Successful repair of an encephalocele wound in a child following a car accident: A case report

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Abstract. Repair of large cranial complex traumas in children is difficult. Notably, children have poorer underlying conditions than adults and are frailer under trauma. In addition, children have more limited treatment options, leading to the need to consider long-term functional and aesthetic outcomes. The present report describes the case of a 2-year-old child weighing 9 kg who experienced a skull fracture with encephalocele after a car accident and had a poor underlying condition. An artificial dura mater combined with bone cement was used to repair the skull, and then a free latissimus dorsi muscle flap (LDMF) combined with a split-thickness skin graft (STSG) was used to cover the wound, allowing the child to overcome the life-threatening situation as soon as possible with a satisfactory outcome. LDMF combined with STSG is an ideal option in repairing head wounds in children. Preoperative imaging and postoperative care also serve an important role in the success of the operation. When the situation is critical, multidisciplinary team treatment can guarantee the safety of the child.

Introduction

The thin structure of the layers of the head often results in the loss of multiple layers of tissue and skull after trauma, and even the exposure of important structures, such as brain tissue (1). However, the limited amount of tissue in the head itself makes it difficult to provide an adequate donor site in the face of large defects. This situation is even more prominent in young children, thus forcing the consideration of free flaps. A free flap refers to a flap that is completely removed from the donor site and incorporates segments of vascularized mucosa, bone or nerve, as well as skin, which allows reconstruction of complex composite defects 'with like tissue' (2). Nutrition is supplied to the flap through microvascular anastomosis surgery and vascular anastomosis in the recipient area. The advantages of free flap reconstruction include selection of well-matched tissue, shape plasticity and reliable vascularity (3). Although free flap surgery in children is challenging, several studies have shown the same or even higher success rates as in adults (4,5). The present report describes the case of a 2-year-old child weighing 9 kg who experienced a skull fracture with encephalocele and life-threatening infection after a car accident. An artificial dura mater combined with bone cement was used to repair the skull, and the wound was then covered with a free latissimus dorsi muscle flap (LDMF) combined with a split-thickness skin graft (STSG), thus achieving a satisfactory result.

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Abbreviations: LDMF, latissimus dorsi muscle flap; STSG, split-thickness skin graft

Key words: trauma, scalp reconstruction, encephalocele, LDMF, STSG

Case report

In July 2020, a 2-year-old boy who was hit by a car and dragged for >100 m was taken to a local hospital for treatment in Tengzhou, China. Imaging revealed multiple fractures to the skull and body. Contusions were noted in the right frontal and temporal lobes of the skull, with a subdural hematoma, but the rest of the brain tissue was normal. The red blood cell count ($3.03x10^{12}$/l; reference range, 4.3-5.8$x10^{12}$/l) and hemoglobin levels (88 g/l; reference range, 130-175 g/l) were decreased, and various inflammatory indicators [white blood cells, 9.88$x10^9$/l (reference range, 3.5-9.5$x10^9$/l); D-dimer, 22.27 mg/l (reference range, 0-0.5 mg/l); C-reactive protein, 98.3 mg/l (reference range, 0-10 mg/l); interleukin-6, 287.5 pg/ml (reference range, 0-7 pg/ml)] were markedly increased. The child weighed only 9 kg, which was below the normal range for their age (reference range, 12.54-14.15 kg). The local hospital managed the wound debridement and provided allograft skin coverage of the wound. Tracheal intubation was preserved after surgery, and the child was transferred to the pediatric intensive care unit (PICU) of Shandong Provincial Hospital (Jinan, China). After admission, the parents of the child were given a critically ill notification. The patient was treated with linazolamide (10 mg/kg, three times a day, intravenous injection for 14 days), a blood transfusion (300 ml plasma, 2U red blood cells suspension leukocyte reduced and 4U cryoprecipitate) and mechanical ventilation. First, the fractures and trauma of the extremities were treated cooperatively using a multidisciplinary team (MDT) approach. The left upper limb underwent debridement and skin grafting, and the left femur fracture underwent open reduction and internal fixation. The head, although the most damaged, having been debrided and covered, was temporarily more stable and did not require MDT treatment. However, after ~1 week, the allograft showed signs of infection and decay (Fig. 1A). The neurosurgeon chose to repair the skull using bone cement and requested that the plastic and reconstruction team cover the wound. Three-dimensional computed tomography angiography (CTA) showed partial leakage of brain tissue within a defect area of 12.10x9.57 cm^2 (Fig. 1B). The child was also in a poor physical condition and would most likely not be able to tolerate the cranium restoration surgery; therefore, LDMF plus STSG was considered to yield better results. The superficial temporal artery was selected as the recipient vessel in the head. The superficial temporal vein is shown in blue in Fig. 1C, whereas the stump of the superficial temporal artery is visible in Fig. 1D.

Surgery was performed on day 9 post-trauma, beginning with removal of the infected leaking brain tissue by the neurosurgeon. The allograft skin was opened and the brain tissue was observed to be expanding along the defect (Fig. 2A). The size of the bulge was ~4x5 cm^2 (Fig. 2B). After an incision was made into the dura mater of the brain tissue at the bulge, the necrotic brain tissue and the subdural hematoma were removed (Fig. 2C). The dural defect was repaired with an artificial dura and bone cement shaping (Fig. 2D). The LDM contours were marked preoperatively (Fig. 2E). A left LDMF was created during surgery; it was separated from the deep fascia layer and deep muscular layer, and was detached keeping the latissimus dorsi muscle intact. The thoracodorsal artery was preserved and the anterior serratus branch of the thoracodorsal artery was dissected (Fig. 2F). Next, split-thickness skin measuring ~15x10 cm^2 was harvested from the right dorsal side. The dorsal thoracic and superficial temporal arteries were anastomosed (Fig. 2G). The muscle flap was matched to the shape of the wound. After the blood supply and venous return were clear, the flap was sutured and covered with an STSG.

The flap was in good condition on the first day after a dressing change (Fig. 2H). Some necrosis was noted at the distal end of the flap on postoperative day 3, but the overall flap tissue survival rate was excellent (Fig. 2I). A total of 1 week post-surgery, it was recommended that the PICU withdraw the ventilator. The child then remained stable, and their physical condition gradually recovered until they were considered out of critical condition. The red blood cell count ($3.96x10^{12}$/l) and hemoglobin levels (123 g/l) increased, whereas their inflammatory marker levels (white blood cells, $13x10^9$/l; D-dimer, 1.22 mg/l; C-reactive protein, <4.00 mg/l) decreased. The sutures were removed at 9 days post-surgery (Fig. 2J). The child was discharged from the hospital 19 days after surgery. A total of 1 month after surgery, the patient returned for follow-up, and the overall recovery was excellent except for partial necrosis of the distal portion of the flap (Fig. 2K). This part also healed after dressing change treatment. At 1 year later, the internal fixation of the left femur was removed.

After a 3-year follow-up period, both the recipient (Fig. 2L) and donor (Fig. 2M) sites of the patient had recovered well. The surgery did not affect limb development, including differences in upper limb strength compared with children of the same age. In October 2023, the patient had mild scoliosis caused by the missing latissimus dorsi muscle, and the child's parents have been informed to pay attention to daily exercise and fixation of orthosis, such as Boston orthosis or Crass Cheneau orthosis. An intelligence test, the Denver Development Screening Test (6), was performed and the result was normal. The patient underwent cranial CT 1 year after surgery and no abnormalities were found. Considering the economic situation of the parents, it was suggested that if they detected no abnormalities, the patient could wait and undergo a cranial CT scan once the body rapidly grows during adolescence. The child has already attended kindergarten and the parents have not identified any other abnormal intellectual or physical activity in their daily lives. The chronological order of the treatments administered to the patient is shown in Fig. 3.

Discussion

Free flap surgery in children is usually considered to be more challenging compared with adults due to the smaller vessels that may be more prone to vasospasm and difficulties in postoperative care. Recovery of the donor area and the impact on patient growth must also be considered (7). However, a number of studies have shown a high success rate of free flap surgery in children. Five articles, including 646 children with a total of 694 free flaps, were reviewed in a previous study, with an overall survival rate of 96.4% of the free flaps (8). Reasons for the high success rate may include the absence of a history of smoking and of underlying diseases affecting the vasculature, and the fact that the vessels are not small relative to the flap volume (9). There may also be a relatively subjective reason, as surgeons who perform free flap surgery in children usually have abundant microsurgical experience (5), which may ensure a certain degree of success. However, pediatric free flap surgery is usually a selective operation, and the child is in good underlying condition to tolerate the surgery and recover quickly. By contrast, in the present case, the child had a life-threatening condition, which posed a significant risk to the surgery.

The success of the procedure also requires adequate preoperative preparation and careful postoperative care. Imaging is important before surgery, including ultrasound, CTA, magnetic resonance angiography, infrared imaging and indocyanine green fluorescein angiography. CTA has excellent specificity and sensitivity in microsurgery, and also has the advantages of being frequently available and cost-effective (10). Notably, the three-dimensional reconstruction of CTA images displays the recipient and donor sites well. In addition, for selective operations, it is possible to screen and detect obesity, hereditary diseases or syndromes, atopic diseases, psychiatric

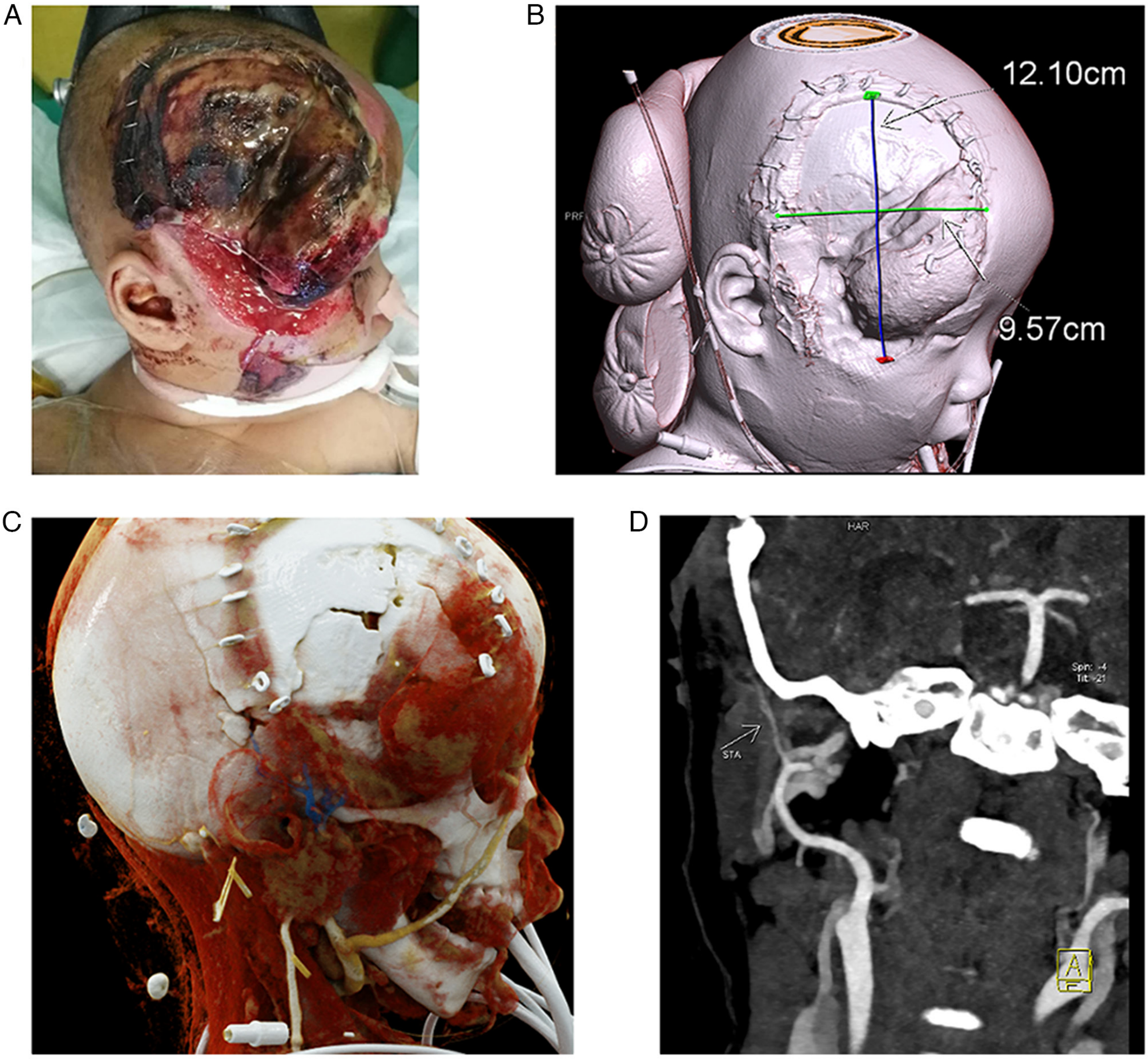

Figure 1. Preoperative situation. (A) Allograft skin covering the brain tissue. (B) 3D-CTA showing the extent of the scalp defect. (C) 3D-CTA showing the vessels in the auriculotemporal region, with arteries in red and veins in blue. (D) White arrow in the CTA pointing to the severed end of the superficial temporal artery. 3D-CTA, three-dimensional computed tomography angiography; STA, superficial temporal artery.

disorders and the presence of a history of radiotherapy (11). As well as preoperative preparation, postoperative care and monitoring are crucial; Li *et al* (4) reported that sedation or general anesthesia could be withheld if the child could cooperate to keep quiet with the parents. However, other studies have suggested that pain medication and sedation can be used appropriately depending on the mental status and tolerance of the child (5,12). Some studies have also suggested that children should be placed in the ICU within 24 h of surgery to ensure regular monitoring of the flap (13). The child in the present case was admitted to the PICU due to a poor underlying condition, thus they were maintained in the PICU post-surgery. Another potential issue is whether the blood vessels of children are more prone to vasospasm (13,14). Although there is no uniform answer, there is a general agreement that monitoring is critical for 3 days post-surgery, a period when vasospasm or embolism are more likely to occur (5). Although necrosis occurred distal to the flap in the present case, no postoperative vascular problems were identified. It may be hypothesized that the necrosis is more likely related to the weak physical condition of the patient and the presence of curvature in the flap.

Donor site selection is also an important issue for free flap surgery in children. As the child grows, the donor site may have growth disturbances or developmental asymmetry, especially in areas where muscle has been excised (9). Although prospective studies are lacking, numerous retrospective studies have shown a low incidence of growth disturbances at the donor site (9,15). In the present case, the wound area had reached 3-4% of the total body surface area. For a child with such a low body weight, the anterolateral femoral flap and the deep inferior epigastric perforator flap do not have as much tissue volume as in adults, and the latissimus dorsi flap was thus considered the most suitable. Moreover, from the infection point of view, this muscle has

Figure 2. Intraoperative and postoperative conditions. (A) Removal of allograft skin; (B) brain tissue expanded along the defect; (C) removal of necrotic brain tissue; (D) bone cement shaping; (E) marking the left LDMF; (F) excision of the left LDMF; (G) immediate vascular anastomosis; (H) dressing change on postoperative day 1; (I) darkening of the distal end of the flap on postoperative day 3; (J) sutures removed at 9 days post-surgery; (K) 1 month after surgery; condition of the (L) recipient and (M) donor sites 3 years after surgery. LDMF, latissimus dorsi muscle flap.

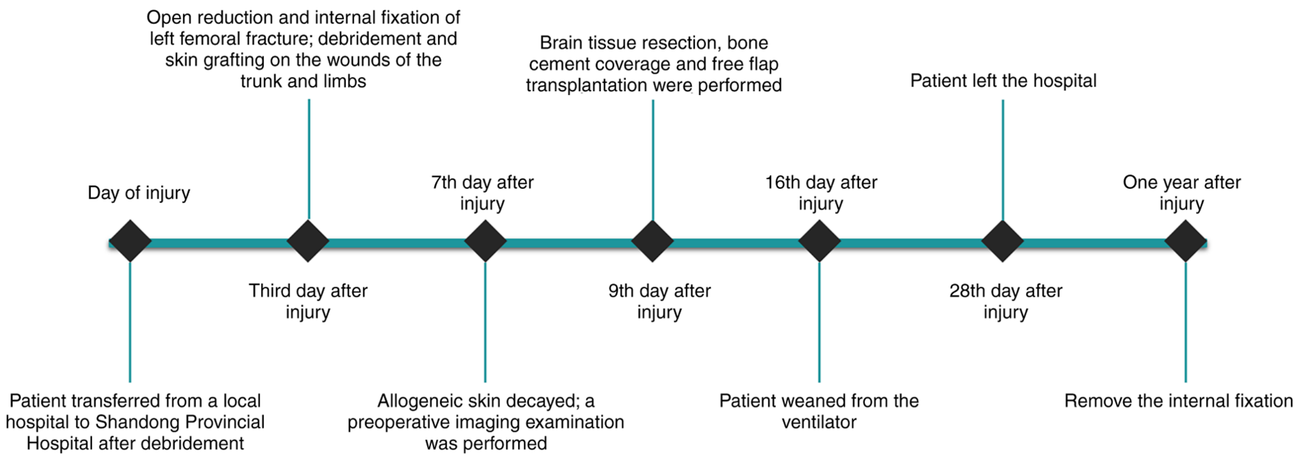

Figure 3. Treatment timeline for the patient.

a stronger resistance to infection. From the perspective of damage to the child, the child had multiple fractures and trauma throughout the body, and their underlying condition was poor. Therefore, taking a muscle flap combined with an STSG could reduce trauma and may be easier to plasticize. Upton and Guo (14) used muscle combined with an STSG when covering injuries in children with trauma and infected wounds. Due to its extensive coverage, thin thickness, flexibility and minimal donor area injury, the LDMF combined with skin graft is considered the best choice for subtotal or total scalp reconstruction (16,17).

In the treatment of the child reported in the present case, cranial trauma coverage was only part of the process. The whole body treatment also relied on the combined efforts of several departments, including PICU, neurosurgery, pediatric orthopedics and imaging. Thus, a MDT treatment approach is very important in the treatment of large complex injuries in children. Currently, in addition to cancer, more pediatric diseases require MDT intervention for safe and considerate treatment.

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Availability of data and materials

Data sharing is not applicable to this article, as no datasets were generated or analyzed during the current study.

Authors' contributions

ZL and GX designed the study, searched the literature and wrote the first draft of the manuscript. PZ obtained and processed patient's and CTA images. XY contributed to acquisition of data and interpreted the relevant information. GX and ZZ were responsible for formulating the patient's treatment plan. CF and RH contributed to analysis and interpretation of data, critical revisions of the intellectual content and confirm the authenticity of all the raw data. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Written informed consent was obtained from the guardians of the patient for the publication of any accompanying images or data included in this article.

Competing interests

The authors declare that they have no competing interests.

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