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Inverted gull-wing hinge decompressive craniotomy for infantile acute subdural hematoma: A case report

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Abstract:

Infantile severe acute subdural hematomas (ASDHs) usually require a decompressive craniotomy. However, these infantile patients often suffer surgical site infection and aseptic bone-flap resorption after external decompression. In this report, we showed a case of a simplified hinge decompressive craniotomy in an infant with severe ASDH. A 2-month-old girl suffered from status epilepticus, impaired consciousness, multiple rib fractures, bilateral fundus hemorrhage, and a right ASDH. We performed a simplified hinge decompressive craniotomy, making a vascularized bone flap with a hinge using the partial temporal bone and temporal muscle and not fixing the bone flap like an inverted gull wing. Cranioplasty was performed 4 weeks after the decompression craniotomy with replaced resorbable substitute dura. Six months after the transfer, her development was generally in line with her age. The decompressive craniotomy with an inverted gull-wing hinge has shown a good outcome.

Keywords:

Aseptic bone-flap resorption, hinge decompressive craniotomy, infantile acute subdural hematoma, inverted gull wing, surgical site infection

Introduction

Especially in infantile severe traumatic brain injury (TBI), not only primary brain damage but also secondary brain damage due to increased intracranial pressure (ICP) caused by brain edema or brain swelling can lead to fatal outcomes. On the other hand, the infantile brain is highly plastic, and a good outcome can be expected with appropriate treatment. The treatment of intracranial hypertension due to severe TBI, especially acute subdural hematoma (ASDH), is often difficult with medical management alone, and decompression craniotomy should be considered. Although decompressive craniotomy with external decompression is a relatively conventional neurosurgical technique, we should consider infantile-specific complications. External decompression may often result in aseptic bone-flap resorption (ABFR), even if cranioplasty is performed with an autologous cranial bone flap. In addition, epidural abscesses and surgical site infections (SSIs) often occur, which leads to aggressive postoperative treatment more difficult.[1]

In this report, we showed a simplified hinge decompressive craniotomy case in an infant with severe ASDH.

Case Report

A 2-month-old girl was referred to our department of pediatrics for status epilepticus. She suffered from impaired consciousness as 4 (equivalent to E1V1M2) by Pediatric Glasgow Coma Scale, multiple rib fractures at different phases, bilateral

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fundus hemorrhage, and multiple purpuras on the body surface [Supplementary Figure 1]. The head computed tomography (CT) scan revealed a right ASDH with an associated extensive area of low density in the right cerebral hemisphere, midline shift, and disruption of sagittal and lambda sutures. She was referred to our department for urgent decompressive craniotomy [Figure 1].

After the skin incision underwent in large question shape with attention to the superficial temporal artery, the gutter was drilled in the entire craniotomy area while dissecting partially only around the gutter and leaving most of the temporal muscle attachment. Fronto-parieto-temporal craniotomy was performed along the gutter by dural scissors, leaving the muscle and base of the temporal bone as a hinge. Inverting the bone flap along this guttered hinge, likewise inverted gull wing, we widely exposed the brain surface to search for the site of bleed and achieved hemostasis by toothbrush curettage technique,[2] avoiding cauterization as much as possible. Expansive duraplasty was performed using Gore-Tex artificial dura, the bone flap was left without anything further, and we closed a surgical incision politely [Supplementary Video 1].

The pediatrician and the emergency physician, who also treated her, administered continuous barbiturates until the left–right difference improved for 2 weeks while monitoring simple electroencephalography (EEG) on the O3 Regional Oximetry. After continuous administration of barbiturates, magnetic resonance imaging showed us the right motor cortex remained. The left insufficiency paralysis and hemilateral spatial neglect were improved by rehabilitation [Figure 1]. However, based on the postoperative CT imaging, we were concerned about the risk of posterior cranial growth inhibition, iatrogenic growing skull fracture, and uneven cranial bone growth due to suture failure and decompression craniotomy [Figure 2].

Cranioplasty was performed 4 weeks after the inverted gull-wing hinge decompression craniotomy, and the Gore-Tex artificial dura mater was replaced with resorbable substitute dura (polyglycolic acid) [Supplementary Video 2]. Prostaglandin E (PGE) ointment and appropriate compression by swimming cap was applied after both surgeries [Supplementary Figure 2]. Two weeks after cranioplasty, she was transferred to a rehabilitation center for the disabled with a medical education center. Six months after the transfer, the osteotomy line had almost fused without ABFR. Her development was generally in line with her age, although she had not fully recovered from her disability [Figure 2].

Discussion

Only a few reports discussed the efficacy and safety of hinge craniotomies, especially in infants. Schmidt *et al*.[3] established a novel craniotomy technique using titanium bone plates in a hinged fashion as a hinge decompressive craniectomy for all ages. Park *et al*.[1] developed a hinge

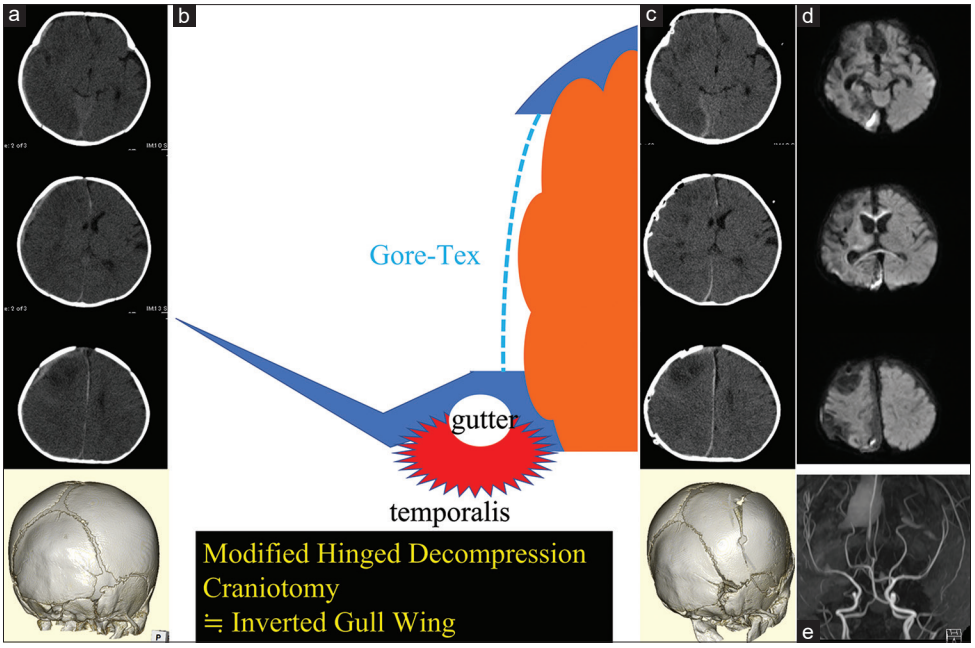

Figure 1: The initial head CT showed a right ASDH, with an extensive LDA in the right cerebral hemisphere, midline shift, and disruption of the sagittal and lambda sutures (a). Illustration of the concept of the inverted gull-wing hinge decompression craniotomy (b). Immediately after surgery, CT showed sufficient decompression (c). Three weeks after craniotomy, MR imaging showed the right motor cortex remained (d), and MR angiography showed postcommunicating artery was adult-type only on the ipsilateral side and fetal-type on the contralateral side (e). CT: Computed tomography, ASDH: Acute subdural hematoma, LDA: Area of low density, MR: Magnetic resonance

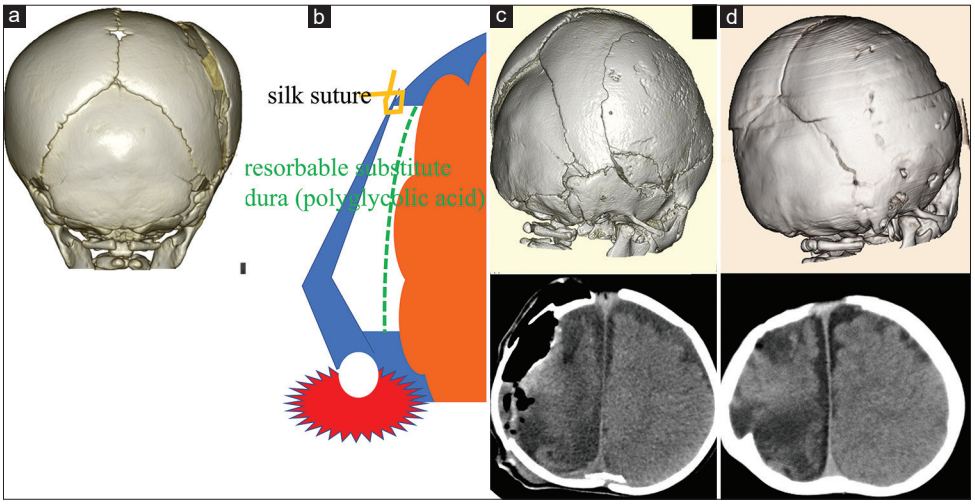

Figure 2: Three weeks after craniotomy, 3D-CT showed somewhat invaginated occipital bone and narrowed the sagittal and lambda sutures due to the decompression craniotomy (a). Illustration of the concept of the cranioplasty with resorbable substitute dura (b). On the first postcranioplasty day, 3D-CT showed an inverted gull-wing hinge bone flap was fixed without gaps (c). Six months after the transfer, 3D-CT showed the osteotomy line had fused without aseptic bone-flap resorption (d). 3D: Three dimensional, CT: Computed tomography

and floating decompressive craniotomy specialized in infantile. Compared with our technique, the original hinge and floating decompressive craniotomy had more superior concepts, such as removing the base of the temporal bone and expansive duraplasty using collected periosteum or resorbable substitute dura. However, our inverted gull-wing technique might enable shorter operative time by omitting fixed absorbable plates. Among the complications of decompressive craniotomy for severe TBI, ABFR is one of the most infantile-specific complications. Several reports told us that the complication rate of ABFR in adults is <10%, while that is about 50% in infants.[4,5] This reason is still unclear, but reports speculated this increased complication rate in younger children, especially in <2.5 years of age, may be related to the increased metabolic demands of the still-growing skull on the calvaria. Therefore, our technique might be more protective not only against ABFR but also against epidural abscesses and SSI. We followed the patient's progress until the last minute, hoping that cranioplasty could be avoided. However, we decided to perform cranioplasty because we observed signs of posterior cranial growth inhibition and iatrogenic growing skull fracture. Artificial dura mater was replaced with resorbable substitute dura (polyglycolic acid), so no artificial matter was left within intracranial space. If our institute had the ICP monitor, we might place the subgaleal drainage catheter to drain out cerebrospinal fluid and decrease ICP.[1]

PGE ointment and appropriate compression realized good operative scar healing repeatedly. A previous report revealed that PGE could ameliorate inflammation, augment angiogenesis at the injured sites during the early phase of tissue repair, and regulate the balance among the three overlapping phases – inflammation, regeneration, and remodeling during wound healing.[6] Other reports investigated that appropriate compression was one of the most successful and evidence-based techniques in preventing and treating hypertrophic scars, venous ulcers, burn scars, and so on.[7] Appropriate compression also controlled the balance among inflammation, regeneration, and remodeling and commonly reduced pain and itching and alleviated edema.[7] Due to the shape of the head and the hair, it has not been easy to apply proper pressure to neurosurgical scar. However, it might be possible to apply pressure with swimming caps. It also completely prevented the infant from scratching the scar without following our instructions. Of course, an elastic bandage applied by a skilled neurosurgeon would be equally or more effective. However, the compression material could be appropriately replaced by anyone, including paramedics and patients' relatives, using a swim cap if it became misaligned or soiled.

The pediatrician and the emergency physician seemed to focus on not only the spike but also the voltage of the simple EEG. This was interesting due to the similarities with our previous basic research after TBI.[8]

We need to observe more cases and follow the long-term course. In this case, it is also necessary to pay attention to developmental disorders similar to pediatric hydrocephalus and craniosynostosis in the future. The compatibility with hypothermia therapy and ICP monitoring should also be examined. Since our simplified hinge decompression craniotomy depends on the infantile specific elasticity of the skin and the thinness of the temporal muscle and cranial bone flap, it is controversial whether it could lead to successful results in children older than 1 year.

Conclusion

If the skull is thin enough and the skin is elastic enough, an inverted gull-wing hinge decompression craniotomy for infantile ASDH might probably help, and that future studies are needed to determine its efficacy and safety.

Declaration of patient consent

The institutional review board approved this study. The authors certify that they have obtained all appropriate patient consent forms. In the form, the legal guardian has given his consent for images and other clinical information to be reported in the journal. The guardian understands that names and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

Acknowledgment

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Nil.

Conflicts of interest

There are no conflicts of interest.

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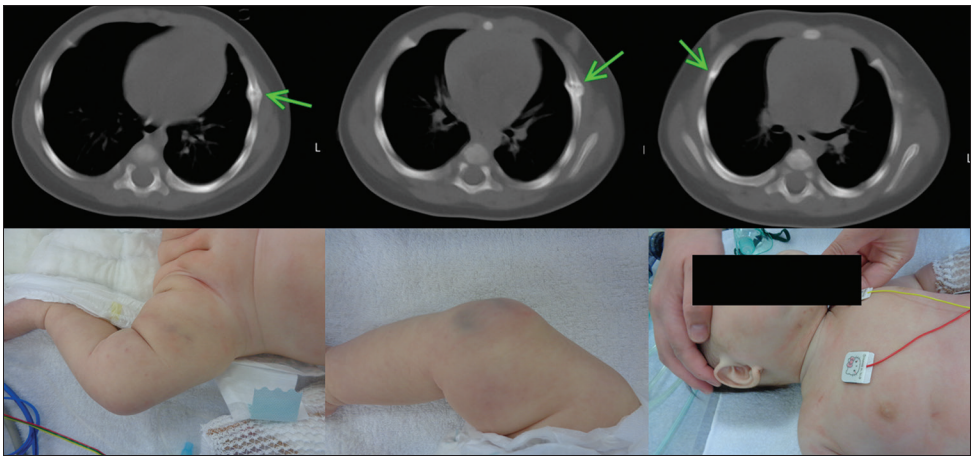
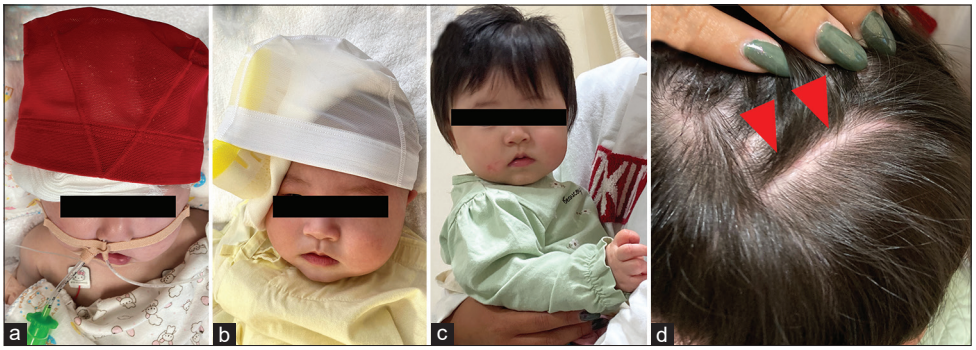


Supplementary Figure 1 (web only): The pediatrician found multiple purpuras on the body surface, and CT revealed multiple rib fractures at different phases (green arrows). CT: Computed tomography



Supplementary Figure 2 (web only): PGE ointment and appropriate compression were applied continuously by the swimming cap after decompression craniotomy (a) and after cranioplasty (b). Six months after the transfer (c) and the skin incision scars had healed, challenging to find even though we brushed her hair up (d). PGE: Prostaglandin, The red arrowhead indicates that the postoperative wound is barely noticeable