Long-Term Outcome After Suboccipital Decompressive Craniectomy for Malignant Cerebellar Infarction

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Background and Purpose—Suboccipital decompressive craniectomy (SDC) is a life-saving intervention for patients with malignant cerebellar infarction. However, long-term outcome has not been systematically analyzed.

Methods—In this monocentric retrospective study we analyzed mortality, long-term functional outcome, and quality of life of all consecutive patients that were treated by SDC for malignant cerebellar infarction in our institution between 1995 and 2006.

Results—A total of 57 patients were identified. All of them were treated by bilateral SDC. An external ventricular drainage was inserted in 82%, necrotic tissue was evacuated in 56% of patients. There were no fatal procedural complications. Five patients were lost for follow-up. In the remaining 52 patients, the mean follow-up interval was 4.7 years (1 to 11 years). Within the first 6 months after surgery 16 of 57 patients (28%) had died. At follow-up, 21 of 52 patients (40%) had died and 4 patients (8%) lived with major disability (mRS 4 or 5). Twenty-one patients (40%) lived functionally independent (mRS 0 to 2). The presence of additional brain stem infarction was associated with poor outcome (mRS ≥4; hazard ratio: 9.1; P=0.001). Quality of life in survivors was moderately lower than in healthy controls.

Conclusions—SDC is a safe procedure in patients with malignant cerebellar infarction. Infarct- but not procedure-related early mortality is substantial. Long-term outcome in survivors is acceptable, particularly in the absence of brain stem infarction. **(*Stroke*. 2009;40:3045-3050.)**

Key Words: cerebellar infarction ■ craniectomy ■ outcome

Patients with cerebellar infarction initially often present with only minor symptoms such as ataxia and oculomotor dysfunction. However, within a few days, a subset of patients dramatically deteriorates because of infarct swelling with consecutive brain stem compression, transforaminal or transtentorial herniation, and occlusive hydrocephalus.[1–6] Although results from prospective randomized trials are lacking, suboccipital decompressive craniectomy (SDC) and insertion of an external ventricular drainage (EVD) are currently recommended as the therapy of choice in the guidelines of the American Stroke Association[7] and the European Stroke Organization.[8]

Numerous reports suggest that SDC reduces mortality in malignant cerebellar infarction.[2,3,6,9–17] However, little is known about the long-term outcome in survivors.

In this monocentric retrospective analysis, we evaluated mortality, long-term functional outcome, quality of life, and prognostic factors in patients with malignant cerebellar infarction treated by standardized SDC.

Patients and Methods

Patient Identification

All patients with acute cerebellar infarction that were treated by SDC in our institution between 1995 and 2006 were included. Patients were identified from a computerized database in which basic data of all stroke patients admitted to our center since 1995 had been prospectively collected.

Surgical Procedure and Medical Management

All patients were treated following a standardized surgical protocol for SDC established in 1995. According to this protocol, SDC was considered the treatment of choice in patients with clinical deterioration and radiological evidence of acute space-occupying cerebellar infarction with signs of brain stem compression, imminent transforaminal/transtentorial herniation, or occlusive hydrocephalus. The surgical protocol aimed at gaining as much additional space as possible for brain swelling. Therefore, the protocol included extension of the craniectomy to the contralateral side to enable lateral cerebellar movement, and evacuation of necrotic tissue. The protocol was kept constant throughout the study period and defined the following surgical interventions: (1) extensive bilateral SDC with duraplasty, optional resection of the posterior arch of atlas, (2) preceding insertion of an EVD in the case of hydrocephalus, and (3) evacuation of necrotic tissue.

Medical management generally followed the German and European guidelines on acute stroke care valid at the time of patient admission. If malignant swelling was expected and SDC considered an option, antiplatelet therapy was withheld. In this case, patients received low-dose heparin only. Osmotic substances such as mannitol were usually not given. Only in the case of acute herniation,

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mannitol was used as a bridging therapy followed by immediate SDC.

Data Retrieval From Patient Charts

The following data were retrieved from medical charts: age, sex, comorbid conditions, vascular risk factors, clinical presentation, clinical course, infarct etiology and extension, modality of admission, time to surgery, details of the surgical procedure, procedural complications, and short-term outcome including in-house mortality. Diagnostic workup to define infarct etiology regularly included imaging of extra- and intracranial vessels (Doppler and Duplex sonography, CT angiography, MR angiography), Holter-ECG, and transthoracic or transesophageal echocardiography. Comorbidity was quantified by the Charlson Index, a validated measure of preexisting morbidity.[18]

Neuroradiological Analysis

Neuroradiological images of all patients were reanalyzed by an experienced neuroradiologist (J.L.). Emphasis was placed on any underlying arterial pathology and the exact infarct extension. Diagnosis of brain stem infarction was made on the basis of MRI or clear evidence of infarction on CT.

Long-Term Follow-Up

Long-term outcome was assessed in 2007. Patients were contacted by telephone. Their clinical status was documented using a structured interview and the modified Rankin Scale (mRS).[19] In addition to this telephone interview, patients were asked to answer a mailed 36-Item Short-Form Health Survey (SF-36) questionnaire.[20] The SF-36 is widely used to measure health-related quality of life and has been validated for patients after stroke.[21,22] It assesses 8 domains on physical, emotional, and mental functioning. Results were compared to historical populations of healthy Germans,[23] nonselected stroke patients,[22] and patients with hemicraniectomy for malignant middle cerebral artery infarction.[22,24] Finally, patients were asked to answer the following question with "Yes" or "No": "Looking back, do you feel that surgery was the right decision for you?"

Outcome Factors

To identify patients who may not have substantially benefited from SDC we defined outcome as poor if major disability persisted or death had occurred at follow-up (mRS ≥4). A comparable dichotomization in favorable (mRS ≤3) and poor (mRS ≥4) has been used in recent trials on surgical stroke therapy, namely on hemicraniectomy in malignant hemispheric infarction.[25–27] The following parameters were selected as variables for poor outcome: age ≥60 years, Charlson Index ≥3, GCS before surgery ≤8, time to surgery ≥3 days, evacuation of necrotic tissue during surgery, bilateral cerebellar infarction, and neuroradiological evidence of brain stem infarction.

Statistical Analysis

The statistical software package SPSS 13.0 was used. Values are given as mean±SD. Because of the low number of patients and outcomes we did not perform a logistic regression analysis on variables possibly predicting poor outcome. Instead, we performed an univariate analysis using the Fisher exact test.

Results

Patient Characteristics

A total of 322 patients with acute cerebellar infarction were identified. Fifty-seven of them (18%) were treated by SDC. The mean age was 59.2 years. To receive surgical treatment, most patients (70%) had to be referred to our stroke center from nearby community hospitals (Table 1). Only a minority of patients (18%) were affected by substantial comorbidity

Table 1. Patient Characteristics

Basic data	
Age (mean±SD)	59.2±12.9 years (27 to 81 years)
Male gender	34/57 (60)
Referral from community hospital	40/57 (70)
Premorbid status	
Charlson Index ≥3*	10/55 (18)
mRS ≥1	14/55 (25)
mRS ≥2	10/55 (18)
mRS ≥3	2/55 (4)
Vascular risk factors	
Arterial hypertension	43/54 (80)
Diabetes	17/53 (32)
Hypercholesterolemia	16/54 (30)
Active smoking	13/54 (24)
Symptom and signs at initial presentation	
Ataxia	25/30 (83)
Oculomotor dysfunction	46/56 (82)
Dysarthria/dysphagia	41/51 (80)
Vertigo	36/51 (71)
Nausea	30/51 (59)
Headache	25/53 (47)
Motor weakness	25/56 (45)
Reduced consciousness (GCS ≤12)	12/54 (22)
Coma (GCS ≤8)	8/56 (14)
Infarct extension	
Cerebellar	57/57 (100)
-unilateral	36/57 (63)
-bilateral	21/57 (37)
-PICA	51/51 (100)
-SCA	31/51 (61)
-AICA	12/51 (24)
Brainstem	29/57 (51)
PCA	16/51 (31)
Infarct etiology	
Large vessel disease	27/57 (47)
Cardiac embolism	7/57 (12)
Vertebral artery dissection	7/57 (12)
Others or unknown	16/57 (28)
Documented arterial occlusion/stenosis	
Basilar artery occlusion	15/57 (26)
Vertebral artery occlusion	5/57 (9)
Vertebrobasilar stenosis	7/57 (12)
Surgical procedure	
SDC	57/57 (100)
EVD	47/57 (82)
Infarct evacuation	32/57 (56)

Values indicate the No. of affected patients to the No. of patients available for analysis and the respective percentage (). *Values ≥3 indicate substantial comorbidity.[18] PICA indicates posterior inferior cerebellar aretery; SCA, superior cerebellar artery; AICA, anterior inferior cerebellar artery; PCA, posterior cerebral artery; SDC, suboccipital decompressive craniectomy; EVD, external ventricular drain.

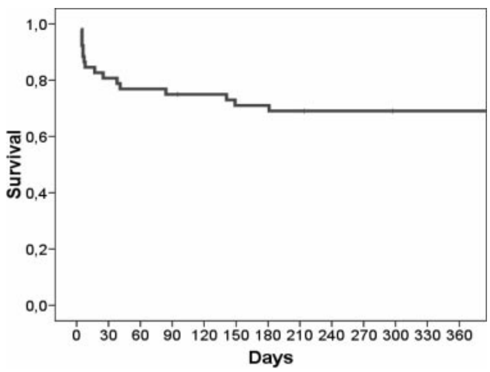

Figure 1. Kaplan–Maier curve showing 1-year-mortality after SDC. Most deaths occurred within the first days to weeks after surgery. After 6 months, mortality was low.

(Charlson Index ≥3), whereas most patients had 1 or more cardiovascular risk factors such as arterial hypertension, diabetes mellitus, or hypercholesterolemia (Table 1). Prior to the cerebellar infarction, almost all patients were functionally independent (Table 1). In the 2 patients with a mRS ≥3, functional dependency was attributable to surgery 2 days before the infarction (hysterectomy and sigma resection, respectively).

Clinical Presentation and Preoperative Course

The most frequent symptoms at onset were vertigo, nausea, and headache. The most frequent neurological signs on admission were ataxia, oculomotor dysfunction, and dysarthria/dysphagia (Table 1). Details on the clinical course before surgery were poorly documented in the patients' charts. Of all clinical data before surgery, only the GCS could be reliably retrieved. According to that, consciousness decreased in most patients (86%) between admission and surgery with a mean GCS drop from 12.6±3.9 to 9.7±4.0.

Infarct Etiology and Neuroradiological Findings

Diagnostic work-up revealed large vessel disease as the most frequent etiology, followed by cardiac embolism and vertebral artery dissection (Table 1). All patients received at least one CT scan, in 33 patients an additional MRI was performed to better delineate infarct extension. Cerebellar infarction was bilateral in 37% of patients (Table 1). The territory of the posterior inferior cerebellar artery (PICA) was always affected. Additional brain stem infarction was found in 51% of patients (Table 1). In the 15 patients (26%) with radiologically documented basilar artery occlusion, recanalization had been achieved before SDC.

Surgical Procedure

In all patients the decision for SDC was made after clinical deterioration and in the presence of radiological signs of brain stem compression, imminent transforaminal/transtentorial herniation, or occlusive hydrocephalus. In all patients SDC was bilateral. Evacuation of necrotic tissue was performed in 56% of patients. An EVD was inserted in 82% of patients. In all but 1 patient (98%) the EVD could be removed within days to weeks. In 1 patient the EVD was eventually replaced by a permanent ventriculo-peritoneal shunt. The mean interval from symptom onset to SDC was 2.1±1.7 days (range=0 to 9 days). Nonfatal procedural complications were seen in 10 patients (18%) and included CSF leakage (n=5), meningitis (n=3), and ventriculitis (n=3).

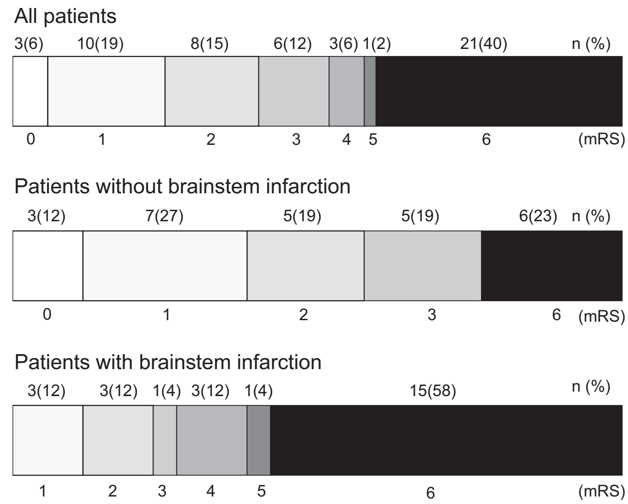

Figure 2. MRS scores at long-term follow-up (mean 4.7 years) in absolute numbers (n) and percent (%) for all patients (n=52) and for subgroups with (n=26) and without brain stem infarction (n=26).

Six additional patients were treated by only inserting an EVD. This was a consequence of impossible surgical positioning in 1 patient with severe comorbidity. In the other 5 cases, it was based on the surgeon's individual decision for reasons that could not be clearly identified from patient charts in this retrospective analysis. Because of the obvious violation of the standard surgical protocol and the very low number of patients treated by "EVD alone," we did not include these patients in any further analysis.

Early Course and Mortality

All patients were treated and monitored on our neurological intensive care unit (ICU) or dedicated stroke unit (SU). The mean duration of ICU or SU treatment was 17.3±10.8 days (range: 3 to 42 days). During this phase, 12 patients died (21%), in all of them mortality was related to the initial infarction: 9 patients died from extensive brain stem infarction, 3 patients from progressive brain stem compression despite SDC. The surviving 45 patients (79%) were referred to neurological rehabilitation. Six months after the cerebellar infarction, 16 of 57 patients (28%) had died (Figure 1).

Long-Term Outcome

After a mean follow-up period of 4.7±2.9 years (range: 1 to 11 years), 21 of 52 patients (40%) had died. None of the late deaths (>6 months after SDC) were related to the initial cerebellar infarction. Five patients were lost for follow-up, leaving 31 survivors. Four of these patients lived with persisting major disability (mRS 4 to 5). Thirteen patients (25%) had an mRS of 0 to 1, 21 patients (40%) an mRS of 0 to 2, and 27 patients (52%) an mRS of 0 to 3. Further details on functional outcome are presented in Figure 2. Twenty-six

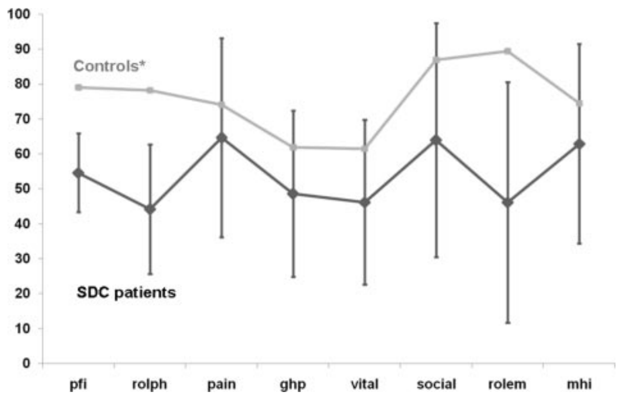

Figure 3. SF-36 scores of patients compared to a healthy German population[23] after correction for age and sex. The following 8 domains of quality of life were assessed: pfi, physical functioning; rolph, physical role functioning; pain, bodily pain; ghp, general health; vital, vitality; social, social functioning; rolem, emotional role functioning; mhi, mental health. For all domains, higher values represent better quality of life. Error bars indicate 95% confidence intervals (not available for the control group because of limited access to raw data).

survivors returned their SF-36 questionnaires. For each individual item, our patients scored moderately lower than controls (Figure 3), which confirmed the expected moderate impairment of quality of life. When compared to historical populations of stroke survivors from the International Stroke Trial[22] and patients after hemicraniectomy for malignant middle cerebral artery infarction,[24] our patients scored similar in 6 of 8 items but substantially better in 2 items: physical functioning (55 versus 30 versus 31) and physical role functioning (44 versus 20 versus 6). When asked to look back, 26 of 27 responding patients (96%) felt that surgery had been the right decision for them.

Factors Associated With Poor Outcome

In univariate analysis, only neuroradiological evidence of brain stem infarction was associated with poor outcome (mRS ≥4) at follow-up (Table 2, Figure 2). Other factors such as age, gender, GCS before surgery, comorbidity, time to surgery, and bilateral versus unilateral cerebellar infarction showed no significant association with poor outcome.

Discussion

We present an analysis of long-term outcome after SDC for malignant cerebellar infarction in a large and homogeneous population of patients. In our series SDC was safe with no fatal procedural complications. However, infarct-related mortality was substantial (28%) within the first 6 months after the stroke and may have been affected by inclusion of 15 patients with recanalized basilar artery occlusion. Despite this, mortality in our study was comparable to previous studies with up to 20 patients, in which early mortality reached 0% to 50%.[10,14,15]

The majority of patients (70%) were referred from community hospitals before SDC, many of them with the clear prospective to receive SDC in the case of clinical deterioration. This referral pattern may have influenced the rate of patients treated by SDC with respect to all admitted patients

Table 2. Univariate Analysis of Variables Possibly Associated With Poor Outcome (mRS ≥4)

Variable	Hazard Ratio	Confidence Interval (95%)	*P* Value
Brain stem infarction	9.05	2.57 to 31.84	0.001
Time to surgery ≥3 days	1.91	0.59 to 6.17	0.38
Male sex	1.69	0.55 to 5.26	0.40
Charlson Index ≥3*	1.60	0.37 to 6.83	0.72
Age ≥60 years	1.59	0.53 to 4.76	0.58
GCS before surgery ≤8	1.47	0.46 to 4.78	0.56
Bilateral cerebellar infarction	1.13	0.36 to 3.53	1.00
Evacuation of necrotic tissue	0.36	0.11 to 1.21	0.14

*Values ≥3 indicate substantial comorbidity.[18]

with acute cerebellar infarction. However, the observed rate of 18% in our study corresponds well to an estimated proportion of 11% to 25% of cerebellar infarctions in which edema may lead to critical space-occupation.[12]

In our survivors, functional long-term outcome was acceptable. Only very few patients lived with persisting major disability. Equally important, quality of life did not seem to be massively impaired. As expected, it was lower than in healthy controls,[23] but differences were moderate. Compared to historical populations of nonselected stroke patients[22] and stroke patients after hemicraniectomy for hemispheric infarction,[22,24] our patients scored quite similar in 6 of the 8 tested domains of the SF-36 but scored substantially better in physical and physical role functioning.

Not surprisingly, the presence of brain stem infarction on neuroradiological imaging was clearly associated with poor outcome in our patients. The issue of whether patients with neuroradiologically confirmed brain stem infarction should be treated by life-saving SDC remains difficult. Our data and data from the literature[12] do not provide sufficient evidence to suggest an optimal treatment strategy in this setting. A practical approach might be to make an individual therapeutic decision based on the extension of the brain stem infarction, the expected associated functional impairment, and the patient's declared or presumptive will.

The best surgical approach for malignant cerebellar infarction is a matter of debate.[1,13–15,28] In our population, the standardized surgical protocol included extensive bilateral SDC and evacuation of necrotic tissue with the aim to create maximum space for progressing edema. Because SDC was the predefined mandatory surgical approach, our study cannot provide evidence on any superiority of SDC or insertion of an EVD as the primary surgical procedure. Future prospective trials may address this question.

If SDC is performed, additional evacuation of necrotic tissue may have an influence on outcome.[13,15] This may be explained by the increased gain of decompression volume for vital cerebellar tissue as well as the reduced induction of cytotoxic edema by less necrotic tissue. Our data do not provide sufficient evidence that evacuation of necrotic tissue is of real benefit. It would be very interesting to investigate its effect in a prospective trial.

The state of consciousness before surgery did not affect outcome in our patients. Other studies have provided conflicting results. While some authors found an association between reduced consciousness and poor outcome,[13] others did not.[14] In light of these and our findings the decision for SDC should not be rejected based on a poor preoperative state of consciousness alone.

In malignant middle cerebral artery infarction age has been shown to be an important predictor for poor outcome after hemicraniectomy.[29] In malignant cerebellar infarction, age may be equally relevant. Hornig et al found an association of age greater than 60 years with poor outcome.[12] Our study could not confirm this finding. In the absence of clear evidence it may not be justified to generally withhold SDC in older patients.

In all of our patients the territory of the PICA was affected. This confirms a previous observation that malignant swelling in isolated AICA and SCA infarction is uncommon.[4] It also demonstrates that patients with PICA infarction are at special risk for life-threatening edema. Outcome was similar in patients with unilateral and bilateral infarction. Therefore, bilateral infarct extension alone should not be considered an exclusion criterion for SDC.

The time interval from symptom onset to SDC did not affect outcome in our patients. This finding may argue against preventive surgery before clinical deterioration. In the absence of prospective controlled trials, it seems reasonable to consider prompt SDC at the time when first signs of secondary clinical deterioration occur. This requires a setting in which continuous clinical observation and permanent availability of neuroradiological and neurosurgical services are warranted. However, many patients are not primarily admitted to specialized stroke centers. Therefore, it remains a challenge of cooperative stroke care to initiate timely referral of initially oligosymptomatic patients to specialized stroke centers.

From an evidence-based point of view, retrospective analyses like the one presented cannot reliably define the exact value of SDC in malignant cerebellar infarction. Only randomized controlled trials comparing surgical and conservative treatment could answer this question beyond all doubt. However, these trials will probably never be performed because depriving affected patients of life-saving SDC may be considered unethical by many (including the authors of this article). However, multicenter randomized controlled trials will be helpful and feasible to define the optimal timing of surgery (before versus after clinical deterioration) or the optimal surgical procedure (eg, EVD versus SDC as the primary treatment or SDC versus SDC plus infarct evacuation).

Summary

SDC is a safe procedure in patients with malignant cerebellar infarction. Although early infarct- but not procedure-related mortality is substantial, long-term outcome in most survivors seems to be acceptable, especially in the absence of brain stem infarction. Randomized controlled trials will be necessary to define the optimal timing of surgery and the optimal surgical procedure.

Disclosures

None.

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