Int J Clin Exp Med 2019;12(6):7894-7899
www.ijcem.com /ISSN:1940-5901/IJCEM0085009

Case Report

A new decompressive craniectomy on the treatment of severe craniocerebral injury (2 cases)

Qianlei Liang[1*], Shaohai Luan[3*], Fan Li[1], Yueting Gao[2], Yongchuan Guo[1]

*Departments of [1]Neurosurgery, [2]Operating Room, China-Japan Union Hospital, Jilin University, Changchun 130033, China; [3]Department of Hepatobiliary-Pancreatic Surgery, Qingdao Municipal Hospital, Qingdao 266000, China. *Equal contributors.*

Received September 3, 2018; Accepted March 12, 2019; Epub June 15, 2019; Published June 30, 2019

Abstract: Severe and extra severe craniocerebral injuries are serious and complicated illnesses with rapid progression, poor prognosis, high disability, and mortality rate. Decompressive craniectomy is the key to the treatment of these patients. This study describes the design of a new decompressive craniectomy and treatment on 2 patients. The surgery has definitive therapeutic effect and the following is the clinical report.

Keywords: Severe craniocerebral injury, new decompressive craniectomy, standard decompressive craniectomy

Introduction

At present, severe and extra severe craniocerebral injury are still the difficulties in clinical neurosurgery, with a high mortality rate of 30%-50% and a high disability rate [1]. Complications such as cerebral contusion and laceration, hydrocephalus, and diffuse brain swelling are often developed and then induce rises of malignant intracranial pressure, which is the main cause of mortality [2-4]. For severe and extra severe craniocerebral injury, conservative treatments are often ineffective, while decompressive craniectomy is the key to cure patients. In this study, a new decompressive craniectomy treatment of severe and extra severe craniocerebral injuries on 2 patients is described and the clinical results are reported.

Case report

Case 1: 29-year-old male, who came to the hospital after two hours of unconsciousness due to falling from a height of 3 meters. Admission physical examination: the patient was in a state of light coma, GCS score of 7 points (E1V2M4), bilateral pupils 3.5 mm, and slow on the pupillary light reflex . Head CT showed: acute subdural hematoma on the frontal and temporal parietal (**Figure 1E**), subdural hematoma evacuation and new decompressive craniectomy in the emergency general anesthesia were given. The patient's postoperative course was uneventful, postoperative GOS score of 5 points after 2 years.

Case 2: 47-year-old man was admitted to the hospital after head injury due to car accident for 5 hours. The patient was in a deep coma, with a GCS score of 4 points (E1V1M2), the left pupil was 4.5 mm, and the right pupil was 3.0 mm. The pupillary light reflex disappeared and bilateral pathological reflexes were positive. CT scan of the head: thin subdural hematoma on the left frontal and temporal parietal, and the right parietal fracture (**Figure 2E**). The left subdural hematoma removal and new decompressive craniectomy in the emergency general anesthesia, new decompressive craniectomy was given on the right. The patient's postoperative course was also uneventful, postoperative GOS score of 4 points after 1.5 years.

Discussion

Current research results confirm that standard decompression craniectomy is effective in the treatment of patients with severe craniocerebral injury accompanied by malignant intracranial hypertension and brain edema. The surgi-

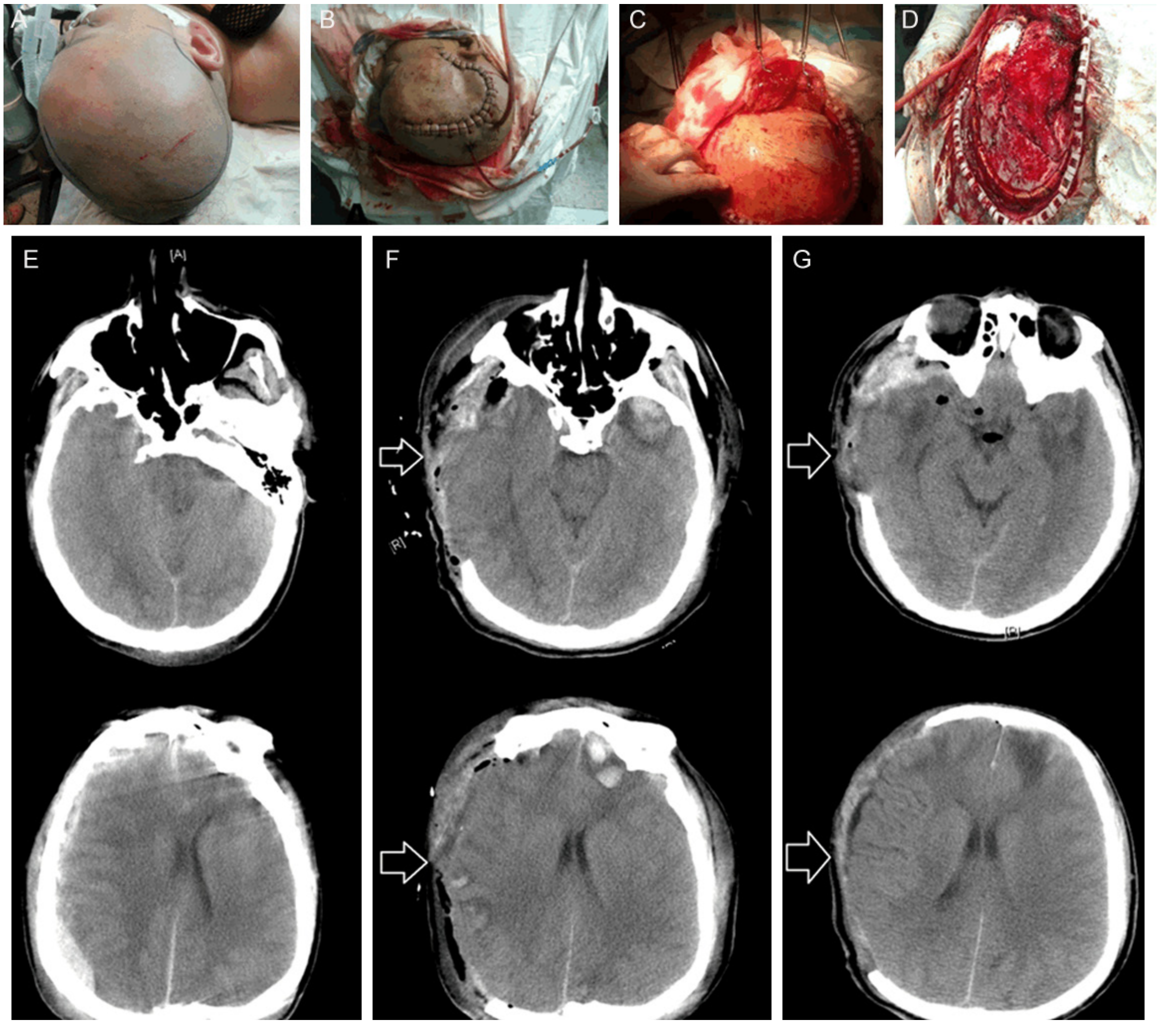

Figure 1. Unilateral decompressive craniectomy. A, B: surgical flap of the scalp; C, D: bone flap; E: CT scan preoperation; F: CT scan after decompressive craniectomy (3 days); G: CT scan after decompressive craniectomy (14 days). Arrows point to the removed unilateral bone flap.

cal procedure of standard decompression was: surgical flaps: The incision begins at 1 cm in front of the tragus, extends from the top of the zygomatic arch to the median line of the parietal bone, and then arcs along the median line to the inferior hairline of the forehead. Bone flap:The median sagittal sinus is opened 2-3 cm beside the bone flaps and free bone flaps are used to bite the sphenoid ridge and temporal bone as far as possible downward.

The surgical procedure of new decompressive craniectomy was: 1) surgical flaps: starting from 1cm ahead of the zygomatic arch upper tragus, extending upward from the back of the auricle to the parietal tuber, passing the middle line of the parietal bone, extending forward to the contralateral forehead within the hairline, then cutting 1-2 cm besides the middle line (**Figure 1A**); the flap incision of bilateral decompressive craniectomy was 2 cm behind the convergence of unilateral flap incisions in the coronal suture (approximately a "W" shaped incision) (**Figure 2A**); 2) bone flap: a free bone flap was applied; the front of the removing unilateral bone flap was flush with the anterior skull base; the inside needed to reach the middle line as far as possible, the back reaching the parietal tuber and the outer or lower side reaching the middle skull base; the interior sphenoid ridge till the superior orbital fissure was completely removed; the greater wing of the sphenoid bone was partially resected and the squama temporalis completely resected, so that the anterior cranial fossa was flush with the middle cranial fossa, and the anterior and middle skull

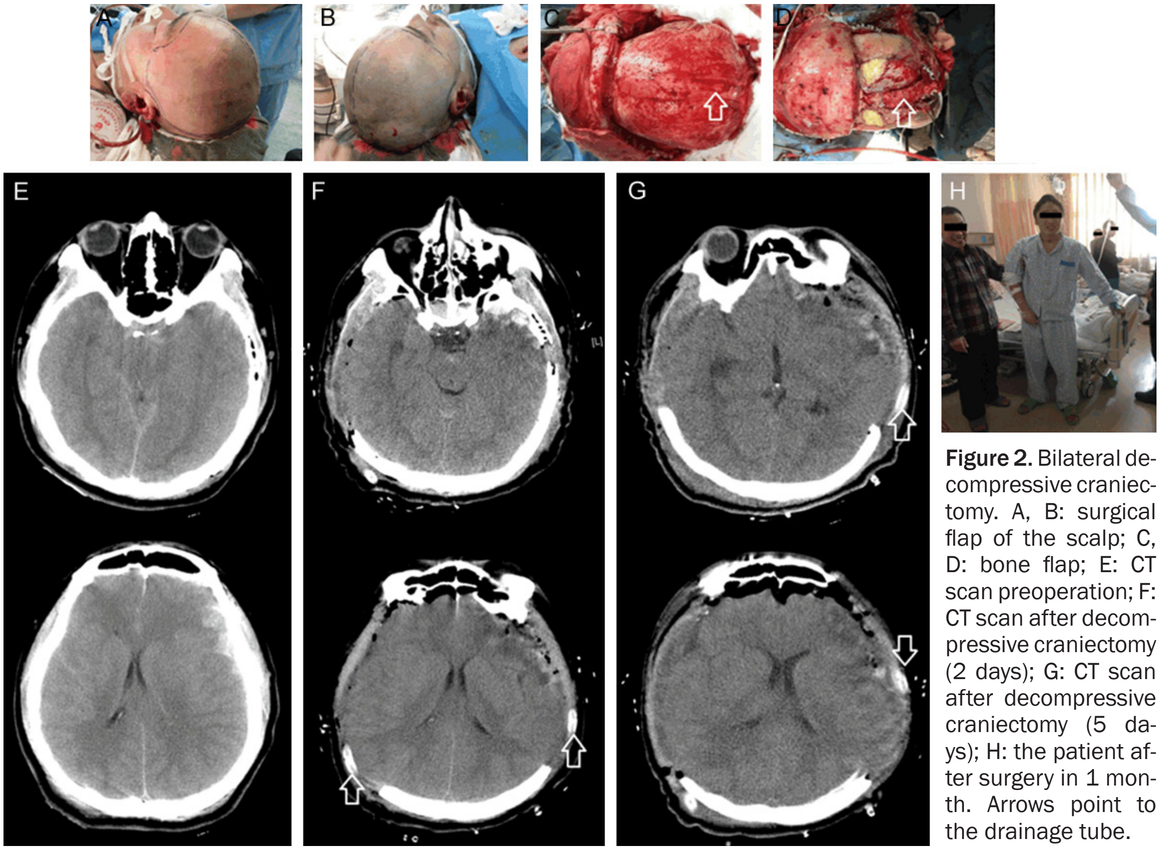

Figure 2. Bilateral decompressive craniectomy. A, B: surgical flap of the scalp; C, D: bone flap; E: CT scan preoperation; F: CT scan after decompressive craniectomy (2 days); G: CT scan after decompressive craniectomy (5 days); H: the patient after surgery in 1 month. Arrows point to the drainage tube.

base would be completely decompressed (**Figure 1D**); the range of the removing bilateral bone flap was the same with the range of the removing unilateral bone flap on both sides; the size of the intermediate beam bone was about 2-3 cm (**Figure 2D**); 3) cutting the dura mater: the dura mater was cut from the front temporal lobe in the shape of a claw. The frontal lobe, the temporal lobe, the parietal lobe, the anterior cranial fossa, the middle cranial fossa and the intracranial hematoma were fully exposed. The differences between new and old decompressive craniectomy are shown in **Table 1**.

In clinical practice, the standard decompressive craniectomy was still inadequate in the following aspects: 1) damage to the combined temporal contusion, the Labbe vein, the transverse sinus, or the superior sagittal sinus, which are often found rather difficult to deal with in the application of standard decompressive craniectomy. Sometimes a "T" shaped incision needs to be added to expand the bone window backward. 2) Since the brain tissue is in a swelling state after the brain injury, and the size of the bone window is definite when applying standard decompression craniectomy, the thin layer of potential subdural hematoma in the skull base cistern and other places cannot be cleared timely, causing cerebrospinal fluid circulation disorder, increasing the incidence of hydrocephalus, and worsening the patient's condition and prognosis; 3) Since the bone window is small in the operation of standard decompressive craniectomy, the temporal lobe, the frontal lobe, and the parietal lobe are not decompressed adequately, leading to cerebral ischemia and hypoxia, disorder of cerebrospinal fluid circulation, obvious secondary swelling of brain tissue after the operation, and incision hernia, further exacerbating the circulation disorder of cerebrospinal fluid and blood, softening the brain tissue in the decompressed area and causing vascular necrosis, increasing intracranial pressure, the rate of cerebral infarction and vascular occlusion, later causing cerebromalacia and cerebral atrophy of surviving patients, and increasing the incidence of epilepsy, and worsening the prognosis [5]; 4) After decompressive craniectomy for severe brain injury, changes of electrolytes and osmotic pressure in extracellular fluid and blood cause intra-

Table 1. Differences between new and standard decompressive craniectomy

		Standard decompressive craniectomy	New decompressive craniectomy
Scope	Surgical flap	The incision begins at 1 cm in front of the tragus, extends from the top of the zygomatic arch to the median line of the parietal bone, and then arcs along the median line to the inferior hairline of the forehead.	Starting from 1 cm ahead of the zygomatic arch upper tragus, extending upward from the back of the auricle to the parietal tuber, passing the middle line of the parietal bone, extending forward to the contralateral forehead within the hairline, then cutting 1-2 cm besides the middle line.
	Bone flap	The median sagittal sinus is opened 2-3 cm beside the bone flaps and free bone flaps are used to bite the sphenoid ridge and temporal bone as far as possible downward.	The front of the removing unilateral bone flap was flush with the anterior skull base; the inside needed to reach the middle line, the back reaching the parietal tuber and the outer or lower side reaching the middle skull base.
	Dura relaxation	The dura was cut to expose part of the frontal and temporal lobes.	The dura mater was cut from the front temporal lobe in the shape of a claw. The frontal lobe, the temporal lobe, the parietal lobe, the anterior cranial fossa, the middle cranial fossa and the intracranial hematoma could be fully exposed.
Incisional hernia and brain tissue incarceration		High probability of occurrence	Low probability of occurrence
Labbe veins and sagittal sinus		Difficulties in handling injuries	Damage treatment is relatively easy
Removal of combined skull base hematoma		Hard	Easy
Reconstruction of cerebrospinal fluid circulation		Poor	Preferably
Wound healing		Better	Poor
Postoperative infection rate		Low	High

cellular edema, also known as osmotic pressure brain edema. Since brain swelling is still evident after standard decompressive craniectomy, the dose of dehydration drugs such as mannitol increases significantly, which is reported to cause up to 20% impairment of renal function. Large doses of mannitol may lead to heart and kidney damage, increase the incidence of complications such as water, electrolyte imbalance, and also lead to hyponatremia and hypokalemia, which at the same time is also a major cause of secondary intracranial cerebral edema .

Considering the disadvantages of standard decompressive craniectomy, this new decompressive craniectomy was designed to make up for the disadvantages of standard decompressive craniectomy to some extent. Its advantages include: 1) full exposure of the lobe, the temporal lobe, and the parietal lobe, making the decompression more complete; removing about 95% of the unilateral supratentorial acute intracranial hematoma, and removing more effectively the hematoma in the anterior skull base and the middle concave bottom, which is conducive to the self-healing of hernia. Full exposure of the skull base, and the anterior longitudinal can clear skull base cistern hemorrhage more precisely, which is conducive to smooth cerebrospinal fluid circulation [6]; 2) full exposure of the veins on the surface and in the depth of the brain such as veins of the Labbe and the lateral fissure veins. Additionally, the lateral fissure cistern and the skull base cistern are fully opened in surgery. Removing the inferior vena hemorrhage, releasing the bloody cerebrospinal fluid, relieve cerebral edema and infarction, while reducing the incidence of arachnoid adhesion and arachnoid particles clogging, and reconstructing the cerebrospinal fluid circulation [6, 7]; 3) Bleeding of the superior sagittal sinus, the bridging veins, the transverse sinus will be controlled, as well as bleeding of the anterior cranial fossa, the middle cranial fossa, and the skull base, so that post-traumatic bleeding will be stopped more thoroughly, and the chance of a second surgery and the incidence of postoperative complications after the second surgery will be reduced; 4) The range of the bone window is large enough so the brain is fully exposed, reducing cerebral contusion and laceration and postoperative complications such as delayed intracerebral hematoma caused by excessive or inappropriate traction of the brain tissue, and reducing the incidence of malignant intracranial hypertension [2, 8, 9]; 5) a more thorough reparation of the torn dura, reducing the incidence of cerebrospinal fluid leakage.

The incidence of poor healing of scalp incisions and postoperative intracranial infection of the new decompressive craniectomy may be higher than the standard decompressive craniectomy. The possible causes of poor scalp healing are: 1) surgical incision: the scalp is rich in blood supply, mainly from the orbitofrontal artery, the superficial temporal artery and various branches, yet due to the large surgical incision on the scalp, damage to the branches of the superficial temporal artery is inevitable, causing poor or prolonged wound healing on the scalp; 2) Patients of severe brain injury need comprehensive treatment combined with mild hypothermia, during the process of which the head wears an ice cap for cooling. The low temperature reduces the blood circulation of the scalp, increasing the incidence of poor wound healing [5].

The causes of increased postoperative infection may be that: severe brain injuries are often accompanied by varying degrees of coma and vomiting, affecting the normal physiological function of patients, weakening immunity, and increasing infection rates. The high risk of intracranial infection in the new decompressive craniectomy is due to: 1) big surgical wound, poor local blood supply, and the incision which is close to the bacteria area through the parietal tuber; 2) long surgical incisions, large amounts of incision sutures, the large area of artificial dura mater required in intraoperative dura mater reparation, as well as the increases of the number and area of foreign matter, increasing the rate of infection; 3) possible open scalp lacerations and open fractures in surgical areas, which needs debridement first, and repeated rinsing by disinfectants such as saline, iodine and 2% of hydrogen peroxide, leading to wet draping, and increasing the chances of infection. In order to reduce postoperative scalp necrosis and the incidence of intracranial infection, surgical incisions and the drainage tube apparatus should be observed closely after the surgery. Dressings and drainage bags should be replaced regularly. The ward should be ventilated and disinfected on time to maintain environmental hygiene. Furthermore, medical care should be strengthened [2, 10].

Conclusion

The new decompressive craniectomy improved the prognosis, reduce disability, and mortality rates in the treatment of patients with severe and extra severe craniocerebral injury.

Acknowledgements

This study was funded by the National Natural Science Foundation of China (No. 81472343).

Disclosure of conflict of interest

None.

Address correspondence to: Yongchuan Guo, Department of Neurosurgery, China-Japan Union Hospital of Jilin University, 126 Xiantai Street, Changchun 130033, Jilin Province, China. Tel: +86 13504310682; E-mail: guoyongchuan@163.com

References

[1] Liu BY. Application of minimally invasive surgery in traumatic brain injury. Chin J Traumatol 2014; 17: 313-316.

[2] Timofeev I and Hutchinson PJ. Outcome after surgical decompression of severe traumatic brain injury. Injury 2006; 37: 1125-1132.

[3] Fujita Y, Algarra NN, Vavilala MS, Prathep S, Prapruettham S and Sharma D. Intraoperative secondary insults during extracranial surgery in children with traumatic brain injury. Childs Nerv Syst 2014; 30: 1201-1208.

[4] Qiao Y, Feng H, Zhao T, Yan H, Zhang H and Zhao X. Postoperative cognitive dysfunction after inhalational anesthesia in elderly patients undergoing major surgery: the influence of anesthetic technique, cerebral injury and systemic inflammation. BMC Anesthesiol 2015; 15: 154.

[5] Brown DA and Wijdicks EF. Decompressive craniectomy in acute brain injury. Handb Clin Neurol 2017; 140: 299-318.

[6] van der Werf AJ. Surgical management of acute subdural hematomas. Clin Neurol Neurosurg 1975; 78: 161-170.

[7] Bullock MR, Chesnut R, Ghajar J, Gordon D, Hartl R, Newell DW, Servadei F, Walters BC, Wilberger JE; Surgical Management of Traumatic Brain Injury Author Group. Surgical management of acute subdural hematomas. Neurosurgery 2006; 58 Suppl: S16-24.

[8] Huang CT, Lin WC, Ho CH, Tung LC, Chu CC, Chou W and Wang CH. Incidence of severe dysphagia after brain surgery in pediatric traumatic brain injury: a nationwide population-based retrospective study. J Head Trauma Rehabil 2014; 29: E31-36.

[9] Honeybul S, Ho KM, Lind CRP and Gillett GR. The current role of decompressive craniectomy for severe traumatic brain injury. J Clin Neurosci 2017; 43: 11-15.

[10] Lammy S, Fivey P and Sangra M. Decompressive craniectomy for malignant middle cerebral artery infarction in a 16-year old boy: a case report. J Med Case Rep 2016; 10: 368.