DECOMPRESSIVE CRANIECTOMY FOLLOWING TRAUMATIC BRAIN INJURY: OUR EXPERIENCE AND REVIEW OF THE LITERATURE

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ABSTRACT

Aim: Uncontrollable rise in intracranial pressure (ICP) after severe brain injury is connected with poor neurological outcome. Reduction of ICP after decompressive craniectomy (DC) is thought to improve recovery. Our experience with DC is discussed.

Materials and methods: In the retrospective study, 14 patients treated by DC were included. For every patient, the effect of treatment was scored by GOSE score (Glasgow Outcome Scale Extended) at discharge and during follow-up. The influence of patient age, initial GCS score, time of surgery, pupillary light reflex, associated injuries, concomitant intracranial procedures and treatment outcomes were studied. Student’s t-test was used for statistical evaluation.

Results: Of 118 patients with severe brain injury, DC was employed in 14 patients, 43% of patients died, 14% remained in persistent vegetative state and 7% severely disabled. A favourable treatment outcome was achieved in 36%. Rated by GOSE score (GOSE 1 to 4), poor treatment outcome was observed in 64% (average GOSE 1.4) and favourable in 36% (average GOSE 6.5). Before and after DC, the average ICP has fallen from (46 ± 19)mmHg to (17 ± 11)mmHg, respectively (p=0.003). Patients treated by DC later than 24 hours after injury, those with GCS rated from 6 to 8 (p=0.0038) and those younger than 50 years, had a better treatment outcome.

Conclusion: DC effectively reduces the rise in ICP following a severe brain injury. Patients with lower neurological dysfunction and patients younger than 50 years benefit the most. The successful treatment outcome was observed in 36% of patients. Our observations confirmed the better outcome of DC when performed later than 24 hours after the injury. Effective and correct treatment of traumatic brain injury leads to better clinical outcome and more successful rehabilitation result.

Key words: Decompressive craniectomy, traumatic brain injury, intracranial pressure, surgery, treatment outcome.

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Introduction

After severe brain injury, in 10% to 15% of patients the intracranial pressure rises significantly and does not react to maximal conservative treatment or to external ventricular drainage placement. Patients with intracranial pressure (ICP) higher than 20mmHg, which does not respond to intensive care interventions, show a statistically significantly higher morbidity and mortality.

Decompressive craniectomy (DC) as a surgical method for lowering elevated ICP has been in use for more than a hundred years. The famous neurosurgeon Harvey Cushing described DC as early as in 1905 as a palliative method against brain herniation in inoperable brain tumours. DC procedure gained no popularity in the seventies due to an unacceptably high morbidity and mortality reports in patients with elevated ICP after severe brain injury, as well as rebound brain swelling and venous infarction. Later reports showed that the DC may successfully lower elevated ICP and treatment outcome after brain injury and extensive infarcts. These improvements may be attributed to better prehospital care and imaging methods, especially with more frequent use of computed tomography (CT), as well as earlier and more aggressive surgical and intensive care therapy. However, morbidity and mortality remain high despite the use of modern monitoring systems and new approaches in treatment of severe brain injuries.
Conservative antioedematous methods such as hyperventilation, mannitol or hypertonic saline infusions, barbiturate coma and external ventricular drainage (EVD) are frequently inadequate for lowering elevated ICP. In such cases, DC is recommended as a treatment option\(^5\). Prospective studies lack sufficient data about success of DC with regard to conservative treatment, which may be a major reason for inadequate employment of this emergency surgical technique\(^1,5-16\).

The aim of the study was to analyse our experience in the treatment of the most severe brain injuries. We analysed the most suitable time and indications for DC where DC was utilized as a last therapeutic option, and to compare our results with reports from the literature.

Materials and methods

The retrospective study at the University Medical Centre, Maribor, encompassed the period from 2005 to 2008. All patients with severe traumatic brain injury (STBI) were included (Glasgow Coma Scale rated from 3 to 8 points) in whom DC was performed due to a rise in ICP that was not responsive to conservative measurements either immediately after the injury or thereafter. All included patients were treated according to the recommended protocols for severe head injury and had an EVD inserted and ICP and cerebral perfusion pressure (CPP) monitored. In some patients, concomitant intracerebral haemorrhage was evacuated concomitantly with DC. The diagnostics were done by CT imaging.

A classical, mostly unilateral DC of 10cm in diameter was performed over the region of the most severe brain swelling. The dura was cut in a longitudinal manner. Brain tissue was separated and protected from galea with lyophilised or artificial dural sheets\(^7,10\). After the DC, ICP and CPP were continuously monitored. Success of the treatment was rated by GOSE score (Glasgow Outcome Scale Extended) at patient discharge and during follow-up.

All postoperative complications and timing of DC were reviewed. The success of treatment was rated according to patients’ age, initial GCS (Glasgow Coma Scale), pupillary light reflex, time from injury to DC and subsequent indications for DC. The statistical significance was tested with Student’s T-test with values of p<0.05 taken to be statistically significant.

Results

From 2005 to 2008, 118 patients with STBI were treated at our institution. Fourteen DC procedures were performed, representing 12% of all severe traumatic brain injuries. The age range was from 6 to 66 years, mean 32.5 years. Two were female, the others were male patients.

In 14 patients that underwent DC, six died (43%), two remained in a persistent vegetative state (14%) and one was severely disabled (7%). In five patients (36%), the GOSE outcome was favourable and in nine patients (64%) it was poor (average GOSE 6.5 and 1.4, respectively).

Early DC was performed within 24 hours after injury in six patients (43%). The average timing from injury to DC procedure was five hours, the average GOSE in this group of patients was 2.2. Of all six patients, one achieved a favourable outcome (GOSE 5 to 8) and five unfavourable (GOSE 1 to 4). In this latter group, four patients died (66%) and one remained severely disabled (GOSE 3).

Late DC was performed later than 24 hours after injury. In this group, eight patients were included (57%). The average time from injury to DC was 6 days. Two patients died (25%). Of those whom survived, four achieved a favourable outcome and two a poor one. The average GOSE in the late DC group was 4 (in 50% of patients, the outcome was favourable and in the other 50% it was unfavourable). The difference between early and late DC was not statistically significant (p=0.205).

The ICP was monitored in all patients with DC. The average ICP before DC ranged from 20mmHg to 70mmHg, mean 46mmHg. After DC, a sharp decline of ICP was observed in all patients to the values below 20mmHg. However, after a day or so, ICP started to rise over 30mmHg. However, CPP improved after DC in all patients. Perfusion of brain tissue was within normal limits, with and without intermittent adrenalin circulatory support. The mean ICP value before DC was (47±19)mmHg and (17±11)mmHg after the DC (p=0.003). In nine patients (64%), DC was carried out due to an uncontrollably elevated ICP. In five patients (36%), DC was performed immediately after admission due to a rapid clinical deterioration and malignant brain swelling.

The pupillary light reflex was present in two patients before DC. In six patients, one pupil was dilated and unresponsive and in the other six both pupils were fixed and dilated. The pupillary light

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reflex was not a prognostically relevant variable in our study.

Of eight patients (57%) with the GCS rated below 5 at the admission, seven achieved an unfavourable result after DC (88%): five (63%) died, two (25%) remained in a persistent vegetative state and one recovered (GOSE 6). The average GOSE score in this group was 2. In the group of six patients (43%) with the GCS rated from 6 to 8, only one died (7%). The average GOSE score was 4.8. The difference of patient outcome in both GCS groups was statistically significant (p=0.038).

The average age of the six patients that died (43%) was 35.5 years and of the remaining eight surviving patients (57%) was 30.3 years (p=0.583). The average age of nine patients with an unfavourable outcome (64%) was 35.7 years, as opposed to 26.8 years in five patients with a good outcome (36%) (p=0.363). DC treatment was more successful in patients younger than 50 years of age (GOSE in two patients over 50 years was 1 and in 12 younger patients was 4).

An improvement in neurological condition was seen only in two of 14 patients. At discharge, these two patients had GOSE scores of 4 and 5. They both improved during the rehabilitation process and achieved a final GOSE score of 6. Due to a fulminant rise of ICP after DC, six patients died: four within eight days and two within two to four months after the operation (in the latter group the ICP was not measured at that time).

In five patients (36%), the cause of the injury was a fall, in 8 patients (57%) a traffic accident and in one (7%) a horse kick in the head. Five patients (36%) had a concomitant polytrauma, which did not affect the outcome after the DC significantly.

The average follow-up period was seven months and the range was five days to two years.

Twelve unilateral and two bilateral DC operations were performed, 85% and 15%, respectively. In regions of decompRESSED brain, haemorrhagic and hypodense zones were present on the CT scans, which regressed spontaneously in a few weeks’ time.

Four patients (28%) developed ventriculitis. One died and three recovered, but the GOSE outcome was poor. In six patients (43%), a ventriculoperitoneal shunt due to a posttraumatic hydrocephalus was needed. One patient developed an extensive infarction in the region of the middle cerebral artery. However, she achieved a good GOSE outcome. In six patients (42%), cranioplasty was performed one to three months after DC.

Discussion

The decompression of the brain tissue by DC is an old surgical principle, used in situations of uncontrollably high ICP. The indications for DC included severe head injuries, cerebellar infarctions and extensive strokes. No clear evidence about the efficacy of DC exists despite some optimistic literature reports. Thus, opinions on when and if a DC should be performed are divided. Early treatment with DC was associated with a high degree of morbidity and mortality that are nowadays lower due to modern approaches in intensive care units. In some cases, DC is performed in patients that may otherwise be successfully treated with conservative measures alone. However, there is a question of the mortality of DC procedure in patients with a poor outcome where DC may have saved the patient. Such patients are likely to remain in a persistent vegetative state. Due to catastrophic results, Ziai et al. do not recommend DC when a CT scan shows signs of transtentorial or uncal herniations.

Although a straightforward comparison among studies relating to DC in severe brain injury is not possible due to the various parameters they considered, they all demonstrated a successful treatment outcome on patients survival after DC, ranging from 16% to 69%.

The results of our study showed 43% mortality. Among the surviving patients, a favourable outcome was documented in 50% and a poor outcome in the other 50%. Using GOSE, a successful outcome was observed in 36% and a poor outcome in 64%. These results are thus comparable to those reported in other retrospective studies (Table 1).

<table>
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<th>Authors</th>
<th>Number of patients</th>
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<td>Aarabi B, Ref. 1, 2006</td>
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<td>40</td>
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<td>241</td>
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<td>39,8</td>
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<td>Ucar T, Ref. 19, 2005</td>
<td>100</td>
<td>84</td>
<td>16</td>
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<tr>
<td>Albanese J, Ref. 2, 2003</td>
<td>40</td>
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<td>25</td>
</tr>
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<td>Ziai WC, Ref. 20, 2003</td>
<td>18</td>
<td>67</td>
<td>33</td>
</tr>
<tr>
<td>Schneider GH, Ref. 17, 2002</td>
<td>62</td>
<td>70,9</td>
<td>29,1</td>
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<td>Whitfield PC, Ref. 21, 2001</td>
<td>26</td>
<td>31</td>
<td>69</td>
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Table 1: Literature review of outcomes of decompressive craniectomies performed in severe brain injuries.
The disadvantage of our study is that only a small number of patients treated by DC were included.

The principal indication for DC in our patients was an uncontrollably high ICP, which did not respond to mannitol, hyperventilation, barbiturates or EVD. In this study, the average observed ICP was 45mmHg before DC, which fell below 20mmHg after DC, at least during in the first six hours after decompression. Later, the values began to rise slowly towards and sometimes over 30mmHg. A similar effect was described by Chibbaro et al.\(^7\). The CPP values also improved after the operation and ranged within normal limits during the treatment. Our results are consistent with literature reports, which show that an ICP over 20mmHg for more than six hours is an adverse prognostic factor. However, a fall in ICP after DC suggests a good recovery\(^10\). Since DC effectively lowers ICP, it is recommended that this procedure is performed as soon as possible after STBI in order to prevent secondary brain injury\(^1, 9, 10\).

Howard et al. reported that there is a correlation between GCS and treatment outcome\(^10\). Despite initially low GCS ratings in patients with a favourable treatment outcome, the sum of GCS scores is 2.5 points higher than in patients with a poorer outcome\(^5, 10\). Additionally, a difference in pupil diameter as small as 0.8mm suggested a better outcome of DC when done in reactive and small pupils\(^10\). Also Aarabi et al. and Ucar et al. report a better outcome of DC treatment in patients with a higher GCS rating\(^1, 15\). Our experience is comparable: the outcome of DC was poor in 88% of patients with a GCS rating between 3 and 5 and favourable in 67% of patients with a GCS rating between 6 and 8. In patients with concomitant polytrauma, a statistically significant adverse effect on the outcome of the treatment was not found, as confirmed by Ucar et al\(^15\). There are reports showing that a higher injury severity score acts as a negative prognostic factor in the development of secondary brain injury and thus in the outcome for these patients\(^10\).

The majority of reports show a better treatment outcome after DC for younger patients\(^15, 16\). Our data are similar. Over 50 years of age may be an unfavourable prognostic factor and the indications for DC are problematic\(^14\). Other did not find the correlation between the treatment outcome and DC\(^10\).

An important factor in the outcome after the DC is the timing between the injury and the operation. Early DC may be conducted within 48 hours after the injury as opposed to late DC after 48 hours. Muench et al. claim that mortality is only 30% when DC is performed in the first four hours after injury and rises later to 90%\(^19\). Also other researchers suggest DC be performed as soon as possible or within 48 hours, before the development of cerebral swelling irreversibly damages the brain tissue\(^20, 21\). To the contrary, Howard et al. did not find any difference between the early and late DC\(^10\). Some authors report, that the success of DC is worse when performed within 24 hours after the injury but better thereafter\(^5\). Morgalla et al. claim that a time interval between the injury and performing DC is as important as the duration of elevated ICP\(^9\). Our observations confirmed the better outcome of DC if performed later than 24 hours after the injury.

There are reports of some adverse effects and complications associated with DC such as: subdural hygromas, ventricular infections and parenchymatous alterations with swelling and hemorrhagic zones in the surrounding area of DC\(^1, 7, 10\). Similar changes in the decompressed brain regions were observed also on CT-images of our patients but they resolved spontaneously in the following weeks. All 14 patients in our study had an EVD inserted. Four patients (28.5%) developed a ventricular infection and one of them died. A further four patients needed the ventriculoperitoneal shunt due to a posttraumatic hydrocephalus and one patient developed a cerebral infarction in the region of the DC. The frequency of the adverse effects was similar to the literature reports, although the percentage of ventricular infection was slightly higher.

In our study, the GOSE score was utilized, despite a wide use of GOS (Glasgow Outcome Scale) in the literature. In our opinion, the GOSE is a more precise, reproducible and reliable indicator of clinical outcome\(^10\).

At the University Medical Centre, Maribor, DC is becoming an increasingly preferred method for the treatment of malignant brain swelling after STBI. Since 2005, the number of DC operations has increased (Table 2). As there are still contradictory views on the use of DC, further studies are required. At this current time, the RESCUEicp study is running in the United Kingdom. Thus, we expect to obtain additional valuable information for treatment of patients with severe brain injury in the future.

DC effectively reduces the rise in ICP following STBI. Patients with less significant neurological
dysfunction as well as patients younger than 50 years of age benefit the most. In our study, a successful treatment outcome after the DC was observed in 36% of patients. These results are thus comparable to those reported in other retrospective studies, although a straightforward comparison among DC studies is not possible due to the various parameters they considered. However, they all demonstrated a successful treatment outcome on patients’ survival after DC, ranging from 16% to 69%. Additionally, an effective and correct management of severe traumatic brain injury leads to better clinical outcome as well as more successful and effective rehabilitation result.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of patients (GCS 3 to 8)</th>
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<td>2</td>
</tr>
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</tr>
<tr>
<td>2007</td>
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<td>5</td>
</tr>
<tr>
<td>2008</td>
<td>28</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>118</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 2: The frequency of decompressive craniectomies in relation to all admitted patients with severe brain injuries at our institution from 2005 to 2008.

References


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