

# A case report of extremely severe 93% total body surface area burns in a 5-year-old boy

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**Abstract. – BACKGROUND:** Large surface area burns with concurrent severe burn sepsis are a rare phenomenon, particularly when the wounds are closed in a short timeframe.

**CASE REPORT:** This study describes a 5-year-old patient with 93% total body surface area (TBSA) burns and severe burn sepsis, who was managed through the use of a 54-day brickwork-mixed graft of self-allogeneic skin operation. The mechanisms of skin healing, in this case, are also discussed.

**CONCLUSIONS:** The brickwork-mixed graft of self-allogeneic skin may be an effective treatment option for patients with large surface area burns and severe burn sepsis. Further research is required to establish the generalizability of these findings. Early wound management and anti-infection measures are crucial in treating severe burns, and the clinical outcomes of the patient and the impact of the chosen treatment method on the patient's recovery and prognosis should be assessed.

*Key Words:*

Skin grafting, Self-allogeneic skin, Burn sepsis.

## Introduction

Patients with large surface area burns and severe burn sepsis are rare in clinical practice. This is especially true when the burn covers more than 90% of the total body surface area (TBSA). After the right amount of time has passed for a wound to heal, the loss of autologous skin makes it hard to choose the best way to do a skin graft. As the injury advances to later stages, managing the patient's condition becomes increasingly challenging. Although cases of survival among such patients have been reported<sup>1</sup>, there is a lack of statistical data in this regard. This case report aims to present a patient who exhibited 93% TBSA burns and concomitant sepsis.

## Case Presentation

A five-year-old boy was brought to our hospital with severe burn injuries due to a house fire incident. He was referred to our hospital after receiving initial treatment at a local hospital and further management and treatment was provided by our team.

### *Initial Management and Treatment at Previous Hospital*

The patient in question underwent a series of medical interventions following the initial injury he sustained. Upon admission to a local hospital, debridement of the burn wounds was performed under emergency general anesthesia, along with the implementation of central venous catheterization and fluid supplementation. Additionally, anti-shock and anti-infective measures were instituted, and the patient was placed under urinary catheterization to monitor changes in urine volume. Following consultation with neurosurgery, debridement and suturing of a scalp laceration were performed. Post-operative tracheal intubation was conducted in the ICU, followed by a tracheostomy procedure and the initiation of artificial respiration and auxiliary support. The patient was regularly monitored for changes in blood gas analysis, vital signs, urine output, and urine specific gravity, with alterations made to the treatment plan as necessary. Escharotomy and xenogenic acellular dermal matrix covering were performed on specific limbs after the patient stabilized, with a subsequent transfer to the present hospital occurring 16 days post-injury.

### *Management and Treatment at Recent Hospital*

#### *Physical examination*

Upon admission, the physical examination of the patient revealed 93% TBSA burns sparing the head, bilateral groin, and right mid-axillary line.

The wounds on the extremities were covered with biological dressing, and the ends of the extremities were warm with limited movement. The wound was heavily polluted, foul-smelling, and covered with purulent secretions. It was scattered with infected necrotic tissue, old granulation tissue hyperplasia was evident, and the visible vascular network had a partial vascular embolism. The patient's trunk was covered with necrotic scab and purulent secretions, and the area of partial scab loss revealed both necrotic tissue at the base of the wound and an increase in the proliferation of old granulation tissue. The wound on the patient's face and neck had moderate exudation and little necrotic tissue. Examination also showed a cervical tracheostomy with fixed cannula and gastric tube that could be appreciated through the nose, which was firmly fixed and unobstructed.

#### ***Course of Management and Treatment at the Recent Hospital***

Since the patient was admitted to our hospital, he underwent 5 operations for his condition.

On the day of admission (16 days after the burn), the patient underwent his first operation,

“whole-body wound debridement and dressing change”. Biological dressings on the wound surfaces of the limbs were removed in stages, as it was necrotic tissue. Intraoperative blood loss was controlled. Large amounts of benzachloramine, gentamicin saline, and sodium polyglucuronic acid medical bio colloid solution were alternately used to rinse the wound, and antibiotic gauze dressings were applied. Silver ion dressings and anti-infective drugs were used externally, and then pressure was applied to the wound with sterile dressings, as we show in Figure 1.

The second operation, “scalp skin extraction + escharotomy and auto-allograft mixed graft of double lower limbs + wound debridement with biological dressings covering double upper limbs + dressing change of face, neck, and trunk”, was carried out on the 9<sup>th</sup> day of admission to the current hospital. Around 6% allogeneic skin was taken from the lower limb of the patient's father for use before surgery, and the skin slices were soaked in sterile gentamicin and dexamethasone external saline for reserve. The patient was then placed in the supine position, and after success-



**Figure 1.** a, The burns wound of the trunk when he was admitted to our hospital; (b), the burns wound of the left lower limb; (c), necrotic tissue in the base of the wound.

ful anesthesia, the tracheal cannula and deep vein catheterization were replaced. Routine disinfection and draping were then performed. Approximately 3% autologous skin was taken from the head of the patient and placed in sterile saline as a reserve. The donor area of the head was given growth-promoting and anti-infective drugs for external use. Moreover, alginate dressing was applied externally, and sterile dressing was applied for pressurized dressing. The scab was cut with a roller knife on the wounds of both lower limbs, and the necrotic and degenerated tissues were removed until fresh bleeding was found in the base. Large amounts of benzachloramine, gentamicin saline, and sodium polyglucuronic acid medical colloids were alternately used to rinse the wound, and antibiotic gauze was applied to completely stop the bleeding. The patient's autologous skin was cut into 0.5x0.5 cm skin slices, and his father's allogeneic skin was cut into 0.5x1.5 cm long skin slices, which were arranged and then grafted on to the wound surfaces of the lower limbs after debridement. Silver ion dressings and anti-infective drugs were used externally, with pressure being applied to the wound with sterile dressings. Toe blood circulation was found to be sufficient, and the wound surfaces of both upper limbs were simply debrided, with some necrotic tissue being retained. Biological dressings were covered, and sterile dressings were pressurized and bandaged. The wounds of the trunk, head, and neck were debrided and dressed, as we show in Figure 2.

On the 17<sup>th</sup> day of admission, the 3<sup>rd</sup> operation, "right trunk skin extraction + escharotomy and auto-allograft mixed graft of double upper limbs and trunk + dressing change of head, neck, and both lower limbs", was performed. Around 6% allogeneic skin was extracted from the lower limb of the patient's father, and the skin slices were soaked in sterile gentamicin and dexamethasone external saline for reserve. The patient was placed in the supine position, and after successful anesthesia, routine disinfection and draping were performed. About 4% autologous skin was taken from the patient's right torso, which was placed in sterile saline as a reserve. The donor area of the trunk was administered with growth-promoting and anti-infective drugs for external use; a biological cellulose dressing was applied externally, and an aseptic dressing was pressurized and bandaged. The wounds of both upper limbs were scabbed with a roller knife to remove the necrotic and degenerating tissue until fresh bleeding occurred in the base. Simple debridement was given to the trunk wound

to remove part of the necrotic tissue, and was alternatively washed with benzachloramine, gentamicin saline, and sodium polyglucuronic acid medical biological colloid solution, and wet compression with antibiotic gauze was done to completely stop the bleeding. The patient's autologous skin was cut into 0.5x0.5 cm skin slices, and his father's allogeneic skin was cut into 0.5x1.5 cm long skin slices, which were arranged in intervals and grafted on the wound surface of both upper limbs and the trunk (lower abdomen) after debridement. Silver ion dressings and anti-infective drugs were used externally, and then a sterile dressing was used to apply pressure on the wound. End blood circulation in the fingers was adequate. Debridement and dressing changes were given to the wounds on the lower limbs. Good vascularization of the grafted skin was observed, and the sterile dressing was pressurized and bandaged see Figure 3.

After 37 days after the burn injury (the 22<sup>nd</sup> day of admission), the fourth operation, "whole-body wound debridement and dressing change", was carried out. The patient was placed in the supine position, and after successful anesthesia, routine disinfection and draping were performed. The wound dressings on both the lower limbs, both arms, the torso, the head, and the neck wound were changed one by one. Adequate survival and growth of the grafted skin slices were observed. Simple body wound debridement was given, and compound *radix arnebiae* oil, polymyxin B plus ointment, and growth-promoting drugs were used externally. Silver-ion dressings and sterile dressings were pressurized and bandaged see Figure 4.

On the 39<sup>th</sup> day of admission, the 5<sup>th</sup> operation, "systemic residual wound debridement plus autologous skin transplantation", was carried out at the current hospital during the course of the stay. The residual wound of the whole body was debrided with a scalpel to remove the necrotic tissue, and aging the granulation tissue was done until the wound was fresh and punctate bleeding occurred. Hemostasis was completely stopped, the wound was rinsed with bromo-geramine, antibiotic normal saline, and Shuyoukang successively, and the wound was wetted with antibiotic gauzes. A motor dermatome was used to remove about 1% of the thin, medium, and thick skin from the femoral part, and then small skin patches were made and transplanted on the wound surface. The skin grafting area was about 1.6%, followed by the external application of a silver ion dressing, antibiotic gauzes, dry gauzes, and pressurized dressings, as we show in Figure 5.



**Figure 2.** a-d, the burn wound condition of the whole body, left upper limb, right upper limb and both lower limbs respectively; (e), the wound of right lower limb after tangential excision; (f), the wound of left lower limb after tangential excision; (g), the right lower limb after skin grafting; (h), taking autologous skin from the patient's scalp; (i), autologous skin slices (0.5x0.5 cm) and allogeneic skin (0.5x1.5 cm).

### **Outcome and Further Plan**

Through these 5 operations, the whole body of the patient's wounds was sealed with skin graft-

ing, and the treatment of burn wounds was completed. The next step was to provide scar rehabilitation treatment.



**Figure 3.** a-b, the skin graft of double lower limbs survived; (c), the wound condition of left upper limb before tangential excision; (d), the wound condition of left upper limb after tangential excision; (e), autologous skin slices (0.5x0.5 cm) and allogeneic skin (0.5x1.5 cm).

## Discussion

### **Multimodal Treatment Centered on Surgery**

#### *Peri-operative treatments*

Considering the patient's situation, i.e., young age, critical condition, and poor tolerance, the treatment plan was to change the dressing regularly in batches, and only about one third of the burn wound area was changed every day. Simultaneously, the patient was provided with a reasonable adjustment of dressings according to the arrangement of skin grafting surgeries. Moreover, if changes in body temperature and wound infection were noticed, the dressing was immediately changed, which not only ensured the effect of a dressing change, but also greatly reduced the damage to the body and the intensity of pain. Furthermore, a plan to improve wound base was also devised while providing infusions to correct electrolyte disorders and acid-base imbalance, while ensuring the protection of the function of each organ, thus improving immunity, along with targeted nutrition support treatment<sup>1</sup> to prevent and correct severe malnutrition. According to the results of blood and wound

secretion cultures, antibiotics were used to treat burn sepsis effectively. The patient's condition was closely monitored, and the therapeutic regimen was adjusted in accordance with the relevant test results. In order to ensure the patient's stable condition, surgical treatment was reserved to be carried out as soon as possible in order to close the wound.

#### **Early Rehabilitation Treatment**

Scar rehabilitation treatment was initiated on the fourth day of admission to our hospital. Because the patient's wounds were deep, scar hyperplasia was inevitable, and some parts were at a greater risk of affecting the child's function and growth. Early intervention for scar formation is closely related to factors such as wound treatment, dressing changes, etc. During the operation, we tried to fix the joint in a functional position and provided moderate compression treatment to the wound at ordinary times to prevent scar hyperplasia. At the time of the dressing change, active communication with the patient's parents was also done in order to teach them how to carry out functional exercises, which may help in early management to better prevent excessive hyperplasia of scars.



**Figure 4.** a, The patient's wound was basically closed, with scattered residual wounds; (b-d), residual wounds of the left upper limb, trunk and double lower limbs respectively



**Figure 5.** a, The wound of the left upper limb on 40<sup>th</sup> day of admission; (b-c), the wound of the right upper limb on 40<sup>th</sup> day of admission; (d), the wound of the double lower limbs on 40<sup>th</sup> day of admission; (e), local wound healing condition.

### ***Multidisciplinary Consultation***

The Department of Burn and Pediatrics of our hospital collaboratively formulated a nutritional program. Multiple data showed that hyper-metabolism is the main cause of poor prognosis after burns, and treatment and alleviation of this issue would be beneficial to the patient and is likely to improve the prognosis<sup>2</sup>. Early and adequate enteral nutrition can also reduce catabolism and further improve the prognosis. We aimed to provide adequate energy supply and essential nutrients for maintaining organ function and survival through appropriate nutritional support, while avoiding hyperglycemia, carbon dioxide retention, organ fat infiltration, and hyperazotemia caused by overfeeding in children. In collaboration with the Pediatrics Department, we developed a personalized program that met both the nutritional needs and special nutritional needs of the patient in early childhood and under burn stress, respectively.

### ***Finding and Applying an Appropriate Wound Covering***

#### *Previous treatment and current plan*

As the patient was a child with a large burn wound, accompanied by severe burn sepsis, it was difficult to find an appropriate wound covering for his treatment. According to general clinical experience<sup>3</sup>, biological dressings or artificial

dermal scaffolds are usually used repeatedly as the covering while waiting for enough autologous skin sources to close the wound for autologous skin grafting. While this method may prolong the treatment period of patients and greatly increase the treatment cost, the autologous skin of patients with large areas of deep burn remains minimal, and the quality of the skin source becomes poor after repeated skin donation in the donor area, making it difficult to reuse it in a short time. In clinical practice, acellular dermal matrix made from pig skin has a weak anti-infection ability and is mostly used for fresh second-degree burn wounds in the early stages<sup>3</sup>. However, it is rarely used for granulation wounds or residual wounds with necrotic tissues in the late stages of burns, where there is a risk of developing subcutaneous pyosis and effusion and where it can cause infection. After receiving “acellular allogeneic dermal dressings” twice at the local hospital, the child developed severe burn sepsis<sup>4</sup>. We believe that the continuation of such strategy cannot fundamentally improve the condition of the child and may even delay the progress.

#### *Meek micro-skin transplantation*

Recent research<sup>3</sup> has looked into how well Meek micro-skin transplantation works as a main way to add skin. This method has been suggested<sup>3</sup> as a good way for burn patients to get rid of scabs

quickly. But as these patients move through the middle and late stages, the survival rate of autologous skin becomes unstable, unreliable, and hard to control. This presents a significant challenge in wound closure, leading to prolonged hospital stays, increased medical costs, and even endangering the patient's life.

Studies<sup>2-4</sup> have shown that people with large, deep burns are more likely to get some kind of infection in the middle and later stages of treatment. But it might not be a good idea to use Meek micro-skin at these stages because the crepe material used does not help wounds drain, which can increase the risk of infection and lower the chance of autologous skin surviving. In children with a severe lack of autologous skin sources, Meek micro-skin transplantation may be a risky option because the only remaining autologous skin graft could fail and kill the child. Additionally, the implementation of autologous stamp skin transplantation is also difficult.

Therefore, it is important to carefully consider the appropriate skin grafting method in the middle and late stages of treatment, when the infection is controlled and base conditions are favorable, in order to optimize the skin grafting area and improve the survival rate of the graft.

#### *Active wound covering techniques*

We considered using an active wound covering – fresh allograft skin mixed with the child's remaining autologous skin. Intermingled transplantation is a technique that combines the use of both autologous and allogeneic skin. This can include the use of large allogeneic skin pieces embedded with small pieces of autologous skin, large allogeneic skin and autologous micro-skin composite grafts, and a 'brickwork' pattern of mixed autologous and allogeneic skin grafts<sup>5-7</sup>.

Large allogeneic skin embedded with small pieces of autologous skin is used to make a longitudinal incision at an equidistant distance of 1 cm on the large allogeneic skin. During the transplantation of the small allogeneic patches, the longitudinal incision is cut into square windows, and the windows are embedded with the autologous small skin patches, with no gap between the edge of each patch and the edge of the window. However, this method is time-consuming and not labor friendly. The local scar after wound healing is more serious, and the need for allogeneic skin is also larger. Although composite grafting of large allograft and autologous microskin is recognized as the most effective method for the treatment of patients with large area deep burns, small particles can be

made by using scissors or a skin rolling mechanism and placed in normal saline to float on the water's surface. The fine skin can be transferred to the allogeneic skin by the silk cloth transfer method. However, because the skin is so small, during transplantation it is difficult to guarantee complete consistency, and autologous skin spacing is difficult to keep uniform, which can lead to some wounds being insufficiently covered. This would increase the risk of bleeding and infection and may lead to the failure of transplantation. Even worse could be acute rejection, heavy wound infection, and poor general condition due to allogeneic skin getting ulcerated accompanied by subcutaneous effusion and empyema, which will directly affect the survival of autologous skin beneath.

Both of these methods mentioned above require a large allogeneic skin, but since January 1<sup>st</sup>, 2015, China has completely stopped using organs from executed prisoners as transplant donors<sup>8</sup>, and the only channel for organ transplantation now is voluntary organ donation after the deaths of citizens. Compared to other countries, it is more difficult to obtain a large number of allogeneic skin in China, and both methods have a risk of the autologous skin not surviving due to the rejection reaction of allogeneic skin. In contrast, an allogeneic skin brick-laying hybrid graft involves preparing autologous skin into small pieces (such as 0.5 cm × 0.5 cm or 0.8 cm × 0.8 cm, etc.), which are then evenly transplanted onto the wound surface at a certain distance. This is followed by the placement of a strip or stamp-shaped allogeneic skin in between the transplanted pieces. This method has achieved good clinical effects in repairing recurrent infections and refractory wounds.

#### *Active wound covering technique used for our patient*

After discussion, we decided to use the skin of the patient's father as the source of allogeneic skin, considering the urgency of the situation coupled with the economic status of the child's family. Two allogeneic skin brick-building mixed grafts were carried out for the patient on an urgent basis. The operation was successful, and the clinical treatment effect was satisfactory. There was almost no descaling in the late observation of the closed wound, and from the appearance, the allograft skin of the father had a good fusion with the wound in the child. The allogeneic skin of the relative and the autogenous skin of the patient were mixed and transplanted in a certain proportion. It was easy to establish a blood supply to both the skin and the



base. The autogenetic epidermal cells gradually replaced the allogeneic epidermal cells through proliferation and spread to cover the allogeneic dermis, so the wound healing was achieved.

#### *Possibly theories behind successful graft without rejection*

According to relevant literature and clinical experience, we consider the following possible reasons for the interphase A mixed graft consisting of both related-donor allograft and auto-blade-thick skin pieces. to repair the wound surface without rejection; (1) “Sandwich phenomenon”. Relative allogeneic skin transplantation is equivalent to homologous gene transplantation with good histocompatibility, low rejection reaction and the allogeneic skin has short time *in vitro* and high activity. When the allograft survived for a certain period of time, the allograft epidermis began to desquamate, and the autologous skin gradually expanded to the four sides. This phenomenon indicates that the allogeneic dermal collagen is retained, and the surrounding autologous epidermal cells gradually crawled to replace the allogeneic epidermis. Finally, the allogeneic dermal tissue was covered under the autogenetic epidermis, and the wound healed; (2) local immune tolerance induced by autologous epidermal cells: due to “autologous skin island effect”, i.e., autologous and allogeneic skin grafts are mixed and autologous epidermal cells induce immune tolerance, so that allogeneic skin is not rejected, while strips of allogeneic skin without allogeneic skin grafts around them will dissolve and fall off; (3) the mechanism of immune tolerance may be related to “immature dendritic cells” and “keratinocytes<sup>10</sup>” etc., but it is not clear yet and needs to be further studied.

### Conclusions

With the progress of burn treatment techniques, the survival rate of patients with large-area deep burns has seen an improvement. Effective anti-shock measures, prompt toxin elimination, and anti-infection strategies, in conjunction with the maintenance of vital organ function, play crucial roles in the management of such patients. However, the most critical and complex aspect of treatment remains the early management of the burn wound. A potential solution to this challenge is the implementation of a combination approach to skin grafting, utilizing both allogeneic skin from healthy donors and autologous skin from the patient. This not only overcomes the limitation of skin availability,

but also has the potential to significantly decrease the overall medical costs associated with treatment, providing a favorable outcome for patients with large-area deep burns and therefore warranting further consideration and promotion.

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#### Conflicts of Interest

The authors declare that they have no conflicts of interest.

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#### Data Availability

The data used to support the findings of this study are included within the article.

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#### Authors' Contributions

All the authors were involved in the clinical case of the patient, preparing and reviewing the manuscript. All authors read and approved the final manuscript.

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#### Informed Consent

The consent form was provided by the authors to the guardian(s) or relative(s) of the case report, whose signature indicates knowledge and consent.

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#### Ethics Approval

The medical Ethics Committee of Jinan Central Hospital approved the exemption of ethical review for articles reporting a single case or series of cases, so there was no consent grant number.

The article “A Case Report of Extremely Severe 93% Total Body Surface Area Burns in a 5-Year-Old Boy” does not involve the leakage of patient privacy and is hereby declared.

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