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Recurrent Scalp Autografting in Pediatric Major Burns: A 20 Year Follow Up Case Study

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Abstract: ***Accidents involving burns affect a large part of the world's population, particularly vulnerable children. Treating children with extensive burns is challenging because of their smaller body surface area. The scalp serves as an important donor site for skin grafts in such cases due to its characteristics that enable faster healing. This case report describes a nine-month-old child with extensive burns on the lower limbs caused by direct flame. The child underwent multiple stages of surgical treatment involving early debridement and partial skin grafting, with the scalp being used as the donor site for the skin grafts in four surgical interventions over two months of hospitalization. This study provides an updated review on the use of the scalp in children with extensive burns to improve understanding of surgical treatment and long-term outcomes for severely burned children. The article also discusses the clinical progress, surgical procedures, and 20-year follow-up after the burn, aiming to advance knowledge in this area for the benefit of future patients with severe burns. The purpose of this article is to report on the clinical use of the scalp as a recurrent donor site for skin grafts in a pediatric burn patient and to evaluate the longterm outcomes of this treatment method.***

Keywords: Burns, Debridement, Skin Graft, Scalp, Pediatric Burns.

1. Introduction

When Burns pose a significant worldwide public health issue, accounting for an estimated 180,000 deaths annually, with most cases occurring in countries with medium and low socioeconomic status [1].

According to the World Health Organization (WHO), burn accidents are the fourth most common type of accidents worldwide [2]-[3]. They occur more frequently in underdeveloped countries, accounting for 90% of all cases compared to developed countries. In Brazil, it is estimated that approximately one million burn accidents occur annually, leading to around 150,000 hospitalizations per year, with children representing 30% of these cases. The males and the age group from 1 to 4 years are the demographics most frequently affected [4].

Non-fatal cases are significant contributors to morbidity, leading to extended hospital stays, functional and aesthetic issues, as well as social stigma and rejection. Children are at a higher risk of burns, as it is the fifth most common cause of non-fatal injuries in this age group. While inadequate adult supervision poses the greatest risk, a significant number of burns are also caused by abuse [5].

The incidence of death from burns has decreased in developed countries. However, the mortality rate from burns in children is seven times higher in underdeveloped countries, revealing a serious public health problem [1].

Burns in young children most commonly occur in domestic environments, with the primary cause being exposure to thermal agents, such as overheated liquids leading to scalding. These accidents account for 37.1% of cases among children aged 0-5 years [6]. The upper limbs are most affected, but injuries can occur in multiple areas of the body due to the volatility of heated liquids, which can affect other parts of the body depending on the splashes of the damaging agent and the child's position during the accident. In contrast, among adults, the main cause of burns was accidents involving direct flames [7].

The severity of burns is determined based on the extent of the injury, its depth, location, and the patient's age. This helps us understand the clinical impact and assess potential systemic effects depending on the affected area. Burns that happen at very young or old ages, or in individuals with pre-existing health conditions, are considered more serious. It is crucial to provide immediate treatment for these injuries to prevent the risk of infection, septic shock, and multiple organ failure [8]. In treating major burns, it is essential to ensure compensation for body fluids lost during the first 24 to 48 hours after injury [8]. Dehydration is one of the main complications of burns. Adequate replacement of these fluids is crucial to maintain the patient's hemodynamic stability and minimize the risks associated with dehydration and hypovolemic shock. Furthermore, after the period of shock and clinical stabilization of the patient, it is necessary to prepare the patient for surgical intervention.

It is important to cover the affected areas early with a skin graft as a fundamental step in treatment. The main goal of this approach is to reduce body losses, restore the lost skin barrier, and prevent complications such as infections and sequelae. Skin grafting is essential to promote the regeneration of

damaged tissue, contributing to healing and restoring the proper function of the affected skin [9].

During early debridement, the goal is to eliminate dead or infected tissue to protect the internal environment either permanently or temporarily. If performed within the first ten days, using an autograft to cover the debrided surfaces is an alternative surgical option for faster healing. In cases of extensive burns, finding donor areas for skin grafting can be a challenge, and the scalp (if unaffected by burns) can serve as a good donor area for harvesting grafts [10].

The use of scalp skin as a donor site for autografts in extensive burns offers the advantage of early re-epithelialization of the donor site. The well-vascularized hair-bearing skin on the head allows the surgeon to perform skin autografts every two weeks. In children, the head region is relatively larger than in adults, allowing for a greater percentage of body surface area for skin removal [11].

In this study, the authors present a clinical case of a 9-month-old child who sustained extensive and deep burns. The child was followed up for long-term care 20 years after the accident. The study describes the surgical techniques used in the treatment and discusses the case's evolution. Additionally, the management and complications of scalp skin grafts are examined through a review of the literature, offering an updated perspective, particularly on early debridement and recurrent use of scalp grafts in children with extensive burns. The specific objective of the research is to gain a better understanding of the surgical treatment of severely burned children and their long-term outcomes.

2. Case Report

The patient was initially treated at a public hospital and stayed there for 3 months. After being discharged, the patient has been receiving follow-up care at a private clinic, where all his medical records and photographic documentation are kept. On December 27, 2003, a 9-month-old child, R.G.A., suffered a direct flame burn in a rural area. After receiving first aid at an Emergency Care Unit, the patient was transferred to a Burn Treatment Center. Upon admission, the patient was found to have second and third-degree burns, totaling 30% of the body surface area burned (% BSAB), with burns on the lower limbs, left gluteus and left lumbar region. Third-degree burns were predominant (Figure 1). Volemic resuscitation was performed with Ringer's lactate, according to the Parkland formula, plus an additional 1500 ml per square meter of body surface area for small children. After the shock phase and stabilization of the general condition, the patient was prepared for surgical intervention, which included debridement and autografting.

Figure 1: (a) Second and third-degree burns on the lower limb, buttocks, and left lumbar region. (b) Second and third-degree burns on the right lower limb.

On the 7th day after the burn, the first surgical intervention was performed. Debridement of the lower limbs was done, and they were covered with autograft taken from the scalp, using a 1:3 mesh (Figure 2).

Figure 2: (a) Debridement of lower limbs. (b) Area covered by autograft with mesh taken from the scalp.

The second operation was performed on the 20th day, involving debridement of the remaining areas of the lower limbs and left gluteus. Partial skin autografts taken from the scalp were used after complete epithelialization. On the 35th day, the third operation was done to remove granulations on the lateral part of the left leg and cover the defects with skin autografts taken from the scalp and lateral portion of the right thigh. The fourth and final operation was carried out on the 55th day. It involved the removal of the granulations from areas of graft loss in the lateral region of the left thigh and left gluteus. Autografts from the scalp were used to cover the defects (Figure 3).

Figure 3: Healing process 55 days after burn with removal of granulations and coverage with new autograft in treated areas.

While in the hospital, the child received continuous monitoring from the anesthesiology team, especially during dressing changes under anesthesia. Continuous blood tests and standardized laboratory tests were conducted. Antibiotics were only given based on the results of wound cultures and antibiograms.

On March 15, 2004, the child was discharged from the hospital. He was in good overall condition, with well-healed grafts and no open wounds. The medical team recommended additional care, physiotherapy, and compression with mesh in the grafted areas. The scalp showed no signs of alopecia-related issues (Figure 4).

Figure 4: (a) Graft donor area after dermatome removal. (b) Healing process, without signs of alopecia.

During the 20-year follow-up, the patient did not have any functional or aesthetic complaints. The mesh grafts, despite their checkered appearance, showed good elasticity, turgor, and color close to normal skin. The scalp, which was used three times during hospitalization, had no areas of hair loss, and the scars were barely noticeable (Figure 5).

Figure 5: Result of the area affected by the burn and the scalp, with no signs of long-term complications.

2.1 Surgical technique

The scalp was shaved and sterilized using a 2% povidoneiodine solution to remove germs. Then, a mixture of 1:200,000 epinephrine and sterile saline (0.9% NaCl) was injected into the space under the scalp to increase the area available for skin harvesting. A Padgett® electric dermatome (Integra LifeSciences Inc., Princeton, NJ, USA) was used to harvest partial slices of scalp skin, with an average thickness of 0.012 inches (0.3 mm). To reduce bleeding at the donor site, a gauze dressing soaked in an epinephrine solution (10 mg of epinephrine in 1 liter of 0.9% NaCl) was applied. Hemostasis was maintained by using a temporary nitrofurazone dressing covered with absorbent gauze and an elastic bandage. The split skin graft sheets were expanded 1:3 using the "Mesh Graft" device (Skin Graft Mesher Zimmer, Ohio, USA) and secured in the recipient areas with 4-0 vicryl stitches. Finally, the wound was dressed in rayon gauze, cotton gauze, and a crepe bandage (refer to Figure 6).

3. Discussion

Burns are defined as traumatic injuries caused by thermal, chemical, or electrical agents that result in the loss of tissue functionality. The consequences impact the individual's life in all areas, causing serious physical consequences that can lead to limitations, as well as psychological and social consequences [12].

The global incidence of burn cases ranks it as the fourth most common type of accident, with higher rates in underdeveloped countries, which contributes significantly to public health concerns [4]. It is estimated that in Brazil alone, there are approximately one million burn-related accidents per year, with two thousand five hundred of these accidents resulting in death [13].

Most burn cases occur at the extremes of age. Children make up 30% of these cases, with the highest incidence seen in those under 4 years of age, particularly in males due to differences in behavior. Domestic accidents are the most common cause, with overheated liquids being the main agent. Scalding most frequently affects the face, upper limbs, and trunk [14].

3.1 Classification

Burns are classified into four degrees according to depth, with partial surface burns being first and second-degrees injuries. First-degree burns affect the epidermis, and their classic presentation is erythema and pain. The structures responsible for re-epithelization are preserved in this form and complete improvement of the condition occurs in 3 to 6 days, without scarring [15].

Second-degree burns affect both the epidermis and the dermis, and they can be classified as superficial or deep. Both types can cause blisters and phlyctenae, but they differ in the appearance of the skin below the blisters. Superficial burns have a pink surface, while deep burns have a whitish appearance and may leave a scar. Superficial burns typically heal in 10-14 days, while deep burns take 25-35 days to heal. Third-degree burns affect the epidermis and the full thickness of the dermis, resulting in loss of sensation at the site and often requiring surgical interventions such as skin grafting. Finally, fourth-degree burns extend through the epidermis, dermis, and subcutaneous tissue, and may reach the underlying muscles and bones, necessitating surgical management with flaps and grafting [15].

3.2 Pathophysiology

The pathophysiology of burns involves an excess of systemic inflammatory response syndrome (SIRS). This leads to an inflammatory process at the burn site, triggered by the activation of the arachidonic acid cascade, kallikrein-bradykinin cascade, activation of the Hageman factor (factor XII), and the coagulation-fibrinolysis system. As a result of this activation, various chemical mediators such as histamine, prostaglandins, kinins, and serotonin are released, leading to increased permeability of the local microvasculature and vasodilation [16].

Moreover, endothelial cells, monocyte-macrophages, and neutrophil polymorphonuclear cells are activated, leading to a generalized inflammatory response due to the release of pro-inflammatory cytokines and oxidative stress. The severity of the inflammatory response at the burn site primarily depends on the extent of the injured area and whether there is concomitant inhalation injury. If the burn affects more than 25% of the body surface, systemic changes may occur, disrupting overall homeostasis. The clinical presentation of a severely burned patient can range from local redness to shock, depending on the extent and depth of the injury. Common symptoms include pain, redness, and swelling. The compromised skin barrier can result in hypothermia, hypovolemia, and subsequent infection. Additionally, the patient may exhibit symptoms of respiratory failure, shock, cardiac arrhythmia, and renal failure [16].

3.3 Initial Treatment

During hospital admission, it is essential to ensure that the care provided follows established protocols and procedures to maintain the team's focus on critical aspects that may otherwise be overlooked. Therefore, every patient with major burns should be treated as a trauma victim, and the initial care recommended by the Advanced Trauma Life Support Course (ATLS) should be administered. It is crucial to document information about the trauma's mechanism in the patient's medical record [16].

The wound is typically cleaned using water and 2% chlorhexidine as a disinfectant. In the absence of chlorhexidine, water, and mild soap can be used. It is important to ensure the removal of all foreign bodies and devitalized tissue. The wounds can then be covered with a topical antimicrobial, such as 1% silver sulfadiazine combined with 0.4% cerium nitrate during the initial days [16].

After cleaning and ensuring clear visibility, it is necessary to measure the extent of the burned area and the depth of the lesion. Accurately determining the amount of the body surface affected by the burn is crucial for estimating the required fluid intake during the initial phase of treatment [16].

In children, the severity of the condition is influenced not only by the depth of the burn, but also by other factors such as the agent causing the burn, exposure time, age, associated health conditions, inhalation injury, and involvement of more than 30% of the body area. When burns affect the face, genitals, and upper or lower limbs, the patient is considered to have major burns [17].

The treatment of severely burned patients requires a comprehensive approach and a multidisciplinary team. Clinical management of the patient involves maintaining respiratory function (establishing the airway and assessing the need for intubation), hemodynamic control, as well as nutritional support and pain control [18].

Dehydration is one of the main complications of burns. This condition can be serious and can lead to complications such as renal failure and septic shock. It can be controlled through intravenous rehydration. The most common protocol is the "Parkland formula," which involves administering 4 ml of fluid per kilogram of the patient's weight for every percentage of burned body surface area, per hour over 24 hours. Half of the total amount should be infused in the first 8 hours and the remainder in the subsequent 16 hours [18].

In children, the maintenance volume should be adjusted due to their smaller body surface area compared to adults, which requires larger initial volumes. The added value should be calculated according to body weight as follows: 100 ml/kg for the first 10 kg; 50 ml/kg for the subsequent 10-20 kg; and 20 ml/kg for the remaining 20-30 kg [15].

From the second day after the burn, there is a decrease in the need for volume infusion. However, there is still loss due to evaporation in the burned areas, and in some patients, volume resuscitation may not be complete. Therefore, it is recommended to monitor diuresis and other variables related to tissue perfusion (such as lactate, base excess, and central venous saturation) to avoid dehydration and tissue hypoperfusion [16].

3.4 Surgical Treatment

With the introduction of early excision and grafting of burns, the length of hospital stay has decreased, resulting in fewer functional and aesthetic issues [19]. Initially, intervention was recommended within the first 5 days after burns, but the term has been extended to any grafting procedure performed before the natural fall off the eschar (usually before the third week), especially in cases where there is uncertainty about the depth of the burn. This technique has the potential to significantly improve clinical and functional outcomes for burn patients, minimizing complications and speeding up the healing process [20].

Early debridement of burns has consistently shown significant benefits in patients without inhalation injury. A comprehensive review indicates that this approach is linked to reduced mortality rates in this patient subgroup. In addition, early debridement also leads to a shorter hospital stay. It's important to note that this strategy is associated with a higher rate of blood transfusion, which may be necessary due to the surgical procedure itself and the extent of the burns. Therefore, early debridement is an advantageous clinical practice for patients without inhalation injury, offering a more effective and targeted approach to burn treatment [8].

Accurate diagnosis of burn depth is crucial to determine whether early surgery is necessary. Superficial burns can often heal on their own with conservative treatment, while deep burns may require surgical intervention such as early

debridement and grafting. Therefore, careful clinical examination and the ability to discern burn depth play a critical role in clinical decision-making to determine the appropriate course of treatment in burn patients.

The burn management approach outlined by ENGRAV (2008) is clinically sound and involves a thorough assessment of burn depth and careful surgical planning. According to this approach, identified third-degree burns should be surgically treated within the first week after the burn injury, recognizing the importance of early intervention for optimizing patient recovery [20]. For intermediate-thickness burns, such as deep second-degree burns, or when there is uncertainty about progression to third-degree burns, it is recommended to wait for 10 days for reevaluation as a cautious approach. This allows healthcare professionals to closely monitor the progress of the injury and make a more accurate determination regarding the need for surgery [21].

The decision to schedule surgery for signs of non-epithelialization before 3 weeks is also strategically sensible, as it recognizes that some burns may require subsequent surgical intervention due to complications in healing. This approach demonstrates the importance of ongoing and adaptive assessment of burns to ensure the best possible outcome for patients [21].

Surgical planning that aims to complete facial skin coverage in 21 days is based on specific goals to improve aesthetic outcomes and minimize scar complications. Eliminating the granulation phase, during which the injured skin is in the process of natural healing, is a strategy that can offer several advantages, including providing a better aesthetic result, less scar fibrosis, and minimizing the risk of hypertrophy and subsequent retraction [21].

Even partial-thickness burns (deep second-degree) can greatly benefit from early treatment. Results have shown that an early surgical approach yields significantly better outcomes compared to spontaneous healing or the application of grafts in areas of granulation and fibrosis. Therefore, it's important to highlight that timely surgical intervention plays a crucial role in achieving more satisfactory results for patients with partial-thickness facial burns. This leads to a substantial improvement in the quality of recovery and minimizes scar complications [20].

The coverage of facial tissue in young burn patients has received significant attention in the field of reconstructive surgery. Over the years, there have been substantial advancements in this procedure, with valuable insights gained from renowned institutions such as the Shriners Burns Institute. The seminal work of ALMAGUER in 1985 provides a fundamental perspective on the long-term results and challenges associated with facial treatment in these patients [9].

In 1964, Crawford performed the first scalp skin grafting on the abdomen and trunk area. The procedure involved harvesting thin strips of shaved scalp using a large-blade scalpel on a 9-year-old girl who had suffered deep burns from mid-calf to the nipple [22]. Subsequently, many authors have documented the use of scalp skin grafting for acute burns, trauma, and surgical wounds [23]. They have also observed scarless wound healing in the donor area of the scalp after single or multiple harvests, with a small number of reported complications [24].

Furthermore, Silverman et al. in 1992 provided critical insights into alternative grafting approaches, with a particular focus on using the scalp as a donor site. This approach may play a crucial role in improving the outcomes of facial and neck burn reconstruction in pediatric patients. These studies emphasize the evolving landscape of facial resurfacing techniques and stress the importance of refining and expanding the range of surgical options available to enhance the quality of life for young burn survivors [23].

The use of the scalp as a donor site for grafts in facial and cervical burns in children has several significant advantages. One of the main benefits is the inconspicuous healing after hair growth on the scalp, leading to superior aesthetics compared to other donor sites, such as the thigh. Scars on the thigh can be more visible and can negatively impact the patient's self-esteem. Additionally, the scalp has a rapid healing capacity, allowing for its reuse in shorter periods, which is especially relevant in growing patients as their reconstruction needs evolve. Another positive aspect is the reduced pain sensation reported by patients compared to the use of alternative donor sites, making the procedure more tolerable and providing a less traumatic experience for children undergoing this surgical approach [24].

An additional reason to consider using the scalp as a donor site is patient comfort. Despite being unsightly, shaving the scalp is less painful compared to the thigh, requiring fewer dressing changes and allowing the patient to walk earlier [25].

This is especially important for elderly patients MIMOUN et al.'s (2006) study provides a comprehensive overview of the potential advantages of using the scalp as a donor site. The authors analyzed a sample of 945 collected samples and demonstrated the significant benefits of using the scalp. These include the ease of obtaining thin-thickness skin grafts with anatomical characteristics like the recipient areas, leading to superior aesthetic results and better graft integration. These findings further support the growing importance of the scalp as a valuable option in reconstructive surgery, affirming its viability as an ideal donor site for thin-thickness skin grafts in pediatric patients [24].

The scalp is a great source of skin grafts due to its rich blood supply and the abundance of dermal appendages in the hair follicles, which promote effective healing. When the skin is injured, the surrounding keratinocytes and hair follicles are activated to regenerate the skin barrier. The fibroblasts found in the hair follicle's papilla and dermal sheath are multipotent mesenchymal stem cells. Additionally, the scalp rarely develops scar hypertrophy, even in patients prone to keloids, making it a favorable donor site for grafts in burn procedures, resulting in efficient healing and good aesthetic outcomes [26].

The scalp's thickness, ranging from 3 to 8 mm, allows for its repeated use as a skin graft donor site, with some studies suggesting it can be used up to 10 times for partial-thickness

burns [11]. However, using the scalp multiple times carries the risk of complications such as folliculitis, alopecia, and the transfer of hair follicles to the recipient area [10]. These potential complications can impact the aesthetics and functionality of both the donor and recipient areas, requiring careful evaluation and surgical planning when considering repeated use of the scalp as a graft donor site.

The study conducted by MacLennan et al. (1998) raises an important concern regarding the treatment of extensive burns in children. The authors observed that in patients requiring multiple skin graft removals, a complication known as hair transfer tends to occur. They highlighted those repeated removals can result in superficialization of the dermal appendages, increasing the risk of accidental transfer of hair bulbs during surgery. As a preventive measure, particularly in the pediatric context, the study recommends selecting a dermatome thickness of around 5 thousandths of an inch. This measure aims to reduce the risk of unwanted hair transfer and ensure more favorable results in the treatment of facial burns in children [27].

Articles have shown that technical errors in defining the desired depth for dermatome removal were responsible for the development of extensive or global alopecia. Factors such as blade angle, pressure, and speed applied to the scalp when harvesting skin using a dermatome influenced the actual graft thickness. Malpass et al. demonstrated a change in thickness from 0.12 to 0.42 mm using a dermatome depth setting of 0.2 mms, with an average harvested graft thickness of 0.23 mm, leading to the conclusion that the most important factor is the surgeon [25].

After scalp grafting, complications have included crusting, redness, temporary uneven appearance, wound infections, scalp deformity, and folliculitis. Crusting usually resolves after 1 month. Redness gradually improves over 1 year or more and is related to the depth of the donor wound. Wound infections, folliculitis, and scalp deformities need aggressive treatment with sensitive antibiotics. If these complications are not controlled, the donor area may experience hair loss or tufted scar deformity [25].

Late complications mainly consist of hair loss, pressure sores in the back of the head, scars, raised scars, tufted scar deformity, and technical errors in harvesting. Small lesions may go unnoticed, but larger ones may require further surgery for aesthetic improvement. These late complications can be prevented by using proper techniques for removing skin from the donor site, positioning the patient correctly after surgery, and promptly treating infections [25].

It is important to prioritize preventing domestic accidents to reduce burns. Educational programs in schools and underprivileged communities, the use of smoke detectors, and changes in legislation can effectively lower the incidence of burns [28].

Since most of these accidents are preventable, the obtained data can be used to develop prevention and public health programs, as well as to understand the profile and cost of treatment. By doing so, we can quantify the number of burn cases in the healthcare system and identify areas where prevention strategies and resources are needed [29].

Epidemiological data from pediatric burn patients can provide valuable information for accident prevention efforts, ultimately helping to reduce the number of cases. Studies indicate that burns result from multiple factors, such as inadequate supervision, using common areas for cooking and sleeping, transferring hot liquids in open containers, as well as impulsive behavior and lack of knowledge among children [29].

4. Conclusion

The treatment of extensively burned children presents challenges in clinical practice due to their complexity, especially when surgical intervention is necessary. Due to the high incidence of burn accidents in children and the difficulties in their management, it is important to establish an appropriate approach to care to improve the patient's quality of life. This case report describes the occurrence and progression of an extensive burn from a direct flame on the lower limbs in a nine-month-old child, who underwent an autograft procedure.

It can be challenging to perform early debridement and use skin grafts in children, particularly when a large area is affected, and the body surface area is smaller. The scalp has proven to be essential as a donor area due to its strong blood supply, which promotes faster healing and allows for quicker re-use. One of the main issues related to using the scalp as a donor area repeatedly is alopecia. To reduce risks and improve outcomes, studies have shown the benefits of using a dermatome with a thickness of less than 0.5 mm. In our case, we observed positive progress using a 0.3 mm skin graft sheet, as seen in the favorable follicle growth during follow-up. In conclusion, this case report demonstrates that the repeated use of the scalp as a donor site for skin grafts in pediatric patients can result in favorable longterm outcomes, both functionally and aesthetically.

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