Efficacy of large decompressive craniectomy in severe traumatic brain injury

LI Gu 李谷, WEN Liang 温良, YANG Xiao-feng 杨小锋*, ZHENG Xiujue 郑秀玉, ZHAN Ren-ya 詹仁雅 and LIU Weiguo 刘伟国

Objective: To investigate the role of large decompressive craniectomy (LDC) in the management of severe and very severe traumatic brain injury (TBI) and compare it with routine decompressive craniectomy (RDC).

Methods: The clinical data of 263 patients with severe TBI (GCS ≤ 8) treated by either LDC or RDC in our department were studied retrospectively in this article. One hundred and thirty-five patients with severe TBI, including 54 patients with very severe TBI (GCS ≤ 5), underwent LDC (LDC group). The other 128 patients with severe TBI, including 49 patients with very severe TBI, underwent RDC (RDC group). The treatment outcome and postoperative complications of the two treatment methods were compared and analyzed in a 6-month follow-up period.

Results: Ninety-six patients (71.7 %) obtained satisfactory treatment outcome in the LDC group, while only 75 cases (58.6 %) obtained satisfactory outcome in the RDC group (P < 0.05). Moreover, the efficacy of LDC in treating very severe TBI was higher than that of RDC (63.0 % vs. 36.7 %, P < 0.01). The chance of reoperation due to refractory intracranial pressure (ICP) in the LDC group was significantly lower than that of the RDC group (P < 0.05), while the incidences of delayed intracranial hematoma and subdural effusion were significantly higher than those of the RDC group (P < 0.05).

Conclusions: LDC is superior to RDC in improving the treatment outcome of severe TBI, especially the very severe ones. LDC can also efficiently reduce the chances of reoperation due to refractory ICP. However, it increases the incidences of delayed intracranial hematoma and contralateral subdural effusion.

Key words: Craniectomy, decompressive; Brain injuries; Complications; Wounds and injuries

High mortality and high morbidity are found in patients with severe traumatic brain injury (TBI) and the total mortality is 30%-50%. In order to reduce the mortality of TBI and the associated disability, the choice of appropriate surgical management is the most important step in treatment of TBI. Standard large decompressive craniectomy (LDC) is a widely-adopted surgical procedure in the Europe and in the USA. In recent years, we have used LDC to treat 135 patients with TBI between 2001 and 2006 and other 128 TBI patients were treated with routine decompressive craniectomy (RDC) as the control group. The results are reported as follows.

METHODS

General data

One hundred and thirty-five patients (91 males and 44 females, with the ratio of male to female of 2.07:1; aged from 7 months to 80 years, mean=46.3 years) with severe TBI, including 54 patients with very severe TBI, underwent LDC. The time from injury to surgery was 0.8-27 hours (mean: 3.6 hours). And 81 patients were injured by traffic accidents, 9 by punch, 8 by falls from certain heights, 8 by slips, and 16 by other reasons. Other 128 patients (90 males and 38 females, with the ratio of male to female of 2.37:1; aged from 3 months to
83 years, mean=48.1 years) with severe TBI, including 49 patients with very severe TBI, underwent RDC. The time from injury to surgery was 0.8-24 hours (mean: 3.7 hours). And 75 patients were injured by traffic accidents, 17 by punch, 12 by falls from certain heights, 7 by slips, and 17 by other reasons.

Classification of brain injuries
All the 263 patients suffering from acute brain injuries received head CT scans before and after hospitalization. The brain injuries included disseminated brain contusion and laceration, epidural hematoma together with subdural hematoma, acute subdural hematoma together with brain contusion and laceration, acute brain contusion and laceration together with intracerebral hematoma and multiple intracerebral hematomas. Pure epidural hematoma was excluded from this study.

Pupil changes and GCS scores
At admission, 38 cases had pupil dilation on both sides and 97 cases had pupil dilation on one side. All patients had a GCS≤8 at administration. In the LDC group, GCS 3-5 was found in 54 cases and GCS 6-8 in 81 cases, with the average GCS of 5.7. In the RDC group, GCS 3-5 was found in 47 cases and GCS 6-8 in 81 cases, with the average GCS of 5.6.

Surgical procedures
All the patients received operations under general anesthesia. The patients in the LDC group received standard LDC as reported before and the patients in the RDC group received RDC according to the location of the hematoma. The general data, classification of brain injuries, pupil changes and GCS of the two groups before surgery were analyzed by statistical methods (Student’s t test or χ² test were used when appropriate). After surgery, the patients received routine treatments like dehydration, ant-infection and nutritional support. Cautions were taken to avoid disturbances in water and electrolyte balance. The treatment outcome and post-operative complications of the patients were compared and analyzed in a 6-month follow-up period. The treatment outcome was evaluated by GOSs (GOS 3-5 was considered as satisfactory and GOS1-2 was considered as unsatisfactory).

Statistical analysis
All the data were expressed as x ± s. χ² test was used to analyze the results between the two cohorts and the two sub-cohorts of very severe TBI (SPSS software 10.0). P value < 0.05 was regarded as statistically significant.

RESULTS
There was no significant difference between the two cohorts and the two sub-cohorts of very severe TBI in their general data, classification of brain injury, pupil changes and GCS scores before surgery (P> 0.05).

Treatment effects
The treatment outcome was better in the LDC group than in the RDC group (P < 0.05, Table 1). The treatment outcome was significantly better in the sub-cohort of very severe TBI in the LDC group than that of the RDC group (P < 0.01, Table 2).

Complications
The chance of reoperation due to refractory intracranial pressure (ICP) in the LDC group was significantly lower than that in the RDC group (P < 0.05), while the incidences of delayed intracranial hematoma and subdural effusion were significantly higher than those of the RDC group (P < 0.05, Table 3).

### Table 1. Comparison of treatment outcome of patients with severe TBI (GCS 3-8) between RDC group and LDC group

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>GOS scores</th>
<th>Effective rate (%) (GOS score 3-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>LDC</td>
<td>135</td>
<td>66</td>
<td>14</td>
</tr>
<tr>
<td>RDC</td>
<td>128</td>
<td>23</td>
<td>16</td>
</tr>
</tbody>
</table>

*P < 0.05, compared with RDC group.

### Table 2. Comparison of treatment outcome of patients with very severe TBI (GCS 3-8) between RDC group and LDC group

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>GOS scores</th>
<th>Effective rate (%) (GOS score 3-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>LDC</td>
<td>54</td>
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<td>10</td>
</tr>
<tr>
<td>RDC</td>
<td>49</td>
<td>7</td>
<td>3</td>
</tr>
</tbody>
</table>

*P < 0.01, compared with RDC group.
DISCUSSION

Patients with TBI always suffer from secondary severe brain edema and increased ICP, which makes the patients in an emergent state. The aim of surgery is to, by clearing the intracerebral hematoma and the devitalized brain tissues due to brain contusion and laceration, reduce the ICP and prevent or alleviate the secondary brain injury before the occurrence of irreversible secondary brain stem injury. The bone window in RDC is small (6-8 cm in diameter) and, despite the complete clearance of the dead brain tissues and careful hemostasis during the surgery, subsequent brain edema and brain swelling after operation usually extrude the brain tissues out of the small bone window. The extruded brain tissues lack blood supply and are prone to incarceration or infarction, which further aggravates brain swelling and leads to uncontrollable secondary brain injury. The bone window in RDC is small (6-8 cm in diameter) and, despite the complete clearance of the dead brain tissues and careful hemostasis during the surgery, subsequent brain edema and brain swelling after operation usually extrude the brain tissues out of the small bone window. The extruded brain tissues lack blood supply and are prone to incarceration or infarction, which further aggravates brain swelling and leads to uncontrollable secondary brain injury. Therefore, reoperation is usually needed to control this intracranial hypertension and save the patients’ lives. In this study, we found that the chance of reoperation due to refractory ICP in the LDC group was significantly lower than that in the RDC group.

Standard LDC [10 cm × (13-15) cm] is effective in reducing ICP and the incidence of secondary brain injury by the innate advantage of the procedure itself. Because complete ICP reduction is achieved, the intracranial space is significantly enlarged and, as a result, the brain functions are largely preserved. This procedure can reduce the secondary intracranial hypertension resulted from brain swelling and brain edema after surgery, improve the blood circulation in the brain regions that control important functions, and thus facilitate the neurological functional recovery after surgery. Our analyses indicate that the application of standard LDC can significantly improve the prognosis of patients with TBI, especially in those with severe TBI.

The incidences of delayed intracranial hematoma and subdural effusion were significantly higher in standard LDC than in RDC. CT scan after operation showed re-bleeding and hematoma formation at the site of brain contusion and laceration, new hematoma formation and even large epidural hematoma, sometimes scattered hematoma, on the opposite side. And 2-20 days after operation, subdural effusion was observed on the opposite side. The reasons of the formation of delayed intracranial hematoma might be that LDC significantly increases the intracranial space and reduces the ICP in short time, which subsequently increases the perfusion pressure of the brain vessels that have already been injured by brain injury itself. These blood vessels are then ruptured and cause delayed intracranial hematoma. Similarly, brain injury itself might have already injured the arachnoid on the opposite side and LDC will eliminate the stuffing effect by increasing ICP at the early stage of brain injury, and the expansion of the brain tissues through large bone defects would increase the subdural space. As a result, subdural effusion occurs. Besides, the expansion of the brain tissues through the bone defects caused by LDC or the excessive shift of the brain will injure the arachnoid on the opposite side and increase the subdural space. Therefore, subdural effusion occurs. We have noticed in our clinical practice that the TBI patients with expansion of brain tissues through the bone defects after surgery usually suffered from subdural effusion as well.

There is no significant difference in the incidence of complications such as postoperative epilepsy, cerebral spinal fluid leakage through the surgical incision, pulmonary infection and irritable ulcer bleeding between the two groups. Previous studies also reported the analyses on other types of complications. TBI usually associates with multiple injuries which complicate and aggravate the development of TBI. The key point to increase the survival rate of patients with TBI is to take...
prompt and effective measures to control the elevated ICP and prevent or alleviate the secondary brain stem injury. We suggest that surgeons should gradually reduce the ICP during standard LDC procedure, clear the blood clots before handling the brain expansion, and use artificial dura, temporalis muscular fasciae or epicranial aponeurosis to patch the dura mater after clearing up the blood clots and the dead brain tissues. These strategies will expand the cranial space, form gradient ICP reduction and prevent brain shift caused by excessive brain expansion, and thus are helpful to reduce the incidences of delayed intracranial hematoma and subdural effusion after surgery.

Postoperative surveillance is very important for the patients who have received LDC, and great cares should be taken to prevent the occurrence of complications. Besides monitoring the consciousness, pupil, vital signs and saturation of blood oxygen of the patients, head CT scan should be routinely performed 1, 3, and 7 days after surgery. When the complications such as delayed intracranial hematoma and subdural effusion occur, secondary surgery should be promptly performed. Besides surveillance of the lung, kidney and digestive tract functions, appropriate nutritional support will help to prevent the occurrence of these complications.

REFERENCES


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