Effectiveness of Decompressive Suboccipital Craniectomy for Cerebellar Infarction

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Abstract

Objective: The adaptation of surgical treatments for cerebellar infarction that have occupied lesions remains subject to discussion. We investigated effectiveness of Decompressive Suboccipital Craniectomy (DSC) for cerebellar infarction and poor prognostic factors affecting surgical results.

Materials and Methods: From October 2006 to June 2017, 14 consecutive patients (12 males, 2 females; age, 42–84 years; mean age ± standard deviation, 65 ± 12 years) admitted to our hospital and underwent DSC under at an admission or clinical course in hospitalization following inclusion criteria: 1) level of consciousness below Glasgow Coma Scale (GCS) 13 or 2) brainstem compression and/or obstructive hydrocephalus due to brain edema by cerebellar infarction. Ventricular drainage was performed simultaneously or later by surgeons' decision.

Results: After 90 days, 12 of the 14 patients survived (85.7%), 10 (71.4%) were independent (modified Rankin scale [mRS] ≤ 2) and four (28.6%) were completely dependent or dead. Comparison between good and poor prognosis demonstrated that the factors affecting prognosis were lesions other than cerebellar infarction (p<0.01) and obstructive hydrocephalus (p<0.05).

Conclusion: Early DSC for cerebellar infarction may be advisable for cerebellar infarction in patients with GCS 13 or worse before advancement of hydrocephalus. Poor prognosis is inevitable in patients causing otherinfarcts other than cerebellum and patients who have already accompanied obstructive hydrocephalus at the time of surgery.

Keywords: Cerebellar infarction; Decompressive suboccipital Craniectomy; Ventricular drainage; Outcome

Introduction

Cerebellar infarction and associated brain edema due to brainstem compression or obstructive hydrocephalus causes consciousness disturbance. The mortality rate when Decompressive Suboccipital Craniectomy (DSC) is not performed is reported to be 84%. There are reports that DSC is effective, but patient selection and the timing of operation remain unknown. We studied 14 patients who underwent DSC for cerebellar infarction and reviewed the literature on indication, timing of surgical intervention and good prognostic factors [1-3].

Materials and Methods

We studied 14 consecutive patients who underwent DSC for cerebellar infarction between October 2006 and June 2017 (10 years, 9 months) at our institution. Emergent surgery was indicated if any of the following were observed at an admission or after hospitalization.

1) Level of consciousness below Glasgow Coma Scale (GCS) 13

2) Brainstem compression and/or obstructive hydrocephalus due to brain edema by cerebellar infarction

For patients the above indications, we evaluated their general condition to ascertain whether there was any obstacle to general anesthesia and the prone position for approximately four hours. Then, after acquiring informed consent from patient's family, we elected to perform emergency surgery. A skin incision was added to the median longitudinal incision from 2 cm to 3 cm above the inion to the fifth cervical vertebra process level, and an approximately 8 cm inverted T-shaped transverse incision was made on the parieto occipital region. Suboccipital Craniectomy was
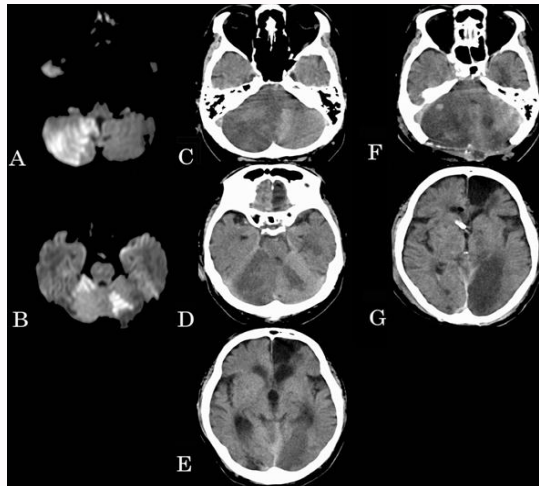
Figure 1: (A, B) Magnetic resonance imaging at admission showed a fresh infarction in the right posterior inferior cerebellar artery and bilateral superior cerebellar artery region. **(C-E)** Computed Tomography (CT) taken 20 hrs after onset of cerebellar infarction shows compression of the brainstem and acute obstructive hydrocephalus, as well as cerebral infarction in the occipital lobe. **(F,G)** Emergency decompressive suboccipital craniectomy and ventricular drainage were performed. Although the decompression effect is observed adequately on CT, the cerebral infarction of the left occipital lobe is clearer.
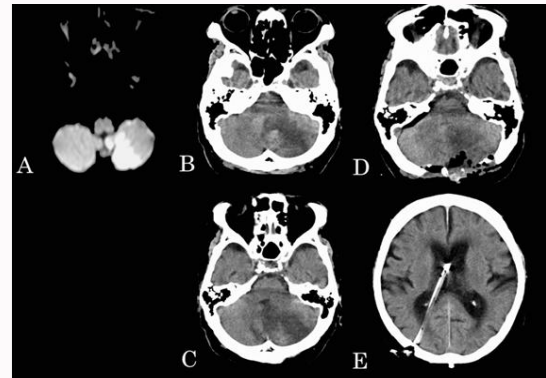

Figure 2: (A) Magnetic resonance imaging at admission shows fresh infarcts in the left posterior inferior cerebellar artery area. **(B,C)** Hemorrhagic cerebellar infarction was confirmed on computed tomography on day five after onset. The brainstem is compressed and a part of the fourth ventricle is obscured. **(D,E)** Emergency decompressive suboccipital craniectomy and ventricular drainage were performed. Decompression effect is observed adequately on the computed tomography.

performed as far as possible, and laminectomy of the first cervical vertebra was done as an option based on preoperative images. An inverted Y-shaped incision was made in the dura mater and internal decompression, such as removal of infracted brain and hemorrhagic infarction, was performed. In addition to external decompression, artificial dura mater made of GORE-TEX membrane was used for duraplasty. Ventricular Drainage (VD) was performed in cases when hydrocephalus was observed before surgery or when it was expected to occur even after DSC by Intraoperative findings and the surgeon judged it necessary.

We retrospectively evaluated patient age, sex, time from onset until surgery, infarction at other sites, and pathology of cerebellar infarction, hemorrhagic infarction, and complication of hydrocephalus and infarction volume by the patient's record. Statistically significant differences between these factors and prognosis were examined. The volume of the infracted lesion was measured on the MRI diffusion-weighted image using AZE virtual place Fujin Raijin 360 (AZE, Tokyo, Japan).Prognosis was evaluated 90 days after onset and expressed according to the modified Rankin Scale (mRS).

Results

Table 1 shows the details of 14 patients (age range, 42 years to 84 years; mean ± standard deviation [SD], 65 ± 12; 12 males). Cerebellar infarction was caused by cardiogenic cerebral embolism in eight patients, atherothrombotic cerebral infarction in six and unknown cause in one. Hemorrhagic infarction was found in nine patients. The Posterior Inferior Cerebellar Artery (PICA), Superior Cerebellar Artery (SCA) and Anterior Inferior Cerebellar Artery (AICA) were involved in twelve, five and one patients, respectively. Seven patients had multiple artery involvement among these three dominant arteries perfusing the cerebellum. Among these, three patients had infarction in the Posterior Cerebral Artery (PCA) and Middle Cerebral Artery (MCA) territories (two and one, respectively). Brainstem compression findings and/or hydrocephalus was observed on CT or

MRI in all cases before DSC as a result.

The time required from onset to surgery was 16:00 - 157:10 hours: minutes (mean ± SD, 60:30 ± 44:21). The volume of the infracted lesion immediately before DSC was 33.4 to 104.7 ml^3 (mean ± SD, 64.3 ± 19.2 ml^3). There were no complications due to the surgical procedure. Prognostic mRS after 90 days was mRS ≤ 2 in 10 patients (71.4%) who did not require total assistance and mRS ≥ 3in four patients (28.6%) who had required total assistance or died. Severe cerebral infarction of the occipital lobe was the cause of poor prognosis in two patients (Cases 7 and 12). In addition, two patients died, one with severe heart failure (Case 5) and one with brainstem hemorrhage (Case 8). Comparing the good and poor prognosis groups, there was no significant difference in age, sex, time from onset to operation, pathology of cerebellar infarction, hemorrhagic infarction and myocardial infarction. Significant differences were found between patients with infarction in other areas than cerebellum and obstructive hydrocephalus combined (Table 2). Representative examples of poor good prognoses are presented below.

Representative Case Presentations

Case 7: Poor prognosis case

A 67-year-old man presented with dysarthria. Fresh infarction was observed in the right PICA and SCA, and left SCA region son MRI at admission (Figure 1A and 1B). Consciousness at arrival to the hospital was assessed as GCS14. Dysarthria was recognised and National Institutes of Health Stroke Scale (NIHSS) score was 3 points. The patient became somnolent on the day after onset, and parenthesis appeared in the right upper limb. Therefore, immediate head CT was performed, which confirmed compression of the brainstem by cerebellar infarction, new cerebral infarction in the left PCA region, acute obstructive hydrocephalus, in addition to known old infarction in the left frontal lobe (Figure 1C–1E). Preoperatively, consciousness was rated as GCS12. Because the therapeutic indication criteria were met, we performed emergency DSC and VD after obtaining informed consent (Figure 1F and 1G). After surgery, the patient's conscious state improved to GCS13. However, cerebral infarction extended to the left thalamus postoperatively due to the left PCA involvement and presented severe cognitive impairment. He required full assistance of activity of daily living and was transferred to a long-term care

Table 1: List of 14 patients undergoing DSC for cerebellar infarction.

Case	Age (y.o.)	Sex	Onset to Operation Time (hr:min)	Territory of Infarction	Aetiology	Hemorrhagic Infarction	Hydrocephalus or Brainstem Compression	Past History	mRS on 90 Days	Infarction Volume (ml³)
1	66	F	16:00	Lt. PICA	ATBI	N	H + B	HT, DM	2	58.4
2	65	M	21:57	Lt. PICA, Lt. AICA	A to A	N	H + B	HT, MI, CI	1	53.4
3	42	M	62:22:00	Bil. PICA, Bil. SCA	ATBI	N	H + B	HU	1	87.1
4	44	M	53:00:00	Lt.PICA, Lt. SCA	Af	N	H + B	Af, HT	0	40.6
5	76	M	39:27:00	Rt. PICA	Af	Y	B	CPE, Af, HF	6	87.8
6	78	F	56:10:00	Bil. PICA	Af	Y	H + B	HT, DM	2	69
7	62	M	20:00	Rt. PICA, Rt. SCA, Lt. PCA	Af	N	H + B	CI, Af, MI,HT	5	104.7
8	72	M	40:10:00	Lt. SCA, Rt. MCA	Af	Y	B	HT, DM	6	64
9	67	M	157:10:00	Lt. PICA, Bil. SCA	ATBI	Y	H	HT	1	54.9
10	84	M	148:10:00	Lt. PICA	Af	Y	H + B	Af	2	62.8
11	59	M	38:50:00	Rt. PICA	Af	Y	H + B	Af, HT	2	52.5
12	67	M	61:28:00	Lt. SCA, Rt. PCA	Af	Y	H + B	Af, DM, MI	4	33.4
13	64	M	31:47:00	Bil. PICA	ATBI	N	H + B	CI, HT	1	74
14	68	M	97:20:00	Rt. PICA	Af	Y	H + B	Af	2	57

M: Male; F: Female; Lt: Left; Rt: Right; Bil: Bilateral; PICA,: Posterior Cerebellar Artery; AICA: Anterior Inferior Cerebellar Artery; SCA: Superior Cerebellar Artery; ATBI: Atherothrombotic Brain Infarction; Af: Atrial Fibrillation; N: No; Y: Yes; H: Hydrocephalus; B: Brainstem Compression; HT: Hypertension; DM: Diabetes Mellitus; MI: Myocardial Infarction; CI: Cerebral Infarction; HU: Hyperuricemia; CPE: Chronic Pulmonary Emphysema; HT: Hypertension; mRS: Modified Rankin Scale.

hospital; mRS was 5 at discharge from our hospital.

Case 10: Good prognosis case

An 84-year-old man with chronic sustained a trial fibrillation presented to our hospital with nausea and occipital pain. Consciousness at arrival to the hospital was rated as GCS15. Mild dysarthria was recognised and NIHSS score was 1 point. MRI showed fresh infarction in the left PICA area at admission (Figure 2A). Hemorrhagic cerebellar infarction was confirmed on head CT five days after onset (Figure 2B and 2C). Consciousness score decreased to JCS 10 and GCS 13 on day seven after onset. DSC and VD were performed, and consciousness recovered to GCS 15 postoperatively (Figure 2D and 2E). Postoperative course was good, VD was removed a week later, and he was discharged from our hospital with mRS2.

Discussion

Discussion continues regarding the adaptation of surgical operations to cases of cerebellar infarction accompanied by cerebellar edema and consciousness disorder. The frequency of cerebellar infarction with cerebellar edema and symptoms is reported to be 17% to 54% [4]. In addition to cytotoxic edema caused by the cerebral infarction itself, the mechanism of this condition includes vasogenic edema due to natural recanalization of occluded vessels, as well as hemorrhagic changes, direct compression of the brainstem and upward herniation of the superior vermis cerebelli through the tentorial notch, downward herniation of the cerebellar tonsils through the foramen magnum and obstructive hydrocephalus, resulting in disturbance of consciousness [4-6]. However, surgical treatment for such patients remains controversial.

In the American Heart Association/American Stroke Association (AHA/ASA) guideline, surgical treatment for cerebellar infarction is described as follows: class I, Level of Evidence B, 'Suboccipital craniectomy with dural expansion should be performed in patients with cerebellar infarctions who deteriorate neurologically despite

Table 2: Comparison between patients with good and poor prognosis for each factor.

	mRS ≤ 2	mRS ≥ 3	P Value
Case (n)	10	4	
y.o.	63.7 ± 13.1	69.3 ± 6.1	NS**
Male (n)	8 (80%)	4 (100%)	NS**
Onset to operation time (hr:min)	68:27 ± 50	40:38 ± 16:57	NS**
Lesions other than cerebellar infarction (n)	0	3	<0.01*
Cardiogenic embolism (n)	5	4	NS*
Hemorrhagic infarction (n)	5	3	NS*
Hydrocephalus (n)	10	2	<0.05*
History of MI (n)	1	2	NS*
Infarction volume (ml³)	61.0 ± 13.0	72.5 ± 31.0	NS**

MI: Myocardial Infarction; mRS: Modified Rankin Scale; NS: Not Significant
*χ² test. **Student's *t*-test

maximal medical therapy'. On the other hand, according to Guidelines for Stroke Treatment in Japan 2015, there is sufficient evidence to perform DSC in cases of cerebral infarction of the unilateral cerebral hemisphere caused by MCA occlusion(Grade A) [3]. However, there is insufficient evidence to support surgical treatment for cerebellar infarction (GradeC1), although many reports have found that decompression surgery is effective for cerebellar infarction [7]. Feely et al. [1] reported on 55 patients with cerebellar infarction who became comatose. The mortality rate was 84% when DSC was not performed, but it was 28% when surgery was performed, and DSC was reported to be effective [1-3]. Ogasawara et al. [3] reported on 10 patients with cerebellar infarction whose consciousness was deteriorated. As a result of DSC, seven of the 10 patients had a good recovery. Tsitsopoulos et al. [2] examined 32 patients who underwent DSC, and 17(53.1%) had a good prognosis.

The preoperative state of consciousness is reported important as

a factor related to poor prognosis, and DSC improves prognosis in half of comatose patients or in patients without brainstem infarction. Regarding age, the density study, which examined broad cerebral infarction in the MCA region, shows surgical effectiveness in patients younger than 70 years [2,3,8,9]. However, in patients with cerebellar infarction, Tsitsopoulos et al. [10] reported that age did not affect prognosis even if patients were older than 70 years. Regarding the state of consciousness when deciding on surgery, Ogasawara et al. [3] reported that a case of deterioration to somnolence surely will become coma afterwards, and recommended DSC when a level of consciousness falls down to somnolence. Therefore, in cases of progressive consciousness disorder, it may be desirable to perform surgical intervention more quickly. More recently, Recently, Kim et al. [11] conducted a retrospective-matched case-control study on efficacy of DSC for patients with cerebellar infarction. As a result, better clinical outcome was obtained in patients with 1) initial GCS score >= 9, 2) without clinical deterioration within 72 hr from the onset, and 3) infarction volume ratio between 0.25 and 0.33 by their radiological criteria, and 4) no brainstem infarction. However, as they mentioned, SDC only by volume ratio without deterioration of consciousness has the risk of refusal of the patient or their family. Furthermore, the volume ratio is calculated by manual drawing using brain CT, as they also mentioned as their limitation, in contrast with our study.

Comparable results as previous reports were obtained in ten patients out of 14 (71.4%) in our series [1-3]. Factors of the poor prognosis include combined infarction in other areas than cerebellum and obstructive hydrocephalus. Regarding the former, more than half of the causes of cortical infarction are accompanied by persistent a trial fibrillation. Surgical indication should be withheld in case poor prognosis is anticipated. Co morbidities such as heart failure may also define prognosis for the postoperative course as in our case. Brainstem involvement is another issue that should be discussed. In our report, the prognosis was poor in a patient with brainstem bleeding due to hemorrhagic infarction. Some reports mentioned that combined brainstem infarction as a cause of poor prognosis and reported that surgical intervention improves prognosis in patients without brainstem infarction. Another factor affecting prognosis was obstructive hydrocephalus [2,3,12]. Even though there was no significant difference in time from onset to surgery, early surgical intervention may be advisable in patients with signs of hydrocephalus at the time of somnolence.

As a surgical method, there is no definite conclusion on whether to perform DSC add VD to hydrocephalus or only perform VD. Among 42 patients with cerebellar infarction, Rieke et al. [13] evaluated 20 undergoing conservative treatments, 15 undergoing VD and 7undergoing DSC. According to their study, VD is recommended in patients with stupor due to hydrocephalus while DSC should be performed in comatose cases with brainstem compression. Januss et al. [14] compared 34 patients undergoing DSC and 14 undergoing VD among 84 patients with acute cerebellar infarction with mass effect on head CT, and found no difference between VD and DSC. On the other hand, severe sequel, such as consciousness disturbance and hemiplegic, have occurred frequently when only VD is performed. There also is a report that the level of consciousness worsens even if only VD is performed for the first time by additional risk for upward tentorial herniation [3,8,15-17]. Limitations of this study include its retrospective nature and the small number of patients from a single facility [18]. The validity of our results should be assessed in a multicentre study with more cases.

Conclusion

We reported on 14 patients undergoing DSC for cerebellar infarction. We suggested that there is a high possibility that a good prognosis will be obtained by DS if there is no infarction other than in the cerebellum and complications of the whole body do not occur in the case of progressive consciousness disturbance.

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