demonstrating a brain stem infarct (arrow). RLS, reaction level scale; mRS, modified Rankin scale.

were 12.6 ± 3.6 and 2.4 ± 2.1, respectively. Both patients who died shortly after surgery were diagnosed with a brain stem infarct. The median follow-up period was 57.6 months (range 15–118 months). At the long-term follow-up, the mean mRS was 2.8 ± 2.1 (Table 2). Only two of the eight surviving patients had an unfavorable outcome, both of which had a brain stem infarct. Among the survivors with good outcome ($n = 6$), the mean mRS was 1.3 ± 0.8 (Table 2).

Discussion

The results of the present case series indicate that urgent decompressive craniectomy with removal of the infarcted tissue accompanied by placement of an external ventricular drainage is life saving in selected patients with expansive bilateral cerebellar infarctions and decreased level of consciousness. Although emergent surgical posterior fossa decompression may be considered a high cost treatment with frequent complications, the majority of our patients recovered uneventfully from the surgical and neurointensive care treatment and reached a good or excellent long-term outcome. However, patients with accompanied brain stem infarcts either died shortly after surgery or had an unfavorable outcome at the long-term follow-up.

Bilateral cerebellar infarctions are considered rare lesions (19, 28). However, owing to the

Table 1 General characteristics of patients with surgically treated bilateral cerebellar infarcts

Case No.	Age/sex	Clinical findings and signs	Predisposing factors	GCS score (initial)	RLS score (initial)	GCS score (at surgery)	RLS score (at surgery)	Time from onset to surgery (h)*	CT score	Responsible vessel
1	47/M	Loss of consciousness, left VIth nerve palsy, right hemiparesis	None	13	2	8	4	24	2 + 2 + 2	PICA + SCA
2	53/F	Headache, vertigo, vomiting, coma, slow pupil reaction	Diabetes mellitus, cardiac failure	8	5	7	5	48	2 + 2 + 3	AICA + SCA
3	55/M	Headache, nausea, ataxia, dysarthria, nystagmus	None	14	2	13	3	12	2 + 2 + 3	AICA + PICA
4	55/M	Dizziness, vertigo, ataxia	Previous myocarditis	14	2	12	3	N/A	1 + 0 + 1	SCA
5	61/F	Dizziness, vertigo, nausea, facial palsy, nystagmus, dysarthria	Angiopathy, arterial hypertension, hypercholesterolemia	13	3	10	3	72	1 + 1 + 0	PICA
6	36/M	Headache, vomiting, loss consciousness, coma	None	5	6	5	6	8	2 + 3 + 3	AICA + SCA
7	36/M	Nausea, dizziness, vertigo, vomiting, nystagmus, double vision, neck stiffness	None	14	2	13	3	48	1 + 2 + 0	PICA
8	72/M	Headache, dizziness, vertigo, gait disturbances, dysarthria, right hemiparesis	Arterial hypertension	14	1	5	6	48	3 + 2 + 2	PICA
9	65/M	Dizziness, vertigo, small non-reactive pupils	Atrial fibrillation	14	2	5	5	24	2 + 1 + 3	PICA
10	69/M	Headache, dizziness, vertigo, vomiting, double vision, dysarthria	Atrial Fibrillation, Dermatomyositis	14	2	11	3	24	1 + 1 + 2	PICA + AICA

CT, Computed Tomography; AICA, anterior inferior cerebellar artery; d, days; F, female; GCS, Glasgow Coma Scale score; h, hours; M, male; PICA, posterior inferior cerebellar artery; RLS, Reaction Level Scale score; SCA, superior cerebellar artery; N/A, data not available.

*Approximate time from ictus to deterioration and surgery.

Table 2 Surgical, post-operative clinical characteristics and long-term outcome

Case No.	EVD (days)	EVD (days of drainage)	Removal of C1 arch	Days of MV	Complications	Brain stem infarct	GCS score (discharge)	Follow-up period (m)	mRS score (long-term)
1	14	3	Yes	13	None	No	14	118	0
2	3	0	No	3	Death	Yes	Death*	–	6
3	2	0	No	0	None	No	15	71	1
4	8	5	No	0	PE	No	13	69	2
5	4	1	No	6	None	Yes	3	–	6†
6	14	2	Yes	10	None	Yes	13	59	4
7	5	0	No	0	None	No	13	47	2
8	6	0	No	3	MN	Yes	13	38	4
9	8	1	Yes	5	PLE	No	14	44	1
10	4	0	Yes	1	None	No	14	15	2

C1, Atlas; EVD, external ventricular drainage; GCS, Glasgow Coma Scale score; m, months; MN, meningitis; mRS, modified Rankin score; MV, mechanical ventilation; PE, pulmonary embolism; PLE, pleural effusion; RLS, Reaction Level Scale score.

*Died during the stay in our unit.

†Died 2 days after the transfer to another hospital.

introduction of modern neuroimaging, mainly by means of diffusion-weighted imaging MRI, bilateral cerebellar infarctions are now detected more frequently (4, 5). Their pathogenesis appears to be similar to unilateral infarction, being caused by atherothrombosis or an embolic event (15, 29). In our series, six patients had at least one predisposing factor for the formation of the infarct, whereas the etiology remained unknown in four patients. Similarly to unilateral ischemic lesions, bilateral posterior fossa infarcts are most frequently attributed to PICA obstruction (4, 15, 16). Infarcts in the area supplied by the SCA follow in frequency, whereas bilateral anterior inferior cerebellar artery ischemic stroke is very rare (17, 30). Depending upon the affected cerebellar and brain stem region, the clinical signs and symptoms vary. Interestingly, most documented cases of bilateral cerebellar

infarctions in the literature included non-expansive lesions without significant neurological compromise that followed conservative treatment.

After the first reports over 50 years ago, numerous publications have suggested that early decompressive surgery using suboccipital craniectomy is beneficial in patients with decreased level of consciousness and expansive unilateral cerebellar infarctions (7–10, 13, 14, 31, 32). Nevertheless, the choice of surgical treatment remains controversial, and various surgical techniques have been applied (9, 11, 33, 34). Because of their rarity, much less information exists about the surgical management of space-occupying bilateral cerebellar infarctions (7, 12, 14). Recently, no difference in the outcomes between patients with unilateral and bilateral cerebellar infarctions operated with suboccipital craniectomy was observed, suggesting that the presence of a bilateral lesion should not be considered a contraindication for surgical decompression (14). Our unit provides neurosurgical coverage from a large region in Sweden where the majority of patients are referred from other primary hospitals. Therefore, we cannot exclude a referral bias in the number of patients admitted for neurosurgical evaluation and treatment. However, the number of patients in need for surgery never reaching our attention was likely low because of the well-established routine of neurosurgical consultation for expansive posterior fossa conditions taking place in our area.

Application of EVD as the sole treatment has been also advocated in patients with massive cerebellar infarctions with developing or already established hydrocephalus (10, 33). The supporters of this approach assume that the presence of hydrocephalus is closely associated with the high mortality in these patients (33). However, the use of EVD provides inadequate relief of the brain stem compression, carries a risk of upward cerebellar herniation and prolonged CSF drainage has been associated with an increased risk of infection (8, 35). Moreover, the expansive effect of the infarct is unlikely to be resolved in several days without decompression and surgical removal of the infarcted tissue (7, 8). In our series, we inserted an external ventricular catheter in all patients. However, CSF drainage was considered necessary in only half of the cases despite preoperative radiological evidence for hydrocephalus, indicating that decompressive surgery *per se* resulted in an improved CSF flow and reduced ICP. Nevertheless, we suggest that EVD should be inserted in all patients because preoperative findings are unlikely to specify which patient will benefit from ICP monitoring and/or CSF drainage.

The decision to perform surgery was individualized because of the scarcity of space-occupying bilateral cerebellar infarctions. Owing to the rather low number of patients in our series, a standardized protocol for surgical treatment cannot be established. However, our results regarding the management of space-occupying bilateral cerebellar infarctions are in agreement with the available reports and guidelines for the management of space-occupying unilateral cerebellar infarctions. In the present series, an acute deterioration of the patient's clinical status and/or an initially depressed level of consciousness was the strongest indication for surgical treatment. We also considered the overall CT score and specifically the compression of the 4th ventricle and the presence of hydrocephalus. Radiological evidence of brain stem infarction did not influence the clinical decision to perform surgery, although it negatively influenced outcome. Noticeably, one case without evidence of hydrocephalus or marked 4th ventricle compression developed a brain stem infarct and died. The present results also indicate that a preoperative MRI, when practically feasible, may provide important prognostic information and help guide clinical management.

In the present series, we aggressively performed surgery immediately following clinical deterioration even in patients without a marked depression of the level of consciousness. In our series, early surgery within 24 h from onset was associated with favorable outcome in all but one patient presenting at the time of surgery with a high CT score. However, because of the limited number of patients, we cannot conclude that rapid surgery is always associated with an improved outcome.

Conclusions

Given the rarity of bilateral cerebellar infarctions, their optimal medical and surgical management is controversial. A detailed radiological and clinical evaluation in addition to best medical treatment in the neurointensive care or stroke unit when needed is strongly suggested. We suggest that an early and aggressive surgical intervention could be beneficial and lifesaving in patients, particularly when there is no established brain stem infarction.

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